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TGD AND EEG

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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 $H = M^4 \times CP_2$ [L155]. 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 [L53, L69](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 [L157].

- 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 [K123, L86].

- 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 [K24, K55] [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 geneneral 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 [L159].

- 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 [L51, L52] 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 [L158]. 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 holgamphy, 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 light-cones. The notion of energy-momentum becomes length scale dependent since one has a scale hierarchy for causal diamonds. This allows to understand the non-conservation of energy as apparent.

  Equivalence Principle in the form expressed by Einstein's equations follows from Poincare invariance once it is realized that GRT space-time is obtained from the many-sheeted space-time of TGD by lumping together the space-time sheets to a regionof 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 [A11]. I have proposed [K45, K27, K119, K87, L157] 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 wormhole throats and boundaries of the space-time surface would be special. This slicing would correspond to Hamilton-Jacobi structure.

- Fractal hierarchy of symmetry algebras with conformal weights, which are non-negative integer multiples of fundamental conformal weights, is essential and distinguishes TGD from string models. Gauge conditions are true only the isomorphic subalgebra and its commutator with the entire algebra and the maximal gauge symmetry to a dynamical symmetry with generators having conformal weights below maximal value. This view also conforms with p-adic mass calculations.

- The realization of the symmetries for 3-surfaces at the boundaries of CD and for light-like orbits of partonic 2-surfaces is known. The problem is how to extend the symmetries to the interior of the space-time surface. It is natural to expect that the symmetries at partonic orbits and light-cone boundary extend to the same symmetries.

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

About the construction of scattering amplitudes

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

- In ZEO [K123, L86] 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 [L153]. 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 [L133, L134] led to a stringy variant of the twistor diagrammatics.

- Fundamental fermions are off-mass-shell in the sense that their momentum components are real algebraic integers in an extension of rationals associated with the space-time surfaces inside CD with a momentum unit determined by the CD size scale. Galois confinement states that the momentum components are integer valued for the physical states.

- The twistorial approach suggests also the generalization of the Yangian symmetry to infinite-dimensional super-conformal algebras, which would determine the vertices and scattering amplitudes in terms of poly-local symmetries.

The twistorial approach is however extremely abstract and lacks a concrete physical interpretation. The holography=holomorphy vision led to a breakthough in the construction of the scattering amplitudes by solving the problem of identifying interaction vertices [L159].

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 3-surfaces. At singularities masslessness property fails and singularities can be said to serve as sources which also in QFT define scattering amplitudes.

3. The singularities are analogs of poles and cuts for the 4-D generalization of the ordinary holomorphic functions. Also for the ordinary holomorphic functions the Laplace equation as analog massless field equation and expressing analyticity fails. Complex analysis generalizes to dimension 4.

4. The conditions at the singularity give a generalization of Newton's "F=ma"! I ended up where I started more than 50 years ago!

5. In dimension 4, and only there, there is an infinite number of exotic diff structures [?], which differ from ordinary ones at singularities of measure zero analogous to defects. These defects correspond naturally to the singularities of minimal surfaces. One can say that for the exotic diff structure there is no singularity.

6. Group theoretically the trace of the SFF can be regarded as a generalization of the Higgs field, which is non-vanishing only at the vertices and this is enough. Singularities take the role of generalized particle vertices and determine the scattering amplitudes. The second fundamental form contracted with the embedding space gamma matrices and slashed between the second quantized induced spinor field and its conjugate gives the universal vertex involving only fermions (bosons are bound states of fermions in TGD). It contains both gauge and gravitational contributions to the scattering amplitudes and there is a complete symmetry between gravitational and gauge interactions. Gravitational couplings come out correctly as the radius squared of CP_2 as $also$ in the $classical$ $picture$.

7. The study of the modified Dirac equation leads to the conclusion that vertices as singularities and defects contain the standard electroweak gauge contribution coming from the induced spinor connection and a contribution from the M^4 spinor connection. M^4 part of the generalized Higgs can give rise to a graviton as an $L = 1$ rotational state of the flux tube representing the graviton. It is not clear whether M^4 Kähler gauge potential can give rise to a spin 1 particle. The vielbein part of M^4 spinor connection is pure gauge and could give rise to gravitational topological field theory.

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 [L146]. 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 tranfer 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

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LaTeX Warning: Citation 'Engel' on page 501 undefined on input line 290.

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Chapter i.
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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 [K1].

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 [A18]. The twistor structure would be induced in some sense, and should coincide with that associated with the induced metric. Clearly, the 2-spheres defining the fibers of twistor spaces of M^4 and CP_2 must allow identification: this 2-sphere defines the S^2 fiber of the twistor space of the space-time surface. This poses a constraint on the embedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces. The existence of Kähler structure allows to lift 4-D Kähler action to its 6-D counterparts and the 6-D counterpart of twistor space is obtained by its dimensional reduction so that one obtains a sphere bundle. This makes possible twistorialization for all space-time surfaces: in general relativity the general metric does not allow this.

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

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

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

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

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

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

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

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

6. General coordinate invariance requires holography so that space-time surfaces are analogous to Bohr orbits for particles identified as 3-surfaces. Bohr orbit property would be naturally realized by a 4-D generalization of holomorphy of string world sheets and implies that the space-time surfaces are minimal surfaces apart from singularities. This holds true for any action as long as it is general coordinate invariant and constructible in terms of the induced geometry. String world sheets and light-like orbits of partonic 2-surfaces correspond to singularities at which the minimal surface property of the space-time surfaces realizing the preferred extremal property fails. Preferred extremals are not completely deterministic, which implies what I call zero energy ontology (ZEO) meaning that the Bohr orbits are the fundamental objects. This leads to a solution of the basic paradox of quantum measurement theory. Also the mathematically ill-defined path integral disappears and leaves only the well-defined functional integral over the Bohr orbits.

7. A string model-like picture emerges from TGD and one ends up with a rather concrete view about the topological counterpart of Feynman diagrammatics. The natural stringy action would be given by the string world sheet area, which is present only in the space-time regions with Minkowskian signature. Gravitational constant could be present as a fundamental constant in string action and the ratio $\hbar/G/R^2$ would be determined by quantum criticality conditions. The hierarchy of Planck constants $h_{eff}/h = n$ 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 [A6] [B10, B8, B9]), which is a generalization of Kac-Moody algebras rather than gauge algebra and suffers a fractal hierarchy of symmetry breakings defining hierarchy of criticalities. TGD is *not* one more quantum field theory like structure based on path integral formalism: path integral is replaced with functional integral over 3-surfaces, and the notion of classical space-time becomes an exact part of the theory. Quantum theory becomes formally a purely classical theory of WCW spinor fields: only state function reduction is something genuinely quantal.

4. TGD view about spinor fields is *not* the standard one. Spinor fields appear at three levels. Spinor modes of the embedding space are analogs of spinor modes characterizing incoming and outgoing states in quantum field theories. Induced second quantized spinor fields at space-time level are analogs of stringy spinor fields. Their modes are localized by the well-definedness of electro-magnetic charge and by number theoretic arguments at string world sheets. Kähler-Dirac action is fixed by supersymmetry implying that ordinary gamma matrices are replaced by what I call Kähler-Dirac gamma matrices - this something new. WCW spinor fields, which are classical in the sense that they are not second quantized, serve as analogs of fields of string field theory and imply a geometrization of quantum theory.

5. TGD is in some sense an extremely conservative geometrization of entire quantum physics: *no* additional structures such as gauge fields as independent dynamical degrees of freedom are introduced: Kähler geometry and associated spinor structure are enough. "Topological" in TGD should not be understood as an attempt to reduce physics to torsion (see for instance [B7]) or something similar. Rather, TGD space-time is topologically non-trivial in all scales and even the visible structures of the everyday world represent non-trivial topology of space-time in the TGD Universe.

6. Twistor space - or rather, a generalization of twistor approach replacing masslessness in 4-D sense with masslessness in 8-D sense and thus allowing description of also massive particles - emerged originally as a technical tool, and its Kähler structure is possible only for $H = M^4 \times CP_2$. It however turned out that much more than a technical tool is in question. What is genuinely new is the infinite-dimensional character of the Kähler geometry making it highly unique, and its generalization to p-adic number fields to describe correlates of cognition. Also the hierarchy of Planck constants $h_{eff} = n \times h$ reduces to the quantum criticality of the TGD Universe and p-adic length scales and Zero Energy Ontology represent something genuinely new.

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

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

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

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

TGD as a Poincare Invariant Theory of Gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space $H = M_\times^4 CP_2$, where M^4 denotes Minkowski space and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [A13, A17, A10, A16].

The identification of the space-time as a sub-manifold [A14, A20] of $M^4 \times CP_2$ leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity.

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

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

TGD as a Generalization of the Hadronic String Model

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

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

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

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

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

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

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

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

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

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

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

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

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

1.1.3 Basic Objections

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

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

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

Topological Field Quantization

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

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

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[1]There 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 H Dirac operator D_H appears in fermionic correlation functions: this is due to the fact that free fermions appearing as building bricks of WCW gamma matrices are modes of D_H. The modes of $_D H$ define the ground states of super-symplectic representations. There is also the modified Dirac operator D_{X^4} acting on the induced spinors at space-time surfaces and it is dictated by symmetry one the action fixing the space-time surfaces as Bohr orbits is fixed. D_H is needed since it determines the expressions of WCW gamma matrices as Noether charges assignable to 3-surfaces at the ends of WCW.

The role of modified Dirac action

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

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

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

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

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

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

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

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

1.1.5   Construction of scattering amplitudes

Reduction of particle reactions to space-time topology

Particle reactions are identified as topology changes [A19, A21, A23]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay $A \to B + C$. Classically this corresponds to a path of WCW leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.

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

Construction of the counterparts of S-matrices

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

1. There are two kinds of state function reductions (SFRs). "Small" SFRs (SSFRs) following the TGD counterpart of a unitary time evolution defines a sequence of SFRs, which is analogous to a sequence of repeated quantum measurements associated with the Zeno effect. In wave mechanics nothing happens in these measurements. In quantum optics these measurements correspond to weak measurements. In TGD SSFR affects the zero energy state but leaves the 3-D state at the passive boundary of CD unaffected.

2. In TGD framework each SSFR is preceded by a counterpart of a unitary time evolution, which means dispersion in the space of CDs and unitary time evolution in fermionic degrees of freedom such that the passive boundary of CDs and 3-D states at it are unaffected but a superposition of CDs with varying active boundaries in the space of CDs is formed. In SSFR a localization in the space of CDs occurs such that the active is fixed. In a statistical sense the size of the CD increases and the increasing distance between the tips of the CD gives rise to the arrow of geometric time.

3. Also "big" SFRS (BSFRs) can occur and they correspond to ordinary SFRs. In BSFR the roles of the active and passive boundary are changed and this means that the arrow of time is changed. Big SFR occurs when the SSFR corresponds to a quantum measurement, which does not commute with the operators, which define the states at the passive boundary of CD as their eigenstates. This means a radical deviation from standard quantum measurement theory and has predictions in all scales.

4. One can assign the counterpart of S-matrix to the unitary time evolution between two subsequent SSFRs and also to the counterpart of S-matrix associated with BSFR. At least in the latter case the dimension of the state space can increase since at least BSFRs lead to the increase of the dimension of algebraic extension of rationals assignable to the space-time surface by $M^8 - H$ duality. Unitarity is therefore replaced with isometry.

5. I have also considered the possibility that unitary S-matrix could be replaced in the fermionic degrees of freedom with Kähler metric of the state space satisfying analogs of unitarity conditions but it seems that this is un-necessary and also too outlandish an idea.

The notion of M-matrix

1. The most ambitious dream is that zero energy states correspond to a complete solution basis for the Dirac operators associated with WCWs associated with the spaces of CDs with fixed passive boundary: this would define an S-matrix assignable to SFR. Also the analog of S-matrix for the localizations of the states to the active boundary assignable to the BSFR changing the state at the passive boundary of CD is needed.

2. If one allows entanglement between positive and 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 [K63]. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of S and represented as scaling with respect to the logarithm of the proper time distance between the tips of CD.

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

1.1.6   TGD as a generalized number theory

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

The Threads in the Development of Quantum TGD

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

1. Quantum T(opological) G(eometro)D(ynamics) as a classical spinor geometry for infinite-dimensional WCW, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness and of quantum biology have been for last decade of the second millenium the basic three strongly interacting threads in the tapestry of quantum TGD.

2. The discussions with Tony Smith initiated a fourth thread which deserves the name "TGD as a generalized number theory". The basic observation was that classical number fields might allow a deeper formulation of quantum TGD. The work with Riemann hypothesis made time ripe for realization that the notion of infinite primes could provide, not only a reformulation, but a deep generalization of quantum TGD. This led to a thorough and rather fruitful revision of the basic views about what the final form and physical content of quantum TGD might be. Together with the vision about the fusion of p-adic and real physics to a larger coherent structure these sub-threads fused to the "physics as generalized number theory" thread.

3. A further thread emerged from the realization that by quantum classical correspondence TGD predicts an infinite hierarchy of macroscopic quantum systems with increasing sizes, that it is not at all clear whether standard quantum mechanics can accommodate this hierarchy, and that a dynamical quantized Planck constant might be necessary and strongly suggested by the failure of strict determinism for the fundamental variational principle. The identification of hierarchy of Planck constants labelling phases of dark matter would be natural. This also led to a solution of a long standing puzzle: what is the proper interpretation of the predicted fractal hierarchy of long ranged classical electro-weak and color gauge fields. Quantum classical correspondences allows only single answer: there is infinite hierarchy of p-adically scaled up variants of standard model physics and for each of them also dark hierarchy. Thus TGD Universe would be fractal in very abstract and deep sense.

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

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

Number theoretic vision very briefly

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

1. The physical interpretation of M^8 is as an analog of momentum space and $M^8 - H$ duality is analogous to momentum-position duality of ordinary wave mechanics.

2. Adelic physics means that all classical number fields, all p-adic number fields and their extensions induced by extensions of rationals and defining adeles, and also finite number fields are basic mathematical building bricks of physics.

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

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

   NMP is mathematically completely analogous to the second law of thermodynamics and number theoretic evolution as an unavoidable statistical increase of the dimension of the algebraic extension of rationals characterizing a given space-time region implies it. There is no paradox involved: the p-adic negentropy measures the conscious information assignable to the entanglement of two systems regarded as a conscious entity whereas ordinary entropy measures the lack of information about the 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 p-adic definite integral which is a crucial element of any variational principle based formulation of the field equations. Here the frustration was not due to the lack of solution but due to the too large number of solutions to the problem, a clear symptom for the sad fact that clever inventions rather than real discoveries might be in question. Quite recently I however learned that the problem of making sense about p-adic integration has been for decades central problem in the frontier of mathematics and a lot of profound work has been done along same intuitive lines as I have proceeded in TGD framework. The basic idea is certainly the notion of algebraic continuation from the world of rationals belonging to the intersection of real world and various p-adic worlds.

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

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

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

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

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

emerge as so called ramified primes of algebraic extension of rationals in question and characterizing string world sheets and partonic 2-surfaces. Preferred p-adic primes would be ramified primes for extensions for which the number of p-adic continuations of two-surfaces to space-time surfaces (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 [K59].

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

Infinite primes

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

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

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

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

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

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

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

Holography in H

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

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

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

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 sub-space which corresponds to a point of sphere $S^2 = SO(3)/O(2)$, where $SO(3)$ is the quaternionic automorphism group. The interpretation could be in terms of a selection of spin quantization axes. The local choice of the preferred complex plane would not be unique and is analogous to the possibility of having non-trivial Hamilton Jacobi structures in M^4 characterized by the choice of $M^2(x)$ and equivalently its normal subspace $E^2(x)$.

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

3. The real part $Re(g(y))$ defines a point of $SU(3)$ and the bundle projection $SU(3) \to CP_2$ 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 $1 \oplus 3 \oplus \bar{3}$. The automorphism property requires that 1 can be transformed to 3 or $\bar{3}$ to themselves: this requires that the decomposition contains $3 \oplus \bar{3}$. Furthermore, it must be possible to transform 3 and $\bar{3}$ to themselves, which requires the presence of 8. This leaves only the decomposition $8 \oplus 3 \oplus \bar{3}$. G_2 gluons would both color octet and triplets. In the TDG framework the only conceivable interpretation would be in terms of ordinary gluons and leptoquark-like gluons. This does not fit with the basic vision of TGD.

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

1.1.8   Hierarchy of Planck Constants and Dark Matter Hierarchy

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

Dark Matter as Large $\hbar$ Phases

D. Da Rocha and Laurent Nottale [E3] 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 [K93].

     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 [K77, K78, K74]) support the view that dark matter might be a key player in living matter.

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

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

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

1.1.9   Twistors in TGD and connection with Veneziano duality

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

Twistor lift at space-time level

8-dimensional generalization of ordinary twistors is highly attractive approach to TGD [K109]. 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 [A18]. 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 space-time surface to the product of twistor spheres. Cosmological constant has spectrum and depends on length scale, and the proposal is that coupling constant evolution reduces to that for cosmological constant playing the role of cutoff length. That cosmological constant could transform from a mere nuisance to a key element of fundamental physics was something totally new and unexpected.

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

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

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

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

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

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

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

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

however leads to a new expansion phase. These jerks would replace smooth cosmic expansion of GRT. The discrete coupling constant evolution predicted by the number theoretical vision could be understood as being induced by that of cosmological constant taking the role of cutoff parameter in QFT picture [L67].

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 [L52]. 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 t-channel resonance poles identified as excitations of strings. The sum over exchanges defined by t-channel resonances indeed reduces at larger values of s to Regge form.

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

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

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

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

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

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

1. How to get rid of the problems with unitarity caused by the zero width of resonances? Could *finite* resonance widths make unitarity possible? Ordinary twistor Grassmannian approach predicts that the virtual momenta are light-like but complex: obviously, the imaginary part of the energy in rest frame would have interpretation as resonance 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 [K106, K16, K73, K14, K40, K52, K56, K95, K103].

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 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 prepared whereas the second end of CD corresponds to a superposition of (negative/positive energy) states with varying particle numbers and single particle quantum numbers just as in ordinary particle physics experiment.

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

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

1. The basic objection is that the arrow of geometric time alternates at embedding space level but we know that arrow of time looks the same in the part of the Universe we live. Possible exceptions however exist, for instance phase conjugate laser beams seem to obey opposite arrow of time. Also biological phenomena might involve non-standard arrow of time at some levels. This led Fantappie [?] 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 ($\delta M_\pm^4 \times CP_2$).

3. The sequence of state function reductions on a fixed boundary of CD leads to the increase of the average temporal distance between the tips of CDs and this gives rise to the experience about flow of time as shifting of contents of perception towards future if the change is what contributes to conscious experience and gives rise to a fixed arrow of time.

4. Contrary to original working hypothesis, state function reduction in the usual sense does not solely determine the ordinary conscious experience. It can however contribute to conscious experience and the act of free will is a good candidate in this respect. TGD view about realization of intentional action assumes that intentional actions involve negative energy signals propagating backwards in geometric time. This would mean that at some level of CD hierarchy the arrow of geometric time indeed changes and the reduction 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) [K59] 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 remaim 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 [K86]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization. Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken's classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the "energy" landscape.

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

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

1.2.6 Classical Non-Determinism Of Kähler Action

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

1. The huge vacuum degeneracy of the Kähler action suggests strongly that the preferred is not always unique. For instance, a sequence of bifurcations can occur so that a given space-time branch can be fixed only by selecting a finite number of 3-surfaces with time like(!) separations on the orbit of 3-surface. Quantum classical correspondence suggest an alternative formulation. Space-time surface decomposes into maximal deterministic regions and their temporal sequences have interpretation a space-time correlate for a sequence of quantum states defined by the initial (or final) states of quantum jumps. This is consistent with the fact that the variational principle selects preferred extremals of Kähler action as generalized Bohr orbits.

2. In the case that non-determinism is located to a finite time interval and is microscopic, this sequence of 3-surfaces has interpretation as a simulation of a classical history, a geometric correlate for contents of consciousness. When non-determinism has long lasting and macroscopic effect one can identify it as volitional non-determinism associated with our choices. Association sequences relate closely with the cognitive space-time sheets defined as space-time sheets having finite time duration.

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

1.2.7 P-Adic Physics As Physics Of Cognition

A further basic element adds a physical theory of cognition to this vision. TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, ...$ p-Adic regions obey the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive 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 [K100] . 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 [K35].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K35]. 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 [K35]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K54, K35]. A particularly fascinating implication is the possibility

to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [K35].

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 [K34, K35]. 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 experiencse 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 [K35]. 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 [K54, K35]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible

social rules and moral.

1.3 Quantum Biology And Quantum Neuroscience In TGD Universe

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

1.3.1 Basic Physical Ideas

The following list gives the basic elements of TGD 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 Bird's Eye of View about the Topics of the Book

The TGD based general view about EEG developed in this book relies on the following general picture.

1. TGD Universe is fractal containing fractal copies of standard model physics at various space-time sheets and labeled by the collection of p-adic primes assignable to elementary particles and by the level of dark matter hierarchy characterized partially by the value of Planck constant labeling the pages of the book like structure formed by singular covering spaces of the embedding space $M^4 \times CP_2$ glued together along a four-dimensional back. Particles at different pages are dark relative to each other since purely local interactions defined in terms of the vertices of Feynman diagram involve only particles at the same page. Fractality includes also a hierarchy of conscious entities-selves- and also moment of consciousness identified as quantum jump has fractal structure.

2. A central notion is that of magnetic body. Magnetic body acts as an intentional agent using biological body as a motor instrument and sensory receptor. There is an entire hierarchy of magnetic bodies associated with various body parts and characterized by the respective p-adic length scale $L_p = L(k)$, $p \simeq 2^k$, and the level of dark matter hierarchy labeled by rational number characterizing the value of Planck constant involved. There are indications that the values of Planck constant given by $\hbar = 2^{11k_d}\hbar_0$ are favored in living matter. The values of p and $\hbar/\hbar_0$ could be seen as kind of intelligence and spiritual quotients.

3. Magnetic body controls the biological body and receives information from it. The hierarchy of EEGs (more generally the counterparts of EEG associated with Z^0, and W bosons and gluons) consisting of dark bosons with energies above thermal threshold by the large value of $\hbar$, is the central aspect of this activity.

4. Cyclotron radiation assignable to cyclotron Bose-Einstein condensates at magnetic body and Josephson radiation assignable to Josephson junctions associated with the cell membrane and other electret type structures abundant in living matter are in a dominant role concerning communication and control. In particular, Cyclotron and Josephson frequencies correspond to EEG frequencies which together with p-adic length scale hypothesis leads to a highly predictive scenario.

5. The vision about DNA as topological quantum computer leads to a rather detailed view about how genome and cell membrane interact. Nucleotides and lipids would be connected by magnetic flux tubes carrying dark matter with varying values of Planck constant and define braiding affected by the 2-D flow of the lipids in liquid crystal state and giving rise to a topological quantum computation with program modules defined by standard liquid flow patterns resulting via quantum self organization process in presence of metabolic energy feed.

6. Sensory qualia could be associated with the generalized di-electric breakdowns between sensory organ and its magnetic body behaving somewhat like a capacitor. The cyclotron phase transitions of Bose-Einstein condensates of biologically important ions generated by the dark EEG photons at the magnetic body generate magnetic somatosensory qualia identifiable as our cognitive and emotional qualia. Long ranged charge entanglement made possible by W MEs (topological light rays) are essential element of all motor control and generate exotic ionization of nuclei (new nuclear physics predicted by TGD) in turn inducing classical electric fields at space-time sheets carrying ordinary matter. These fields generate various responses such as ionic waves and nerve pulses yielding the desired physiological responses.

1.4.1   Topics of the "TGD and EEG"

The book contains 3 parts.

1. The 1st part of the book begins with a chapter describing the magnetic sensory canvas hypothesis. It is followed by two chapters describing a model of bio-super-conductivity and high Tc super-conductivity relying on the notions of magnetic body (MB) and dark matter as $h_{eff} = n \times h_0$ phases of ordinary matter. The TGD based notion of classical field differs from its Maxwellian counterpart and I have included a chapter about classical fields in many-sheeted space.

2. 2nd part represents chapters devoted to TGD inspired models for hearing, music experience, and language.

3. The 3rd part is followed by chapters representing models for EEG and nerve pulse. The last chapter discusses the vision that sensory perception and motor action represent time reversals of each other in zero energy ontology (ZEO).

1.5   Sources

The eight online books about TGD [K116, K110, K85, K67, K20, K64, K43, K96] and nine online books about TGD inspired theory of consciousness and quantum biology [K106, K16,

K73, K14, K40, K52, K56, K95, K103] 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: The notion of magnetic body and bio-superconductivity

Magnetic Sensory Canvas Hypothesis

There are very general objections against the idea that ultimate sensory representations are realized inside brain. For instance, any computer scientist, unless informed about materialistic dogmas, would argue that the processing of the sensory data must be separated from its representation. How this could occur if sensory and other representations are realized inside brain, is however difficult to see.

In TGD approach these objections lead to the view that the magnetic flux tube structures associated with the primary sensory organs and higher levels of central nervous system define a hierarchy of sensory and other representations outside brain with magnetic flux tubes serving as the sensory canvas to which place coding by magnetic transition frequencies generates sensory sub-selves and associates with them various sensory qualia and features by quantum entanglement. Thus brain could be much like a RAM memory containing a collection of features in random order and the ordering would be induced by the sensory map to the magnetic sensory canvas. MEs define the sensory projections and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size at least. Thus TGD based view about sensory representations is a diametrical opposite of the standard view in which sensory representations are miniatures.

The construction of a more detailed model is based on the following assumptions.

(a) Sensory qualia are at the level of primary sensory organs having their own magnetic bodies and entangled with the cognitive and symbolic representations of the perceptive field in brain in turn entangled with the points of the sensory magnetic canvas. The entanglement between primary sensory organs and brain and TGD based view about long term memory resolves the basic objections against this view, and one can understand the differences between sensory experience, imagination, dreams, and hallucinations and various strange phenomena like synesthesia, Anton's syndrome, and blind sight.

(b) Second essential element is the mirror mechanism of long term memories. To remember something in the geometric past at temporal distance T is to look at a magnetic mirror with length $L = cT/2$. At quantum level quantum entanglement is involved and means sharing of mental images between recent me and the me of the geometric past (or some other self responsible for the memory representations). This requires that magnetic flux tubes involved with long term memories have astrophysical lengths with light year being the natural length unit. For magnetic fields this indeed makes sense. This picture can be applied to construct a model of long term episodal and declarative memories. The magnetic body (the "me") uses brain as a time mirror by generating a negative energy ME representing a signal propagating along magnetic flux tube to the brain

and entangling magnetic body with brain. The negative energy ME is time reflected as a positive energy ME able to communicate classical information to the magnetic body possibly using p-adic cognitive code. Phase conjugate laser wave is the physical counterpart of negative energy ME.

Zero energy ontology (ZEO) has provided a justification and precise definition for the notion of negative energy signal at quantum level. The arrow of time and negative energy have as quantum correlate the boundary of CD at which the state remains invariant under repeated state function reductions which in ordinary quantum theory would leave the state invariant.

(c) Libet's findings about strange causal anomalies related to the passive aspects of consciousness support strongly the notion of magnetic body and lead to the conclusion that sensory experiences are geometric memories of magnetic body in time scale of .5 seconds about what happens in at the level of material body. Libet's findings about active aspects of consciousness in turn allow to conclude that motor activity is very much like active precognition and mirror image of sensory perception. A beautiful general scenario unifying sensory perception, long term memories, and motor action emerges and allows to explain phenomena like sensory rivalry difficult to understand in neuro-science framework. It must be however admitted that sensory canvas hypothesis is far from being established even in TGD framework: one can also defend the minimal model in which personal magnetic body is responsible only for the realization of long term memories and sensory, symbolic, and cognitive representations are realized only at the level of the material body.

(d) Dark matter hierarchy based on a hierarchy of increasing values of Planck constant predicts a hierarchy of generalized EEGs. The generalized EEGs make it possible for the magnetic bodies to receive sensory information from biological body and quantum control it. The resulting detailed model of ordinary EEG predicts correctly the band structure and narrow resonance bands.

Quantum Model for Bio-Superconductivity: I

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 concepts suggested 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 criticism against "dropping" is that particle can topologically condense on several space-time sheets which therefore are not separate worlds: this is indeed assumed in the recent view about GRT and QFT limit of TGD. Dropping could therefore occur only at larger space-time sheet at the boundary of the smaller one. The expansion of the space-time sheet (flux tube) in p-adic phase transition liberates also zero point kinetic energy (cyclotron energy).

The possibility of large $\hbar$ quantum coherent phases makes the assumption about thermal isolation between space-time sheets un-necessary. The establishment of thermal equilibrium would rely on the phase transitions transforming ordinary to dark matter and vice versa. Biophotons could be produced from dark photons in this manner. The flow from a flux tube portion with larger value of h_{eff} to that with a smaller value liberates cyclotron energy.

A crucial element is quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity. This led to the proposal that there are two kinds of Cooper pairs, exotic Cooper pairs with spin $S = 1$ and counterparts of ordinary BCS type Cooper pairs with spin $S = 0$. 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 would 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 flux tubes would be carriers of dark particles and magnetic fields would be crucial for super-conductivity. Two parallel flux tubes carrying magnetic fluxes in opposite directions is the simplest candidate for super-conducting system. This conforms with the observation that antiferromagnetism is somehow crucial for high temperature super-conductivity. The spin interaction energy is proportional to Planck constant and can be above thermal energy: if the hypothesis that dark cyclotron energy spectrum is universal is accepted, then the energies would be in bio-photon range and high temperature super-conductivity is obtained. If fluxes are parallel spin $S = 1$ Cooper pairs are stable. $L = 2$ states are in question since the members of the pair are at different flux tubes. These two kinds of Cooper pairs could correspond to BCS type and 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 μm) 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.

3. 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.

(a) 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.

(b) 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 cycloctron 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.

(c) 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.

Quantum Model for Bio-Superconductivity: II

The models for EEG and its variants and for nerve pulse rely on a general model of high T_c superconductivity. The general vision behind model of cell membrane as super-conductor inspired by the identification of dark matter in terms of hierarchy of Planck constants and the notion of magnetic body was considered in the previous chapter. In this chapter the vision is tested by applying it to various anomalous findings about the behavior of the cell membrane.

The topics discussed are following.

(a) There are several findings challenging the standard thermodynamical view about cell membrane. TGD suggests a model in which various transmembrane proteins (receptors,

channels, pumps) act as Josephson junction between superconductors assignable to the interior and exterior of cell membrane.

The most feasible model for cell membrane and charge transfer found hitherto relies on Pollack's observations about fourth gel like phase of water. The model for the findings leads to a generalization of the cell membrane as Josephson junction obtained by adding to Josephson energy the difference of the cyclotron energies of dark ion at two sides of the cell membrane. Cyclotron energy difference replaces chemical potential difference in the generalization of the thermodynamical model inspired by Zero Energy Ontology, and replacing thermodynamical distributions with their quantal "square roots". Charge transfer would be induced by a phase transition changing the value of Planck constant at either or both sides of the membrane. This would induce the change of the equilibrium concentrations of ions and also charge transfer.

(b) Water memory, chiral selection of biomolecules, burning of water by radiowaves represent further intriguing effects whose understanding seems to require new physics. Dark matter identified in term of hierarchy of Planck constants and the notion of magnetic body define an attractive candidate in this respect. Scaled up variants of weak physics defined by the hierarchy of Planck constants and p-adic length scale hierarchy could explain chiral selection.

(c) Hafedh Abdelmelek and collaborators have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The TGD based explanation would be in terms of dark supra currents.

(d) DC currents of Becker have been known for a long time. An attractive interpretation is as supra currents. The basic prediction is that the resistance should not depend on he length of the conduction pathway. One can also construct a quantum model for the current.

(e) TGD inspires two views about cell membrane which need not be contradictory. For the first model cell is far from vacuum extremal, for the second model nearly vacuum extremal. There are several constraints on the model coming from the TGD based identification of bio-photons, the new view about metabolism. It seem that that the first model might be enough when generalized along lines inspired by Pollack's findings about the fourth phase of water.

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity.

Tajmar et al have proposed the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual Thomson field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of Thomson field. The required value of gravimagnetic Thomson field is however 28 orders of magnitude larger than General Relativity suggests. TGD inspired proposal is based on the notion of gravitational Planck constant assignable to the flux tubes connecting to massive objects. It turns out that the TGD estimate for the Thomson field has correct order of magnitude. The identification $h_{eff} = h_{gr}$ at particle physics and atomic length scales emerges naturally.

A vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible and ultraviolet range receives strong quantitative support. Also a mechanism for how magnetic bodies couple bio-chemistry emerges. The vision conforms with Penrose's intuitions about the role of quantum gravity in biology.

TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology

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.

(a) 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.

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.

(b) 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).

(c) 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.

1.6.2 PART II: Quantum Model for Hearing

Quantum Model for Hearing

The quantum model of hearing has evolved through several twists and turns. The emergence of zero energy ontology, the explanation of dark matter in terms of a hierachy of Planck constants requiring a generalization of the notion of embedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy led to a breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane. This also modified dramatically the speculative ideas about the role of neutrinos in hearing.

Also in the recent view long range weak play a key role. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other wheras for standard ground state classical Z^0

fields are very weak. Neutrinos are present but it seems that they do not define cognitive representations in the time scales characterizing neural activity. Electrons and quarks for which the time scales of causal diamonds correspond to fundamental biorhythms, take this role.

The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

(a) TGD inspires two views about cell membrane: the wiews need not be contradictory. For the first model cell is far from vacuum extremal, for the second model nearly vacuum extremal with classical Z^0 fields in key role.

    i. There are several constraints on the first model coming from the TGD based identification of bio-photons as energy conserving decay products of dark photons and one ends up to a new view about metabolism and gneralization to of the notion of Josephson junction so that Josephson energy includes besides electrostatic energy also the difference of cyclotron energies at two sides of the membrane. It seem that that the first model might be enough when generalized along lines inspired by Pollack's findings about the fourth phase of water.

    ii. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that at least some cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as biophotons (energies) and EEG radiation (frequencies) emerge since the values of Planck constant can be very large. Contrary to the original believe, this model does not require non-standard value of Weinberg angle and this model and first model allow a hybrid.

(b) DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.

(c) Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.

(d) Josephson frequencies of biologically important ions are in one-one correspondence with the qualia and Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic manner in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both biophotons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.

(e) At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action can be indeed seen as a time reversed sensory perception so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions

induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

The model for hearing follows as a special case from the general model for sensory receptor and representations.

(a) Concerning hearing, the basic questions relate to the precise identification of the hearing quale, to the representation of pitch of the sound at the magnetic body, and to the representation of various geometric data about sound. The electromagnetic charge of the quark pair (or equivalently electroweak isospin) looks like an excellent candidate in this respect so that charge increment would define one fundamental hearing quale.

This quale need not correspond to pitch. The vision about hearing as a frequency quale suggests that cyclotron transition frequency corresponds to the pitch. Sound frequency would be coded to an increment of cyclotron frequency and pitch would be a quale assignable to magnetic body rather than biological body. Hearing would in a well-defined sense represent a higher level sensory modality not understandable without the notion of magnetic body. The strength of the magnetic field would code for cyclotron frequency and therefore for the pitch. One of the mysteries related to hearing is the ability to hear frequencies much higher than the maximum rate of nerve pulses which is below kHz. The coding by Josephson frequencies and representation of them as quale of the magnetic body resolves this mystery.

(b) At the quantative level the first challenge is to understand the typical hearing ranges (humans, mice, bats, sea mammals) and here the time scales of CDs associated with quarks and leptons give intriguing hints. Also their cyclotron frequencies are involved and large values of Planck constant are unavoidable. Josephson frequencies are given by the effective membrane potential (Z^0 potential must be included) divided by Planck constant and it is possible to represent arbitrarily low frequencies in terms of membrane potential by allowing Planck constant to have high enough values.

(c) The extreme rapidity of signalling from hair cells to brain is one of the mysteries of hearing and here Josephson radiation (biophotons) provides a direct neuronal window with practically instantaneous communication. Microtubules could be associated with the flux tubes along which Josephson radiation propagates and also microtubular conformational waves could be involved.

(d) Hearing represent in many respects an exceptional quale: consider only music experience, language, internal speech, the understanding and production of speech, and right brain sings- left brain talks metaphor. This conforms with the assumption that magnetic body is involved in essential manner with hearing. Zero energy ontology leads to a vision explaining basic aspects of music experience and the notion of memetic code plus possible realization of genetic code as temporal patterns could provide first principle understanding of language.

What Music Could Teach about Consciousness?

Recently I have been reading the book by Oliver Sacks titled "Musicophilia" dealing with various aspects of music experience. Humans as a species indeed have a very special relation to music. But is it really genuine characteristic of human consciousness? One can even ask whether consciousness emerges only in higher species or whether it could be in some form a characteric of any living or even inanimate system? I am not the only quantum consciousness theorists forced to consider panpsychism in some form. In this framework one can ask whether music like aspects of conscious experience could be universal and only especially highly developed in humans?

In this chapter I restrict the consideration to those stories of *Musicophilia*, which I find of special interest from the point of view of TGD inspired theory of consciousness. The outcome isa more precise formulation for the general TGD inspired vision about brain based on basic ideas of quantum TGD.

Zero Energy Ontology (ZEO) implies a new view about the relation between geometric and experienced time and allowing to generalize quantum measurement theory to a theory of consciousness.

Strong form of holography implies the analog of AdS/CFT duality between 2-D representation of physics based on string world sheets and partonic 2-surfaces and 4-D space-time representations. This duality is not tautology and this inspires the idea that these two representations correspond to two modes for consciousness motivating "Left brain talks, right brain sings" metaphor.

(a) Language and music could relate to two dual representations of conscious information - local and holistic, cognitive and sensory. Discretization of function/its Fourier transform as a collection of its values at discrete set values of time/frequencies would correspond local/holistic approximations of function. In principle any conscious entity - self- could utilize these two representational modes at appropriate quantum criticality.

(b) The holistic "musical consciousness" is assignable to right brain hemisphere and according to the stories of Sacks seems to characterized by episodal sensory memories. TGD based view about memories relies on ZEO: the memories would be mental images with sensory input from geometric past, genuine sensory experiences of time reversed sub-selves! This picture simplifies considerably and one can see all memories - sensory, cognitive, or emotional - as analogs of phantom pain, which would be also a sensory memory and even more a genuine sensory experience. It is even possible that our biological bodies are used by two selves: right brain hemisphere sleeps when we are awake and vice versa. Even the experiences of epileptics about having double consciousness could be understood.

(c) A more concrete realization of "Left brain talks, right brain sings" metaphor relies on the assumption that "magneto-anatomy" is universal. Only the "magneto-physiology" characterized by the values of h_{eff} characterizing quantum criticality and defining a kind of intelligence quotient dictating the span of long term memory and planned action varies.

h_{eff} would differ for the magnetic bodies of various brain areas, and the spectrum of h_{eff} for right and left brain would differ and characterize their specializations. For instance, the value of h_{eff} would be large (small) for the cognitive areas of left (right) brain and small (large) for some higher sensory areas of right (left) brain. Magnetic bodies form a fractal hierarchy and one can characterize even individual cells and neurons by the value of h_{eff} associated with them. The spectrum for h_{eff} allows also to distinguish between members of the same species since it defines the skill profile. This obviously goes far beyond the genetic determinism.

Is Non-associative Physics and Language Possible only in Many-Sheeted Space-time?

Language is an essentially non-associative structure as the necessity to parse linguistic expressions essential also for computation using the hierarchy of brackets makes obvious. Hilbert space operators are associative so that non-associative quantum physics does not seem plausible without an extension of what one means with physics. Associativity of the classical physics at the level of *single* space-time sheet in the sense that tangent or normal spaces of space-time sheets are associative as sub-spaces of the octonionic tangent space of 8-D embedding space $M^4 \times CP_2$ is one of the key conjectures of TGD. But what about many-sheeted space-time? The sheets of the many-sheeted space-time form hierarchies labelled by p-adic primes and values of Planck constants $h_{eff} = n \times h$. Could these hierarchies provide space-time correlates for the parsing hierarchies of language and music, which in TGD framework can be seen as kind of dual for the spoken language? For instance, could the braided flux tubes inside larger braided flux tubes inside... realize the parsing hierarchies of language, in particular topological quantum computer programs? And could the great differences between organisms at very different levels of evolution but having very similar genomes be understood in terms of widely different numbers of levels in the parsing hierarchy of braided flux tubes-

that is in terms of magnetic bodies as indeed proposed. If the intronic portions of DNA connected by magnetic flux tubes to the lipids of lipid layers of nuclear and cellular membranes make them topological quantum computers, the parsing hierarchy could be realized at the level of braided magnetic bodies of DNA. The mathematics needed to describe the breaking of associativity at fundamental level seems to exist. The hierarchy of braid group algebras forming an operad combined with the notions of quasi-bialgebra and quasi-Hopf algebra discovered by Drinfeld are highly suggestive concerning the realization of weak breaking of associativity.

1.6.3   PART III: Quantum Model for EEG and Nerve Pulse

Dark Matter Hierarchy and Hierarchy of EEGs

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

Also long range weak forces play a key role. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other whereas for standard ground state classical Z^0 fields are very weak. This leads to a correct prediction for the frequencies of peak sensitivity for photoreceptors - something highly non-trivial remembering that also the large parity breaking effects in living matter find a natural explanation. It must be however emphasizef that there is also alternative model of Josephson junctions which seems to provide a better explanation for the role of protons in metabolism. Second quantitative key observation was that for electrons and quarks the time scales of causal diamonds correspond to fundamental biorhythms assignable to central nervous system.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity. A fractal hierarchy of EEGs and its generalizations identified in terms of Josephson radiation is predicted with levels labeled by p-adic length scales and the value of $\hbar$ at various levels of dark matter hierarchy. Cell membrane would represent only one level in this hierarchy. Besides EEG one would have its counterparts for various organs, organelles and even cell. Also the possibility of ZEG, WEG and QEG corresponding to Z^0 bosons, W bosons, and gluons must be considered.

1. Fractal hierarchy of EEGs

EEG is replaced with a fractal hierarchy of EEGs corresponding to various values of Planck constants involved.

(a) There are at least three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions in magnetic field $B_{end} = .2$ Gauss, and to the Josephson frequencies f_J or theire generalizations associated with Josephson junctions assigned with cell membranes. If Josephson radiation modulates cyclogtron radiation also the frqequencies $mf_J \pm nf_c$ appear in the spectrum. Perhaps the most natural option is generalization of Josephson junction so that generalized Josephson frequencies are sums for differences of cyclotron frequencies for flux tubes in the interior resp. exterior of cell membrane and of Josephson frequency f_J. This implies that the information provided by cell membrane oscillations and nerve pulse patterns is coded to frequency modulations for differences of cyclotron frequencies defining EEG rhythms.

(b) In standard model $f_J = ZeV/\hbar$ would determined by the membrane potential and would correspond to energy in infrared. This sounds completely reasonable. TGD suggests two models for the cell membrane.

(c) TGD inspires two views about cell membrane: the wiews need not be contradictory. For the first model cell is far from vacuum extremal, for the second model nearly vacuum extremal with classical Z^0 fields in key role.

    i. There are several constraints on the first model coming from the TGD based identification of bio-photons as energy conserving decay products of dark photons and one ends up to a new view about metabolism and gneralization to of the notion of Josephson junction so that Josephson energy includes besides electrostatic energy also the difference of cyclotron energies at two sides of the membrane. It seem that that the first model might be enough when generalized along lines inspired by Pollack's findings about the fourth phase of water.

    ii. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that at least some cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as biophotons (energies) and EEG radiation (frequencies) emerge since the values of Planck constant can be very large. Contrary to the original believe, this model does not require non-standard value of Weinberg angle and this model and first model allow a hybrid.

(d) An important point is that the ions involved must behave like bosons or to form Cooper pairs. For cyclotron condensates either Cooper pairs of ordinary fermionic ions or exotic ions chemically similar to their standard counterparts obtained from neutral bosonic atom by making one or more neutral color flux tubes connecting nucleons charged. For Josephson radiation only the latter option works. TGD based nuclear physics indeed predicts this kind of nuclei and there is experimental evidence for their existence.

(e) For cyclotron frequencies the extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but nonvanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands while Josephson radiation would propagate along flux tubes parallel to the cell membrane. Far from biological body one expects both kinds of flux quanta to fuse to form larger ones so that one has parallel space-time sheets carrying cyclotron *resp.* Josephson radiation. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

(f) Josephson frequencies are assignable to the cell membrane and would naturally correspond to the communication of sensory data to the magnetic body. This would suggest that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via genome expression. This picture might be too naive. Josephson radiation would induce transitions between cyclotron states should generate sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as time reversal of sensory perception allwed by zero energy ontology would mean that same mechanisms are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

(g) The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. For 5 Hz

Josephson frequency and membrane potential and for V=.70 mV corresponding to the resting potential of neuron one obtains $r = (0.96, 1.20, 1.34, 1.01) \times 2^{47}$. For Ca^{++} ion r is very near to a power of 2.

2. Basic aspects of EEG

Consider now how one could understand basic characteristics of EEG during wake-up and sleep in this framework.

(a) For small amplitudes and for the lowest harmonics this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites.

(b) For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

(c) In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. The simplest explanation is that the value of Planck constant increases by a factor 2 in a phase transition having interpretation as a leakage of cell membrane space-time sheet between the pages of Big Book defined by the generalized embedding space. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. This stage could correspond to a value of Planck constant which is 4 times its value in wake-up state.

The generalization of the model for EEG hierarchy to the case of ZEGs is straightforward and Josephson frequency spectrum is the same. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

3. The effects of ELF em fields on brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains were crucial for the development of the model of EEG. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and its generalizations.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around 10^{-7} V/m and second corresponds to the range $1 - 10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

(a) Cyclotron frequencies led to the vision about cyclotron condensates of biologically important ions and their Cooper pairs at the flux quanta of dark magnetic field with so large Planck constant that the energies of cyclotron photons are above thermal threshold. The model for EEG and biophotons in terms of Josephson radiation from cell membrane which is almost vacuum extremal allows to make this model more quantitative.

(b) The temperature window has one interpretation in terms of a competion of almost vacuum extremal property of cell membrane possible above some critical temperature and high T_c super-conductivity possible below some critical temperature.

(c) The amplitude window 10^{-7} V/mfollows from a quantized form of Faraday law whose existence is supported by the fact that space-time sheets are analogs of Bohr orbits in exact sene. The quantisation condition relates the amplitude of electric field to Planck constant and frequency. For the value $r = \hbar/\hbar_0 = 2^{47}$ of Planck constant required by 5 Hz Josephson frequency the 10^{-7} V/m amplitude is predicted correctly.

(d) The amplitude window around 1-10 V/m (EEG amplitudes are in the range 5-10 V/m) follows if the values of Planck constant in the range $10^7 r - 10^8 r$ can be justified. A possible justification is based on the observation that for $r_1 = 10^8 r$ the Compton wave length of intermediate gauge bosons corresponds to $k = 163$ defining Gaussian Mersenne and wavelength corresponding to 2 eV energy for photon which also corresponds to bio-photon energies assignable to 70 mV resting potential of neuron membrane. Electron's Compton length corresponds for $r_1 = 10^8 r$ to 28 cm, which defines the size scale of brain. One might hope that these findings could allow to build an internally consistent story about what happens.

4. Vision about biological evolution and evolution of brain

The proposed model for EEG, the idea that Gaussian Mersennes (four of them are in the range 10 nm-2.5 micrometers) define p-adic length scales allowing exotic variants of color and electro-weak physics with light intermediate gauge bosons at space-time sheets near vacuum extremals, and the assumption that the preferred values of Planck constant are such that they relate these p-adic scales to each other leads to a detailed quantitative vision about evolution of life as emergence of longer scales belonging to this hierarchy and as special case also to a vision about evolution of cell, nervous system, EEG, and long term memory. The model predicts a hierarchy of preferred size scales for various sub-systems of organisms and corresponding time scales identifiable in terms of bio-rhythms and memory span.

Quantum Model for EEG

In the previous chapter the overall TGD based view about EEG was discussed. According to this view, the basic function of EEG is to induce cyclotron phase transitions at the magnetic body and thus to produce what might be called higher level sensory qualia identified as emotions and cognitions. In this chapter the relationship between EEG and nerve pulse patterns is discussed in TGD framework.

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. The deep difference between TGD and the conventional neuroscience is the presence of the hierarchy of magnetic bodies, cyclotron transitions, and MEs. This makes possible to consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits.

Nerve pulses generate EEG MEs and the frequency of the nerve pulses determines the rate at which EEG MEs are generated rather than the frequency of EEG MEs. Pendulum metaphor suggests how spike patterns amplify EEG waves at frequencies, which appear as resonances in the autocorrelation function of the spike sequence: when the pendulum is kicked at correct half of its period its oscillation frequency remains unchanged but amplitude and phase suffer discontinuous changes. The EEG waves generated by subsequent nerve pulses tend to interfere constructively resulting in amplification if the EEG frequency corresponds to a resonance frequency of the spike autocorrelation function.

1. Generalization of the model for sensory receptor and new view about hearing

The relationship between nerve pulse patterns and EEG (also ZEG) is one of the basic challenges of the theory. The question is whether nerve pulse patterns could give rise to EEG patterns and vice versa, and what could be the underlying mechanisms. In TGD framework on ecan consider alternatives for the identification of EEG resonance frequencies as resonance frequencies of nerve circuits and dark matter hierarchy challenges the earlier speculative TGD inspired models for sensory qualia and sensory organ. An updating of the capacitor model of the sensory receptor by replacing the capacitor with Josephson junctions between sensory organ and its magnetic body must be considered. The question arises whether sensory organs define not only sensory, but also corresponding cognitive and emotional representations. The fact that nerve pulses tend to destroy the temporal coherence of cognitive and emotional

representations encourages the identification of glial cells and their magnetic bodies as carriers of higher level cognitive and emotional representations. The model of hearing leads to further ideas. For instance, the transformation of the sensory input to signals propagating along axonal microtubuli could make possible to feed sensory input into brain and possibly back to sensory organs at least in the case of vision and hearing.

2. Features

Walter Freeman has identified spatially amplitude modulated synchronous but non-periodic EEG patterns serving as correlates for conscious percepts. The identification as MEs is possible and the spectrum of durations for the synchronous time patterns encourages the interpretation of these patterns as an electromagnetic realization of genetic code words. A compression of memetic code words defined by the nerve pulse patterns giving rise to abstraction and classification would be in question. The representation would be achieved by the amplitude modulation of the alpha waves by higher harmonics of alpha frequencies. In the case of hearing the contraction seems to be un-necessary and memetic code could perhaps be realized also at the level of features. This would explain the completely exceptional role of the language in cognition.

3. Synchronization

Synchronization in and between various cortical areas is known to occur with millisecond precision. Also disjoint brain regions can be in synchrony. This is difficult to understand without synchronizing agent oscillating at kHz frequency. In TGD framework magnetic body is the natural agent inducing the synchrony and MEs could induce the synchronization. Synchronization would naturally occur at the frequency corresponding to a duration of the bit of the memetic code.

4. Stochastic resonance

Concerning the mapping of EEG frequencies to nerve pulse patterns, stochastic resonance promotes itself as a basic mechanism. In bistable systems stochastic resonance allows to amplify very weak periodic signals by utilizing white noise. Stochastic resonance is known to be relevant also at the neuronal level as demonstrated by the autocorrelation functions for spike sequences exhibiting peaks at the harmonics of the signal frequency. Neuron is however far from being bistable system, and this raises the question whether bi-stability might be present at some deeper quantal level.

5. Temporal codings

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input. For high stimulus intensities the duration of the bit of the p-adic cognitive codeword tends to become shorter. This is comparable to the increase of the speech rate during a high state of arousal, and conforms with the observed shift of EEG towards higher frequencies in this kind of situation. There is a lot of experimental evidence supporting the existence of various kinds of temporal codings, and these codings are discussed in TGD framework.

6. Scaling law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. The law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form $L = v/f$ and relates ELF self size characterized by ELF frequency f to the self size L and to the effective phase velocity v of the EEG wave.

Scaling law is also suggested by the experimental work with the effects of ELF radiation in water. Scaling law can be explained in terms of phase transitions transforming large h_{eff} photons to ordinary ones and vice versa. The chapter ends with the discussion about possible implications of the scaling law concerning EEG.

TGD leads to a proposal that the values of h_{eff} are such that energy spectrum of the cyclotron photons does not depend on the mass of the ion. This implies a universal energy spectrum and there are reasons for the hypothesis that biophotons result in the energy conserving transformations of dark photons to ordinary ones.

EEG and the structure of magnetosphere

Roughly 15 years ago I proposed the idea that Earth's magnetosphere (MS) could serve as a sensory canvas in the sense that biological systems, in particular the vertebrate brain, could have sensory representations realized at the "personal" magnetic body (MB) closely associated with the MS of the Earth. EEG would make communications to and control by MB possible.

At that time I did not yet have the idea about number theoretical realization of the hierarchy of Planck constants $h_{eff} = nh_0$ in the framework of adelic physics fusing the physics of sensory experience and cognition. This hierarchy is crucial for understanding the basic aspects of living matter such as metabolism, coherence in long scales, correlates of cognition, and even evolution.

Also the concept of zero energy ontology (ZEO) forming now the basis of the quantum TGD was missing although there was already the about communication to past using negative energy signals. ZEO is now in a central role in the understanding of self-organization - not only the biological one. The new view about time predicting that time reversal occurs in ordinary state function reductions (SFRs) allows to understand homeostasis as self-organized quantum criticality.

For these reasons it is interesting to consider the notion of sensory canvas from the new perspective. This article discusses besides the earlier ideas about the MS also the proposal that it is possible to associate EEG bands to the regions of MS via the correspondence between EEG frequency with the distance of the region from Earth. Also the idea that the structure of MS could be a fractal analog of the vertebrate body is tested quantitatively by comparing various scales involved.

TGD Inspired Model for Nerve Pulse

The basic idea behind the model of nerve pulse is that some kind of quantum jump reduces the magnitude of membrane potential below the threshold leading to the generation of nerve pulse. Several identification of this quantum jump have been discussed during years but no really convincing option has been found. The evolution of ideas about dark matter hierarchy and associated hierarchy of Planck constants led to a breakthrough in several sectors. The assignment of long ranged classical weak and color gauge fields to dark matter hierarchy was the crucial step and led among other things to a model of high T_c superconductivity predicting the basic scales of cell, to a generalization of the genetic code to a hierarchy of genetic codes.

1. Background

The basic philosophy behind the model is following.

(a) In TGD Universe the function of EEG and its variants is to make possible communications from the cell membrane to the magnetic body and the control of the biological body by the magnetic body via magnetic flux sheets traversing DNA by inducing gene expression. This leads to the notions of super- and hyper-genome predicting coherent gene expression at level of organs and population.

(b) The assignment the predicted ranged classical weak and color gauge fields to dark matter hierarchy was a crucial step in the evolution of the model, and led among other things to a model of high T_c superconductivity predicting the basic scales of cell, and also to a possible generalization of EXG to a hierarchy of ZXGs, WXGs, and GXGs corresponding to Z^0, W bosons and gluons.

(c) Dark matter hierarchy and the associated hierarchy of Planck constants play a key role in the model. For instance, in the case of EEG Planck constant must be so large that the energies of dark EEG photons are above thermal energy at the physiological temperature. The assumption that a considerable fraction of the ionic currents through the cell membrane are dark currents flowing along the magnetic flux tubes explains the strange findings about ionic currents through cell membrane. Concerning the model of nerve pulse generation, one input comes from the model of DNA as a topological quantum computer and experimental findings challenging Hodgkin-Huxley model as even approximate description of the situation.

(d) The identification of the cell interior as gel phase containing most of water as structured water around cytoskeleton - rather than water containing bio-molecules as solutes as assumed in Hodkin-Huxley model - allows to understand many of the anomalous behaviors associated with the cell membrane and also the different densities of ions in the interior and exterior of cell at qualitative level. The proposal of Pollack that basic biological functions involve phase transitions of gel phase generalizes in TGD framework to a proposal that these phase transitions are induced by quantum phase transitions changing the value of Planck constant. In particular, gel-sol phase transition for the peripheral cytoskeleton induced by the primary wave would accompany nerve pulse propagation. This view about nerve pulse is not consistent with Hodkin-Huxley model.

(e) Pollack's experiments [?]emonstrate the existence of what he calls the fourth phase of water. This phase contains negatively charged regions - exclusion zones - serving in TGD Universe as candidates for prebiotic cells. The positive charge resides outside the exclusion region at the flux tubes of the magnetic body associated with the exclusion zones as dark proton strings defining dark nuclei realizing vertebrate genetic code [K42]. This vision leads to a generalization of the model of cell membrane Josephson junctions assignable to transmembrane proteins. Josephson energy becomes sum of Coulombic term and difference of cyclotron energies at the two sides of the membrane. The thermodynamical model for cell membrane is replaced with its "square root" forced by Zero Energy Ontology, and means the replacement of Boltzmann weights with their square roots appearing in the wave functions for dark particles. The phase transitions changing Planck constant change the equilibrium distributions of ions and this process should be behind the generation of nerve pulse.

2. New view about nerve pulse generation

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several manners for how this could happen. For years ago I learned that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) leads to a rather precise model for the generation of nerve pulse.

(a) The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences

having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

In the microscopic description continuous Josephson junction is replaced with a distribution of Josephson junctions defined by transmembrane proteins such acting as pumps and channels.

(b) During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

(c) Nerve pulse itself would correspond to a phase transition changing the value of Planck constant h_{eff} at the either side or both sides of the cell membrane at the flux tube associated with the transmembrane protein. This would induce transition to a new ionic equilibrium since cyclotron energies for ions change. This transition would give rise to the change of the membrane potential. Cyclotron energy difference would however dominate in the generalized Josephson energy. This phase transition should be adiabatic and should not require heat or generate it.

(d) The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that solitonic velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as tqc sine also microtubule-cell membrane systems are good candidates for performers of tqc. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane tqc would represent higher level tqc distinguishing between multi-cellulars and mono-cellulars.

(e) New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The assumption of only bosonic ions leads to a highly predictive model. The new nuclear physics predicted by TGD predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

3. The function of neural transmitters

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. Electromagnetic membrane oscillations induced by Z^0 MEs provide a realization of the memetic code as a fundamental cognitive code. The binding of various information molecules to the corresponding receptors gives rise to neuronal qualia analogous to tastes and odors but providing information about external world whereas ordinary receptors give information about nearby environment. At our level of hierarchy these qualia

probably correspond to emotions in consistency with the finding that neurotransmitters can be identified as information molecules. Neurotransmitters might be also seen as conscious links in quantum web. The view that inhibition actually requires active energy feed and that excitation occurs automatically in the absence of the energy feed and induces entanglement with environment, is defended. This view conforms with Huxley's vision about brain as a filter inhibiting conscious experiences.

4. Microtubular level

The view about what happens at the micro-tubular level during synchronous neuronal firing relies on a many-sheeted model for sol-gel phase transitions as conscious bits and on the seesaw mechanism of remote metabolism according to which sol-gel transitions induces gel-sol transitions elsewhere in the cell and vice versa. Micro-tubular surfaces can be seen as analogs of cortical sensory and motor areas providing kind of conscious log files about sensory and motor history of the cell in terms of conformational transitions of tubulin dimers representing conscious bits.

What happens at the micro-tubular level during the nerve pulse, how gel phase differs from sol phase, and what occurs in sol-gel transition, belong to the principal challenges for quantum theories of consciousness. Charge entanglement associated with various bosonic ions allows to tackle these questions. The Bose-Einstein condensates of hydrogen atoms at tubular $k = 139$ space-time sheets form a bundle behaving like a liquid crystal identifiable as the gel phase. Positive and negative energy IR photons at energy of .1 eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this B-E condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler has demonstrated that photons with this energy have a maximal effect on cells.

Negative energy MEs are especially important: they make possible intentional action at the micro-tubular level, they are crucial for the understanding of the micro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called seesaw mechanism of energy metabolism. Seesaw mechanism minimizes dissipative losses and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions, and thus define fundamental micro-tubular representation of declarative long term memories. Also the notion of micro-tubuli as quantum antennae becomes precisely defined.

The model of DNA as topological quantum computer brings in a new element. Microtubule-axonal membrane system could perform topological quantum computation just as DNA-membrane (nuclear and perhaps also cell membrane) system has been proposed to do. The braiding of the magnetic flux tubes connecting microtubules to axon would define tqc programs and also provide a representations for sensory input from sensory organs in time scale shorter than millisecond if one assumes that gel-sol-gel transition of microtubule accompanies the nerve pulse. Whether one it one say that nerve pulse is initiated at microtubular or axonal level or by both collectively is not clear since the magnetic flux tubes connecting these two systems make them to act like single coherent whole.

Sensory Perception and Motor Action as Time Reversals of Each Other: a Royal Road to the Understanding of Other Minds?

The notion of mirror neuron is extremely attractive because it could allow the understanding of the observed goal directed behaviors of living systems by inducing corresponding imagined or even real actions. The sensory input about behavior would automatically induce the neural activity representing intention about the behavior or imagined behavior. Mirror neuron hypothesis was derived originally for monkeys but has been considerably generalized. For instance, in the case of humans mirro neurons could allow an almost automatic understanding of intentions and emotions of other people.

In TGD framework the objections against mirror neuron hypothesis motivate its replacement with what I call time mirror hypothesis inspired by zero energy ontology, and stating that

motor action and sensory perception are in a well-defined sense time reversals of each other. This hypothesis could explain the time anomalies assignable to mirror neurons if they are indeed involved (reactions tend assigned to mirror neurons tend to be "too fast") and also Libet's findings. This inspires the notion of quantum monadology: parts of brain would be continually time mirroring each other. Also magnetic body would be involved. The time mirror relationship could correspond to directed attention having as space-time correlates magnetic flux tubes carrying dark photon signals in both time directions. Time mirror hypothesis is applied to the entrainment of the speech motor regions with auditory areas at the opposite side of brain occurring at resonance frequency 4.5 Hz as discovered by Poeppel and Assaneo.

This vision allows to build a model of sensory memories with motivation coming from the findings challenging the standard view about them. This model in turn inspires a very general model of motor action applying also to basic biochemical processes such as transcription, replication, and translation as being induced by topological quantum computer programs running in non-standard time direction.

About TGD View of Neuron

The realization that saltation as a conduction over the myelinated portions of the axon is still poorly understood phenomenon inspired a careful reanalysis of the earlier TGD inspired visions of nerve pulse conduction, EEG and of brain based on the new view about space-time, the notion of the magnetic body carrying $h_{eff} > h$ phases behaving like dark matter, and the zero energy ontology (ZEO) based quantum measurement theory extending to a theory of consciousness.

The TGD view about nerve pulse replaces nerve pulse as a wave assignable to a generalized Josephson junction formed by lipid layers of the cell membrane for which Josephson frequency f_J is replaced by the sum $F_J = f_J + \Delta f_c$, where Δf_c is the difference between cyclotron frequencies for transversal flux tubes at the different sides of the axon. What propagates is the deviation of membrane potential below the critical value for the generation of action potential. There would be no action potential in the myelinated portions of the axon and it would be generated only in the non-myelinated portions of length about 1 μm and gives rise to chemical effects and also communicate a signal to the magnetic body if the notion of generalized Josephson junction is accepted.

An interesting challenge for the model is the discovery that the density of the voltage gated ionic channels in the dendrites of neurons is considerably lower for humans than for mammals. The general model suggests that the spatiotemporal patterns of Josephson radiation emitted by segments between nearby ionic channels or pumps define analogs of sentences of language having nerve pulse as a punctuation mark analogous to the stop codon for DNA, then these sentences would be longer for humans, which could relate to the emergence of the human language capacity.

Quantum Statistical Brain

This chapter was originally inspired by the findings of Li et al, which can be summarized as follows. Humans know the uncertainty of their working memory and use it to make decisions; the content and the uncertainty of working memory can be decoded from BOLD signals; decoding errors predict memory errors at the single-trial level; decoded uncertainty correlates with behavioral reports of working memory uncertainty.

Later I learned about the findings of Manassi and Whitney about the stability illusion of perceptions making the world look smoothly changing and effectively shifting the perception towards the past.

It is not too surprising that the states of feature detector neurons obey a statistical distribution. It is however not obvious that the reliability of the memory should correlate with the width of this distribution and that even the subjective estimate for the reliability should reflect this width.

If one accepts the notion of a quantum brain, the distribution of features could reflect the non-determinism of the outcome in the reduction of entanglement quantum measurements producing sensations.

Zero energy ontology (ZEO) leads to the notion of 4-D brain and suggests that the feature ensemble is not spatial, as it should be in standard quantum theory, but a temporal ensemble formed by the memory mental images of the feature. Quite generally, in ZEO sequences of "small" state function reductions (SSFRs) as counterparts of so called weak measurements would form temporal ensembles of memory mental images so that the connection with short term memory would be direct. This picture explains the findings of both Li et al and Manassi and Whitney.

Part I

The notion of magnetic body and bio-superconductivity

Chapter 2

Magnetic Sensory Canvas Hypothesis

2.1 Introduction

There are very general objections against the idea that the ultimate sensory representations are inside brain. For instance, any computer scientist, unless informed about materialistic dogmas, would argue that the processing of the sensory data must be separated from its representation. How this could occur if sensory and other representations are realized inside brain, is however difficult to see. The classical experiments of Libet relating to the active and passive aspects of conscious experience [?, ?, ?] provide a strong empirical support for the view that signals from central nervous system (CNS) spend.3-.5 seconds to propagate somewhere else. If the propagation occurs with the velocity of light, the distance in question is measured using the circumference of the Earth as a natural unit.

2.1.1 Sensory Canvas Hypothesis

In TGD approach these objections lead to the view that the magnetic flux tube structures associated with the central nervous system (CNS) could define a hierarchy of sensory, symbolic, and cognitive representations outside brain with magnetic flux quanta of the magnetic bodies serving as the canvas to which place coding by magnetic frequency generates subselves (mental images about "simple feeling of existence") and associates with them various sensory qualia and symbolic and cognitive features by quantum entanglement. Thus brain could be much like a RAM memory containing a collection of features in random order and the ordering would be induced only by the sensory map to the magnetic sensory canvas. Are our sensory representations at the magnetic flux tubes of Earth's magnetic field or are personal magnetic bodies needed? Since space travellers experience the world very much like us and have survived, the most plausible conclusion is that the magnetic sensory canvas is personal. This conclusion is also supported by the fact that the value of the magnetic field explaining the harmonics of 15 Hz as Ca^{++} cyclotron frequencies is.2 Gauss rather than.5 Gauss.

2.1.2 Why The World Is Not Experienced To Rotate As Head Rotates?

The question which originally led to the notion of the sensory magnetic canvas was "Why the world is not experienced to rotate as head rotates?". If one assumes that sensory representations are completely inside the cortex and that the positions of various visual mental images in the visual cortex remain fixed with respect to cortex as is done in the standard

neuroscience, the entire sensory representation rotates thus with the head and one could argue that the world is experienced to rotate.

If one accepts the sensory magnetic sensory canvas hypothesis situation changes. Assuming that

(a) the objects of the perceptive field induce sensory mental images (sub-selves) already at the level of sensory organs (in particular, retinas) and representations at corresponding magnetic bodies;

(b) these mental images, being self-organization patterns, whose boundaries are determined by the gradients of illumination, do not rotate as the head or eye rotates;

(c) the points of the retina correspond to fixed points of the visual cortex in topographic way;

(d) the projections to the sensory magnetic canvas from the visual cortex occur orthogonally;

one can answer the question. Note that the personal sensory magnetic body is fixed with respect to head and rotates with it whereas the representation projected to it and defining a self-organization pattern does not. In other words, magnetic body acts like a canvas.

MEs define this sensory projection and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size at least. Thus TGD based view about sensory and other representations is a diametrical opposite of the standard view in which sensory representations are miniatures.

Some comments about terminology are in order. Sensory representations involve besides the primary sensory qualia the symbolic representations constructed by brain giving meaning for the sensory input. I will use also the phrase "cognitive representation". Space-time correlates for cognitive representations are tentatively identified as p-adic space-time sheets coinciding with real space-time sheets in resolution defined by some cutoff length scale: in general the intersection with real space-time sheets is discrete set of rational points common to reals and p-adic number fields. p-Adic space-time sheets are also identified as correlates for intentions and the realization of intention as action is tentatively identified as a quantum jump replacing p-adic space-time sheet with a real one in such a way that conservation laws are satisfied.

2.1.3   Model For The Sensory Representations

The construction of a more detailed model is based on the following assumptions.

(a) Sensory qualia are at the level of primary sensory organs having their own magnetic bodies and entangled with the cognitive and symbolic representations of the perceptive field in brain in turn entangled with the points of the sensory magnetic canvas. The entanglement between primary sensory organs and brain and TGD based view about long term memory resolves the basic objections against this view, and one can understand the differences between sensory experience, imagination, dreams, and hallucinations and various strange phenomena like synesthesia, Anton's syndrome, and blind sight.

(b) Second essential element is the mirror mechanism of long term memories. To remember something in the geometric past at temporal distance T is to look at a magnetic mirror with length $L = cT/2$. At quantum level quantum entanglement is involved and means sharing of mental images between recent me and the me of the geometric past (or some other self responsible for the memory representations). This requires that magnetic flux tubes involved with long term memories have astrophysical lengths with light year being the natural length unit. For magnetic fields this indeed makes sense. This picture is of course dramatically over-simplified. A more realistic model of long term episodal and declarative memories in which the magnetic body uses time mirror mechanism by sending entangling negative energy ME to the brain making possible sharing of mental images. From brain negative energy MEs are time reflected back as positive energy MEs and are possibly amplified. Positive energy MEs can give rise to classically

communicated declarative memories. This means that the distance along a flux tube of the personal magnetic body codes for the temporal distance to geometric past.

(c) The already mentioned findings of Libet about strange causal anomalies related to the passive aspects of consciousness lead to the conclusion that sensory experiences are geometric memories of the personal magnetic body in time scale of.3-.5 seconds about what happens in at the level of material body. Libet's findings about active aspects of consciousness in turn allow to conclude that also motor activity must involve time mirror mechanism with negative energy topological light rays sent to the geometric past and inducing the neural activity as a response. Without this mechanism we could not survive using.3-.5 seconds old sensory data. A beautiful general scenario for the realization of intentions and unifying sensory perception, long term memories, and motor action emerges and allows to explain phenomena like sensory rivalry difficult to understand in neuroscience framework.

The flux tube structure associated with the Earth's magnetic field could define or at least closely relate sensory canvases of Mother Gaia and of smaller magnetospheric selves. It is quite conceivable that also magnetosphere contains various kinds of representations of the information from brain and body. The local direction of Earth's magnetic field at cortex should fix the orientation of the projectors associated with the sensory representations in the co-rotating inner magnetosphere. Pyramidal neurons contain magnetic crystals and also haemoglobin molecules are magnetic and their alignment with the local magnetic field of Earth would make this possible.

These representations could be responsible for the third person perspective which is also an integral part of our consciousness: the mechanism providing the third person aspect would be sharing of the mental images by quantum entanglement. Out-of-body experiences and near death experiences could be one particular manifestation for this component of consciousness. The magnetospheric representations could be also responsible for long term memory representations.

There are reasons to believe that also the non-rotating outer magnetosphere might contain representations. For these representations the projectors should be parallel to the flux tubes of a magnetic field which is stationary with respect to Earth. The flux tubes of the outer magnetosphere might be able to penetrate to some extent the inner magnetosphere and attach to brain or body. For instance, the magnetic field created by the magnetic particles in lungs is of the same magnitude as the magnetic field in the plasma sheet at the night side of Earth.

2.1.4   EEG as a Communication and Control Tool of Magnetic Body

The progress made during the year 2005 in the understanding of the dark matter hierarchy stimulated a quantum leap in many branches of TGD with the model of the magnetic body included. This forced some updating of also this chapter although I tried to not destroy the original flavor of the chapter. I also added a section about about a hierarchy of generalized EEGs associated with the dark matter hierarchy making possible for the magnetic bodies to receive sensory information from biological body and quantum control it. The chapter "The Hierarchy of Generalized EEGs and Dark Matter Hierarchy" [K35] provides a detailed vision about magnetic body as an intentional agent receiving sensory input from the biological body and using it as a motor instrument.

In this chapter a general vision about the magnetic sensory canvas hypothesis is discussed. The discussion continues in [K53]. These chapters are not a reviews of the final results after the dust has settled but document the development of ideas as it has occurred and is still occurring. There are many mammoth bones and little inconsistencies, and often the simple final picture is achieved by a lot of painful sidetracking. The very name "Magnetic sensory canvas hypothesis" of this chapter is a good example of this problem: both symbolic, cognitive and sensory mental images entangle with the magnetic body so that the attribute "sensory" is somewhat misleading. Furthermore, motor control aspect is equally important.

Perhaps a better title would be "Magnetic body hypothesis". My sincere apologies for the reader for this: I can do only my best!

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` [L11].

2.2 A model for aensory representations, long term memories, and motor actions

In this section a model of sensory representations will be developed from the assumptions that sensory representations are realized on magnetic body (magnetic sensory canvas) and that sensory organs are the seats of the sensory qualia. It turns out that the model is essentially equivalent with the model of long term memories and that its temporal mirror image yields a general model for motor actions. The general vision is inspired by and explains Libet's strange findings about active and passive aspects of consciousness.

2.2.1 Magnetic Body As The Sensory Canvas

Many-sheeted space-time concept makes it possible to project the sensory, symbolic and cognitive mental images the external world using MEs and magnetic flux tube structures.

(a) Place coding by cyclotron frequency scale could easily wake-up mental images representing the positions of the objects of the perceptive field in the magnetic body. A more attractive manner to see the situation is to identify magnetic body as an active perceiver sending negative energy topological light rays time reflected at the biological body as positive energy topological light rays and providing information about its state much like the ordinary reflection of light provides information about the object of the perceptive field.

(b) The distance of the point of the flux tube from the sensory organ could be coded to the thickness of the flux tube which in turn defines the cyclotron frequency. Most naturally, the strength of the field is the strength of the corresponding Maxwellian magnetic field and the density of the magnetic flux tubes is scaled accordingly from the requirement of the quantization of magnetic flux.

(c) The radial EEG MEs assigned with the cortical axons in the TGD based model of EEG could serve as projectors having contacts with the magnetic flux tubes of the personal magnetic body. MEs would entangle cortical mental images and sensory mental images at sensory organs with the "simple feeling of existence" mental images at the points of the magnetic body. Note that the magnetic bodies of sensory organs could carry the fundamental sensory representations.

(d) The EEG frequency and its harmonics associated with ME would induce magnetic quantum phase transitions at the magnetic canvas and wake-up mental image at a distance corresponding to the estimated distance of the object of the perceptive field but which need not be same. The association of visual colors with the points of the perceptive field would result from the retina-magnetic body entanglement. Auditory experience might involve a similar mapping but might use Z^0 magnetic field as canvas. Also ears contain strong back-projections necessary for auditory dreams.

(e) EEG MEs serving as projections to the magnetic canvas results in the cyclotron transitions at the magnetic flux tubes of endogenous magnetic field having strength $\simeq .2$ Gauss (experiments of Blackman and others), which is 2/5 times the nominal value.5 Gauss for the Earth's magnetic field. At the magnetic flux tubes of the personal magnetic canvas similar process occurs. The rate for the transitions should be maximized in both cases. At the magnetic body this is achieved if the super-conduction ion at the magnetic flux tube is first "kicked" to a smaller space-time sheet wherefrom it "drops"

back to the magnetic flux tube, and because of its zero point kinetic energy enters into a high n cyclotron state, which in turn decays by emitting harmonics of the cyclotron frequency. The "kicking" is achieved if the ELF ME responsible for the entanglement contain microwave MEs, which generate flux tubes connecting magnetic flux tube with smaller space-time sheets. This in turn leads to the breaking of super-conductivity and primitive metabolic cycle in which ions flow to the atomic space-time sheets and back to the magnetic flux tube. This would mean that the microwave radiation from brain serves as the "food" of the primitive plasmoid like life form representing the simple "feeling of existence" mental image at the magnetic sensory canvas.

Both the quantum entanglement with the mediation of of ELF MEs giving rise to the fusion of mental images, and a classical communication by the transfer (say) microwave MEs and inducing self-organization at the magnetic body, are involved. This mechanism is the basic mechanism of remote mental interactions in TGD Universe.

(f) An entire hierarchy of sensory representations are predicted and also primary sensory organs could have this kind of representations at their personal magnetic bodies. For instance, retinae could carry this kind of representations realized in the same manner as the cortical representations. These representations would entangle with cortical representations.

2.2.2 The Mental Images At The Personal Magnetic Body

The sizes of the images of the objects of the cortical sensory representation located outside the body would not correspond to the real size of the objects of the perceptive field. The sizes of ELF ME are typically of order Earth size and this gives upper bound for the size of the representative objects. If brain itself generates the magnetic canvas then it might be natural to expect that the scaling factor involved is one but one must be very cautious in making any strong conclusions. The problem are that it is not at all clear how this scaling factor could be achieved and how it could be useful. Furthermore, the requirement that the magnetic field strength along the flux tube varies very slowly supports the view that the sub-selves at magnetic body ("simple feeling of existence")can have sizes of order ELF ME.

The mapping of the apparent EEG wavelengths to ELF ME lengths $L = c/f$ defined by the formula $\lambda = v/f = (v/c)L$ for EEG frequency f in terms of its apparent wavelength $\lambda = v/f$ would is consistent with the idea that cortical objects could be scaled-up by a factor $c/v \sim 10^7$! Thus these mental images could be even of the order of the size of Earth! If so they could be extremely stable against external perturbations. In particular, the motion of the head and body would not affect the magnetic and Z^0 magnetic fields in this distance scale so that the problem of reference frame would be solved since "me" would be understood as a gigantic magnetic structure using brain and body as a sensory and motor organ. Obviously, this picture is the diametrical opposite provided by the standard neuroscience.

A more detailed model for the sensory representations requires a more comprehensive view about the personal magnetic body. One can make only tentative guesses in this respect.

(a) The personal magnetic body interacts with the external world, in particular, with the Earth's magnetic field and with the solar wind carried by the solar magnetic field. Hence the idea about personal magnetic body as a structure analogous to the Earth's magnetosphere is worth of testing. Personal magnetosphere could decompose into a part moving with the physical body and analogous to the inner magnetosphere, and a stationary, highly stretched, part analogous to the outer magnetosphere at the night side of Earth. Also part residing outside the Earth's magnetosphere should be present. Earth's magnetosphere-solar magnetic field interaction would be replaced by personal magnetosphere-Earth's magnetosphere interaction.

(b) Solar wind might enclose part of the personal magnetic body inside the Earth's magnetosphere, whereas the interaction with the flux tubes of the Earth's magnetic field could force the flux tubes of the personal magnetic body to be more or less parallel to them. Incoherent summation of the personal and terrestrial magnetic fields, fractality, plus

the fact that the field strengths associated with the flux tubes of the personal magnetic body should decrease much slower with the distance from Earth's surface than those of the Earth's magnetic field, are consistent the possibility that the flux tubes of the personal magnetic body with field strengths stronger that of the Earth's magnetic field reside inside the magnetic flux tubes of the Earth's magnetic field in far-away regions. That part of the personal magnetic body which corresponds to field strengths weaker that the strength of the Earth's magnetic field could quite well have size measured in light years.

(c) The highly self-organizing plasma sheet at the equitorial plane at the night side of the Earth's outer magnetosphere is an especially interesting structure as far as personal and magnetospheric sensory representations are considered. For the fractal option the plasma sheet of the Earth's magnetosphere would contain plasma sheets inside plasma sheets, in particular the plasma sheets associated with the personal magnetic bodies. Personal and magnetospheric sensory representations would correspond to different levels of the same fractal structure.

(d) Also the intra-terrestrial part of the Earth's magnetosphere is important for the magnetospheric sensory representations and, if the fractality hypothesis holds true, also for the personal ones. The strange co-incidences of important cavity resonance frequencies of intra-terrestrial structures with EEG resonance frequencies, and the fractal correspondence between the architectures of brain and magnetosphere [K53] support the view that personal magnetic body extends also to the interior of Earth. The flux tubes of the Earth's magnetic field (with field strength increasing faster than for the flux tubes of the personal magnetic body) would be however contained *inside* those of the personal magnetic body in this region. The intra-terrestrial consciousness would therefore represent sub-...-selves of ours, something analogous to Id whereas magnetospheric sensory representations would correspond to the super ego. This interpretation conforms with the proposal that intra-terrestrial life forms are possible in the many-sheeted space-time, and that crop circle formations could be interpreted as attempts of ITs to communicate about their existence [K32, K33].

(e) Probably it makes sense to speak about Z^0 magnetosphere (both solar and terrestrial). Z^0 magnetic flux tube structures are crucial for the model of long term memories [K84], and the sizes of the flux tube structures associated with the personal Z^0 magnetic body should be measured in light years. This suggests that also much weaker personal magnetic and Z^0 magnetic fields with the lengths of the closed flux tubes measured in light years are relevant.

2.2.3 Cortex As A Collection Of Attributes Assigned To The Objects Of Perceptive Field Represented At Magnetic Canvas

One of the basic problems related to the understanding of the information processing in brain is how various attributes are assigned to the object of the perceptive field. What is known that brain recognizes features and these features/attributes seem to be located in a more or less random looking manner all around cortex. This brings strongly in mind random access memory or computer game in which various little program modules realized as records in random access memory represent collection of standard sound effects. A strong hint is the empirical evidence for the view that the resonance frequencies associated with the autocorrelation functions of nerve pulse patterns, and thus presumably also coding EEG frequencies, are same for the features associated with a given object of the perceptive field. The challenge is to understand how the picture based on a collection of MEs projecting features to the magnetic canvas could allow to understand what is behind these observations.

The view about MEs associating attributes to the object of the perceptive field by waking up sub-selves in the magnetic flux tube structure serving as a sensory canvas suggests an elegant interpretation for these facts.

(a) Brain writes the music played by the sensory organs to notes. Accordingly, cortex can be regarded as a collection of regions specialized to represent various kinds of standard

features interpreted as cognitive and symbolic representations for the sensory input whereas sensory qualia are realized at the level of sensory organs. Features need not be simple: arbitrary complicated collections of them, such as symbolic representations familiar faces are also possible features. Even entire dynamical processes (selves) could serve as features. Cortical mental images entangled also with sensory mental images a the level of sensory organs and at various organs. The pain in the heart is really in the heart.

(b) Basic feature-regions are like computer records. The information about the position of the feature in perceptive field could be represented by the entanglement of the feature with a particular part of, say, primary sensory area representing a point of the perceptive sphere.

(c) The direction of the point of the perceptive field could be coded basically by the direction of the magnetic flux tube emerging from the particular position of the sensory area providing map for solid angles of the perceptive field. The mechanism would be based on resonance with Alfven waves associated with the magnetic flux tubes of personal magnetic body amplifying MEs in the direction of magnetic flux tubes. The length (fundamental frequency) of ME would code for the distance of the point of the perceptive field to the distance of the point of the sensory magnetic canvas. Frequency coding could be achieved by varying the local value of the magnetic field responsible for generating the cyclotron frequency. This coding could be either dynamical or static in which case distance could be most naturally coded to linear structures, most naturally in direction orthogonal to the cortical surface.

(d) Features would be basically associated with sensory organs, various neural pathways and brain areas and coded partially by nerve pulse patterns. Features could be practically all kinds of sub-selves generated by brain activity. Primary qualia could be realized at the level of sensory receptors if entire sensory pathways entangle with the magnetic body. It seems that the identification of sensory organs as seats of sensory qualia is the most, and perhaps the only, plausible option in TGD framework.

(e) Projector MEs would be orthogonal to the sensory area where they emanate. The topographic mapping of the perceptive field to the sensory areas would guarantee that sensory images would remain stationary under rotations of head: although sensory magnetic sensory canvas would move the image projected to it would be stationary. MEs and magnetic flux tubes must be parallel if Alfven wave resonance is involved. In this manner the experiences could remain private and the contribution from the other brains would remain negligible. Note however that people in very intimate contact could gradually share there magnetic sensory canvases: the anecdotes about gradually developing telepathic communications between the teachers and students of the meditative practices could involve this kind of sharing of computer screen between several users.

(f) In this coding EEG MES would entangle with essentially all symbolic information about the perceptive field and the spectroscopy of consciousness would be realized in a strong sense.

Of course, the extreme flexibility of the entanglement mechanism of binding means that one can imagine almost unlimited number of variants about this basic option and the proposed variant can be defended only as the simplest one found hitherto. One can also allow the possibility that the sequence of entanglements begins from the perceptive field with the primary mental images at the level of sensory organs being entangled with objects of perceptive field.

Fractality suggests that there is a hierarchy of representations. In particular, cortex areas, brain nuclei and even cells could possess their own representations. The inactivity of the primary sensory areas during REM sleep could mean that during dream state sensory representations are non-cortical lower level representations or realized at higher sensory areas. Of course, lower level structures could define the projections to the magnetic sensory canvas also during wake-up consciousness. For instance, relay station like nuclei could act as relay stations for the projections realized at the magnetic body. Any brain area defining topographical map of sensory data is could candidate for defining a sensory representation.

The projector regions could serve as kind of central entanglers. Also the nuclei believed to somehow generate EEG resonance frequencies responsible for the binding of mental images are good candidates for the central entanglers. Thalamus is believed to generate 40 Hz rhythm and is thus a good candidate for the central sensory entangler and projector. Hippocampus generates hippocampal theta and could be the central memory entangler and projector. Frontal lobes generate slow EEG waves during cognitive activities and could act as cognitive entanglers and projectors.

This kind of architecture is expected to be realized at various length scales. Perhaps even at the length scale of genes. The remaining question is how motor activities are realized in this picture. The metaphor for consciousness as a computer sitting at its own terminal, which originally stimulated my personal attempts to understand consciousness, might help here. Computer screen corresponds to the magnetic canvas. The one who sits there presumably corresponds to our magnetic body (as far as conscious-to-us intentions are considered). The central unit corresponds to the brain. Sensory projector MEs are generated automatically by nerve pulse activity and code the picture on the monitor. W MEs as active quantum holograms acting as control commands generating nerve pulse patterns would provide a realization of keyboard. Thus it would seem that those aspects of the computer which are usually not regarded as fundamental in Turing machine paradigm are the most crucial for understanding the brain consciousness and computer programmers seem to mimic what happens inside (and outside) their own brain.

2.2.4   Place Coding

If the personal magnetic body corresponds to the sensory experiencer and the intentional agent, the distance from the brain along the magnetic flux tube represents the temporal distance to the geometric past. It is however quite possible and even plausible that the length of the magnetic flux tube can code for some spatial distance and even more general geometric data. The arrow of the geometric time would order the spatial points. This kind of mapping from the spatial domain to the temporal domain to the personal magnetic body is naturally induced by any scanning like process performed by CNS, say saccadic motion or EEG waves propagating along cortex. Thus it makes sense to speak about place coding even if one does not assume that our body and environment are mapped to the personal magnetic body in a topographical manner.

The required place coding by frequency is easy to achieve. Any cylindrical flux tube for which magnetic field in the cylindrical coordinates is obtained from a vector potential $A_\phi(z, \rho, \phi) = B(z)\rho$ varying slowly with z gives rise to a magnetic field whose z-component varies slowly with z and for which the radial component $B_{rho} = \partial_z B(z)\rho$ is small. From the quantization of the magnetic flux the flux tube thickness behaves as

$$\frac{r}{r_0} \propto \frac{B_{earth}}{\sqrt{B(z)}} \quad,$$

and flux tube gets thinner if the field strength increases and vice versa. It the strength of the magnetic field is that of Earth's magnetic field at the surface of the retina or secondary sensory organ, one obtains frequency coding

$$\frac{f}{f_{earth}} = \frac{B(z)}{B_{earth}} \quad.$$

This means that a given EEG frequency associated with, say color mental image, induces a magnetic quantum phase transition at a definite value of z and wakes up visual sub-self at that position. The resulting experience is colored point at a specific point of the visual field.

Optimal situation is achieved if the gradient of B with respect to z is very small. This would suggest that self sizes are of order of the size of ELF MEs waking-up the mental images. This would mean that the total increment of $B(z)$ along flux tube would be measured using

B_{earth} as a natural unit. p-Adic length scale hypothesis suggests that the thickness of the magnetic flux tube varies between two p-adic length scales and thus by a small power of 2.

It deserves to be noticed that a given EEG frequency f can wake up a number of copies of sensory images corresponding to various ions at positions related to each other by

$$\frac{B(z_1)}{B(z_2)} = \frac{A_1 Z_2}{A_2 Z_1} \quad .$$

Here A_i and Z_i denote the mass numbers and charges of the ions, results. If $B(z)$ varies very slowly along the flux tube, the number of separate mental images is however small since the condition above cannot be satisfied for too large ratios on the right hand side. If $B(z)$ increases along the flux tube, the images associated with the light ions are nearer to the eye than those associated with the heavy ions.

This observation suggests that ions with nearly the same mass numbers could give rise to multiple sensory representations associated perhaps with same sensory sub-self. Of course, the degeneracy of the mental images might be undesirable and could be eliminated by adjusting the gradient of B to be so small that multiple sensory images are not generated inside given magnetic self. By a small adjusting of the strength of the magnetic field at eyeball or the radius of the secondary visual sensory organ could shifts between various types of ionic visual consciousness could be induced. For heavy ions, isotopic degeneracy would lead to large number of alternative modes of ionic consciousness and this might give rise to enhanced cognitive abilities.

How faithful is the metric correspondence between the visual field and its image at the magnetic body? The answer is to this question is not obvious. Also eyes are accompanied by magnetic bodies which could carry visual representations and primary sensory qualia. It could be that these representation are responsible for all what relates to the experienced metric aspects of the visual field. If this is the case, the representations at the personal magnetic body could be much more abstract and free from the constraint of the isometric correspondence. The hierarchy of sensory areas in brain indeed corresponds to an increasingly higher level of abstraction.

2.2.5   Magnetospheric Sensory Representations

It is difficult to exclude magnetospheric sensory representations if one accepts the notion of personal magnetic body and representations at it. These representations could give rise to the third person aspect of consciousness. Magnetosphere could contain multi-brained collective selves receiving sensory input from several brains simultaneously. Also Z^0 magnetosphere could contain representations carrying both sensory and and higher level symbolic and cognitive information from several brains.

The location of the magnetospheric representations could be stationary with respect to the inner magnetosphere. This would require that the MEs projecting the information to the magnetosphere emanate from the head in a direction which is fixed with respect to the local direction of the magnetic field of Earth (the MEs associated with the personal magnetic body would project in a direction orthogonal to the surface of cortex). Most naturally this direction would be the direction of the local magnetic field since this makes possible amplification based on Alfven wave resonance. Stationarity of the directions of MEs projecting to the magnetosphere could be achieved by the interaction of the magnetic dipoles with Earth's magnetic field forcing the directions of the magnetic dipoles to the direction of Earth's magnetic field and thus making brain a compass. Brain is indeed full of magnetic materials, human brain is a compass and humans have magnetic navigation sense.

Also eyes contain magnetic materials and presumably act as compasses so that eyes could generate the required magnetic fields defining a preferred reference frame for visual subselves. One can consider a hierarchy of compasses defined by the hierarchy of magnetic fields at various sheets of the many-sheeted space-time. For the sense of balance this kind of a preferred direction is essential.

Also a Z^0 magnetic compass based on Earth's magnetic field and Z^0 magnetic materials is possible. The fact that Z^0 magnetic fields are associated with hearing so closely in TGD framework supports the view that Z^0 magnetic compass could be related to the sense of balance. Children love to spin around. Since all atomic nuclei couple to Z^0 force, this spinning however generates net Z^0 currents generating additional Z^0 magnetic fields perturbing the Earth's Z^0 magnetic field. This in turn could cheat the Z^0 compass. This indeed happens. When the spinning stops, sensation of dizziness results and the world is experienced to spin.

2.2.6 Remote Mental Interactions And Sensory Magnetic Canvas Hypothesis

Could the possible sensory inputs from other brains to the personal magnetic body interfere with the sensory inputs from "my brain" ? This is probably not the case. It is however possible that the entanglement with the other magnetic bodies and possibly existing magnetospheric multi-brained selves leads to the sharing of mental images. Perhaps this is exactly what happens during sleep and actually makes possible development of social structures and culture. Note that this picture is consistent with what near death experiences and various altered states of consciousness achieved in meditative practices suggest.

There is some evidence for the possibility of a interaction between minds via projected sensory representations. Some dogs are able to anticipate the epileptic attacks of their master and are systematically trained for this purpose. Some dogs have an amazing skill to precognize that their master is coming home: ordinary sensory perception such as olfaction is excluded as an explanation. The practitioners of transcendental meditation claim that collective meditation can have a definite positive effect on conflict situations occurring at the other side of the world proportional to the square of the number of participants (coherence). The vision of Sheldrake [I55] about morphogenetic fields making possible the claimed learning at the level of species could be modelled concretely in terms of this interaction.

The immediate prediction is that large scale phenomena affecting the magnetic field of Earth should have direct effects on our consciousness by the perturbation of the sensory representations at the other side of the world. There would be however no effect on primary sensory qualia if they are seated at the level of sensory organs nor on cognitive and symbolic mental images produced in brain. Telepathic sharing of mental images having would be one possible effect induced by Schumann resonances: the signature would be sensory experience with no neurophysiological correlates (in particular, there would be no back projection to sensory organs).

It is known that the statistics about mental states of patients of mental hospitals demonstrates strong correlation with magnetic storms induced by sun-spots. The magnetic perturbations induced by lightnings known as sferics are known to have a direct effect on EEG and brain functioning [F7]. Tectonic activity, such as Earth quakes, can induce various kinds of hallucinations such as encounters with UFOs and religious experiences [?] perhaps involving sharing of mental images. Animals are even able to anticipate earth quakes. When the car ferry Estonia suffered a shipwreck for few years ago taking with it almost thousand people into the depths, hundreds of people reported they had experienced a nightmare obviously relating to this event. Sharing of mental images or sensory percepts produced by back-projection from symbolic representations created by or communicated to brain could be in question.

The known general features of remote mental interactions support the view that magnetospheric multi-brained selves serve as a kind of relay station or medium allowing the remote mental viewer to entangle with the target. Remote viewer would essentially see with the yes of this higher level self [K81, K15].

2.2.7 Mirror Mechanism Of Geometric Memories

The mirror mechanism of long term memories involves several purely TGD based features [K84].

(a) The classical non-determinism making possible time-like quantum entanglement and sharing of mental images.

(b) Space-time sheets with a negative time orientation allowing classical signals associated with negative energy MEs to propagate backwards in time and making possible entanglement.

(c) The identification of the personal magnetic body as the experiencing intentional agent sending negative energy MEs parallel to the magnetic flux tubes to the brain acting as the time mirror (see **Fig. http://tgdtheory.fi/appfigures/timemirror.jpg** or **Fig. ??** in the appendix of this book). This option, forcing to take completely seriously the notion of the magnetic body, provides the most elegant identification of the time mirror discovered hitherto. If brain is identified as the sender of the negative energy MEs, the identification of the mirror and correct timing of pose problems. One possibility is that the closed flux loops associated with the personal magnetic and Z^0 magnetic bodies having sizes of order light years making it possible for negative energy MEs to repeatedly reflect along them and return back to the brain of the geometric past.

(d) The possibility of MEs and magnetic flux tubes interacting weakly with the ordinary matter but strongly with living matter in cell length scales.

Time mirror mechanism

Classically the mechanism of long term memory is extremely simple: one looks at time mirror at a distance of one light year and sees oneself in the geometric past at a distance of two years. Since the geometric past changes in each quantum jump, this mechanism explains why our long term memories are so unstable. One could see also other persons in the mirror and this could explain telepathic communications, the communications with the deceased, as well as identification experiences. The most natural identification of the seer is as the magnetic body and the mirror as the brain (my first guess was time mirror image of this!). The distance along the magnetic flux tube would corresponds to the distance to the geometric past.

For the time-mirror model (see **Fig. http://tgdtheory.fi/appfigures/timemirror.jpg** or **Fig. ??** in the appendix of this book) of long term memory recall the ULF dark MEs must be generated both at the personal magnetic body and in the brain.

(a) At the personal magnetic body cyclotron phase transition would give rise to negative energy neutral MEs sucking energy from the biological body of the geometric past. This radiation would be reflected back to the geometric future as positive energy neutral MEs. The response would depend on the state of the brain. Motor action would differ from memory recall only in that it would involve negative energy W MEs inducing exotic ionization at both ends and leading to a physiological outcome. The entanglement via W MEs could induce direct sensory memories relying on sharing and fusion of mental images.

(b) The ULF radiation representing the response to the memory recall would correspond to Josephson radiation giving rise to a scaled up dark EEG in the relevant time scale characterized by the level of the dark matter hierarchy. The de-coherence of higher level dark photons to single ordinary EEG dark photon or their decay to EEG dark photons is probably involved with the memory call and would transform the response from the geometric past to ordinary cognitive and emotional input at personal magnetic body.

The assumption that the lengths scales of MEs and magnetic structures are identical implies that the frequency of ME equal to the magnetic transition frequency f_m fixes the length of the two MEs involved and thus the temporal location of the long term memory in the geometric past:

$$T = \frac{2}{f_m} \quad .$$

This represents a frequency coding for the temporal location. In standard physics the idea about brain generating MEs with a frequency scale of the order of the inverse of lifetime does not make sense: in TGD context situation is different since this process occurs in subjective time. By the arguments discussed in more detail below, positive energy neutral MEs are ideal for communication of long term memories to the geometric future. The concrete mechanism for the generation of MEs as associated with transitions between almost degenerate configurations of spin glass with slightly different classical gravitational energies is discussed in [K84].

More detailed model for long term memories

The realization of long term memories might be the basic function of the personal magnetic body.

(a) Spontaneous episodal memories would be based on negative energy MEs entangling the geometric now with the geometric past and making possible sharing of mental images. In particular, sensory memories would rely on this mechanism. This mechanism could also make possible only the communication of the desire to remember to the geometric past in the case of an active memory recall and non-episodal memories. One can however wonder what distinguishes the resulting experience from precognition by the self of the geometric past: could it be that to precognize now is to remember in the geometric future? The fact that MEs represent channelled energy means that distance is not a problem as far as energetics is considered.

(b) In the case of non-episodal memories the information could be communicated classically from the geometric past as "bits" and be coded into the light like vacuum current associated with ME. If the magnetic body is the "me", positive energy MEs could simply travel along the same magnetic flux tube along which the negative energy ME arrived. Magnetic flux tube would act as a wave guide amplifying ME by Alfven resonance.

(c) Neural MEs with negative energies are especially favored for quantum communications. The reasons are many-fold. The interaction with the matter is very weak in long length scales but strong in cellular length scales, negative energy implies that ME is identifiable as a virtual particle and analogous to a part of a Feynman diagram so that no dissipation is involved and quantum communication is possible. The reversal of the arrow of geometric time means also that there is not macroscopic dissipative dynamics which would spoil the quantum coherence.

(d) The requirement that the receival process is highly selective suggests a resonance mechanism. This requires that the fundamental frequencies associated with MEs are somehow universal. p-Adic length scale hypothesis indeed predicts hierarchies of universal frequencies. A stronger requirement is that the receiving and sending structures are somehow similar, and many-sheeted space-time allows to realize this kind of option. Negative energy energy ME cannot be emitted unless there is a receiver absorbing the negative energy and in this manner providing energy for the sender by buy now-let others pay mechanism. The time mirrored positive energy ME can even amplify the reflected negative energy signal by stimulated transition to the ground state if the receiver is a many-sheeted analog of a population inverted laser.

(e) Negative energy MEs represent time reversed level of the p-adic length scale hierarchy so that the dissipative effects associated with the space-time sheets with the normal arrow of time should not interfere with the quantum communication. This at least, when the energy of the negative energy ME has a magnitude larger than the thermal energy associated with the space-time sheets with which it interacts: there is simply no system which could make a transition to a lower energy state by the absorption of a negative energy ME. Furthermore, since systems with reversed arrow of geometric time are expected to have extremely low density, the dissipative effects in the reversed direction of time are expected to be small. Since the generation of negative energy MEs does not require energy feed, the memory recall to the geometric past occurs more

or less spontaneously, and the scanning of the geometric past becomes possible. In the case of precognition precognizer must intentionally receive negative energy MEs from the geometric future so that energy feed is needed. This perhaps explains why precognition is so rare. Note that p-adic variant of pre-cognition having interpretation as intentionality occurs easily since p-adic energy is conserved only in piecewise manner.

If this picture has captured something essential from the nature of the long term memories, the conclusion is that we are not at the top of the magnetic sensory hierarchy. Human body and brain generates extremely weak magnetic fields and the corresponding magnetic flux tube structures could make possible long term memories. Near death experiences [K19] could be understood in this framework if the weak magnetic fields associated with the higher levels of the fractal hierarchy of magnetic structures utilize brain and body as kind of sensory and motor organs. Note that there is a flux tubes inside flux tubes structure so that ordinary sensory experiences can be associated also with these flux tubes.

2.2.8 Sensory Perception, Motor Action, And Time

TGD view about sensory perception differs dramatically from that of the standard neuro-science in that sensory organs (plus possibly their magnetic bodies) are carriers of basic sensory representations and the magnetic body rather than body or brain is the experiencer with which we can identify ourselves. Magnetic body is also the intentional agent and both motor action, sensory perception, and long term memory which all involve also intentional elements, are based on the time mirror mechanism. Intentions are represented by p-adic MEs generated at the magnetic body. p-Adic ME is then transformed to a desire about a particular action and represented as a negative energy ME propagating to the direction of the geometric past. Actions are realized as responses to the negative energy MEs as various kinds of neural activities and as a generation of positive energy MEs. A more realistic model involves an entire sequence of this kind of steps proceeding like a sequence of sub-program calls downwards along the hierarchy of the magnetic bodies down to the level of CNS. A good metaphor is obtained by regarding magnetic bodies as bosses in the hierarchy of some organization and CNS as the lowest level ultimately realizing the desire of the big boss.

Sensory organs as seats of qualia

According to the music metaphor, sensory organs are responsible for the music whereas brain writes it into notes by building symbolic and cognitive representations communicated to the magnetic body. Back projection to the sensory organs is an essential aspect of this process and is discussed in [K39]. Sensory perception at the level of magnetic body involves the generation of negative energy MEs entangling with sensory organs involving possibly also brain as an intermediate entangler.

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking [K39]. One can also consider the possibility that sensory organs and their magnetic bodies define the sensory capacitors whose discharges give rise to sensory qualia and that these magnetic bodies give also rise to low level cognitive and emotional representations.

Neuronal/symbolic level would do its best to symbolically represent what occurs naturally at the level of qualia. Color constancy could be understood as a basic characteristic of color qualia represented symbolically at the neuronal level. Center-surround opponency for the conjugate colors is the neural counterpart for the contrast phenomenon in which the boundary for a region of the perceptive field with a given color carries the conjugate color (black-white opponency associated with the luminance is only a special case of this). The contrast phenomenon at the level of visual qualia could derive from the vanishing of the net color quantum numbers for the electrodes of the retinal color capacitors.

The basic prediction is the presence of the back projection at least in the sensory modalities in which hallucinations are possible. MEs with MEs mechanism is the most natural

candidate for realizing the back projection, negative/positive energy MEs would realize the back projection based on quantum/classical communications, and the capacitor model of the sensory receptor can be applied to model photoreceptors and retina. This picture integrates nicely with the various speculations about the role of the ciliary micro-tubules in vision. The obvious question is how the presence and character of the back projection reflects itself in the structure of the sensory pathways and sensory organs.

Basic facts about how gastrulation and neurulation proceed during the development of the embryo, lead to testable hypothesis about the character of the back projection for various sensory modalities. According to the hypothesis, one can speak about "brain senses" and "skin senses" according to whether the back projection is based on quantum or classical communications.

How motor action differs from sensory perception?

There is a deep similarity between sensory perception and motor action in TGD framework, the basic difference being that classical signals propagate in different direction in CNS and in geometric time. Motor action is initiated by the magnetic body by the sending of negative energy to motor organs by generating negative energy MEs, and proceeds by similar processes backwards in the geometric time to the level of brain and magnetic body, very much like an instruction of a boss at the top of organization to the lower levels of hierarchy and induces lower level instructions. The analogy with computer program calls (quantum communications, desires) and their executions (classical signals, actions) is also obvious. Also classical signals from the magnetic body to the body and brain are possible.

Analogous picture applies to sensory perception with motor organs replaced by sensory organs except that the fundamental communications occur to geometric future from biological body to magnetic body via a hierarchy of EEGs. There is however also an active building of sensory percepts by feedback from the magnetic body which selects between quantum superposed alternative percepts already at the level of sensory organs.

Sensory *resp.* motor imagination differ from sensory perception *resp.* motor action only in that the magnetic body entangles with some higher level of CNS. Therefore there is no danger that imagined motor action would become real or that imagined sensory perception would be experienced as real. This picture is in accordance with the idea of quantum credit card implying maximal flexibility, and with respect to the geometric time would mean that motor actions are only apparently initiated from the brain.

Strange time delays of consciousness: experiments related to the active role of consciousness

Libet has carried out classical experiments about active and passive aspects of consciousness [**?**, **?**]. It has gradually become clear that these experiments can be interpreted as a support for the identification of "me" as the personal magnetic body.The first class of experiments [**?**, **?**] is related to the active role of consciousness. For example, the human subject moves his hand at free will. What happens is that neurophysiological processes (changes in EEG, readiness potential) start $T_1 = .35 - .45$ seconds before the conscious decision to move the hand whereas the awareness about the decision to move the hand comes $T_2 = .2 - .1$ seconds before the hand movement. Decision seems to be followed by the action rather than action by decision! This is in apparent accordance with the point of view that consciousness is indeed a passive spectator and the act of free will is pure illusion. What is interesting from the p-adic point of view, is that the most plausible estimates for the time delays involved are $T_1 \simeq .45$ seconds and $T_2 = .1$ seconds [**?**]. T_1 is very near to the p-adic time scale $T(6, 43) = .4$ seconds and T_2 to the fundamental p-adic time scale $T(2, 127)$ defining the duration of the memetic codon.

One can imagine two explanations for the paradoxal findings. The explanations turn out to be mutually consistent.

1. The geometric past changes in quantum jump

Quantum jump between histories picture explains the time delays associated with the active aspect of consciousness nicely and also gives an example of two kinds of causalities.

(a) The simplest assumption is that the subjective experience of the hand movement corresponds to the moment, when subject person experiences that hand movement occurs.

(b) The space-time surfaces (resulting as the final state of quantum jump) associated with the new quantum history differ in a detectable manner from the old quantum history already before the moment of hand movement since otherwise the new space-time surface would contain an instantaneous and discontinuous jump from the initial to final body configuration, which is not allowed by field equations. Same argument applies to the state of brain. $\Delta T \sim .5$ seconds seems to be the relevant time scale.

(c) The attempt of the experimenter to be objective means that in an ideal experiment the observations correspond to the new deterministic history in the associated quantum jump and hence experimenter sees neurophysiological processes as the (apparent) cause of the hand movement with respect to geometric time. With respect to the subjective time the cause of the hand movement is the decision of the subject person.

2. Motor action is initiated from the magnetic body and proceeds to shorter length scales in reversed direction of geometric time

The vision that motor actions are initiated by magnetic body by feeding negative energy to motor organs and proceed upwards in CNS in a reversed time direction is in accordance with the idea of quantum credit card implying maximal flexibility and would mean that motor actions are only apparently initiated from brain. Motor organs send negative energy MEs to get metabolic energy, say to cortex. If there is lapse $\sim .5$ seconds involved then the observed lapse would find explanation. This view concretizes the idea about the editing of the geometric past and is consistent with the more general explanation discussed above.

This view about motor action means that it proceeds from long length scales to short ones whereas in the standard neuroscience view motor motor action would be planned and initiated in the brain and proceed to the level of motor organs, from short to long length scales. This certainly seems to be the case if one looks only the classical communications (say nerve pulse patterns). The extreme coherence of and synchrony of motor activities is however in conflict with this picture: neuronal communications are simply too slow to achieve the synchrony. This has been emphasized by Mae-Wan Ho [I51]. Since quantum communications proceed backwards in geometric time, classical signalling such as nerve pulses from brain to motor organs are actually reactions to the initiation of the motor action from the magnetic body.

Strange time delays of consciousness: experiments related to the passive role of consciousness

Libet's experiments [?] about the strange time delays related to the passive aspects of consciousness have served as a continual source of inspiration and headache. Every time I read again about these experiments, I feel equally confused and must start explanations from scratch.

What is so important and puzzling is that the backwards time referral of sensory experience is so immensely long: about.5 seconds. The time taken for nerve pulses to travel through brain is not more than .01 seconds and the time to arrive from sensory organs is at most.1 seconds (for axon with length of 1 meter and very slow conduction velocity 10 m/s). For the purposes of survival it would be advantageous to have a sensory input with a minimal time delay.

Why then this long delay? TGD inspired answer is simple: the "me" does not correspond to the material body but to the magnetic body associated with the physical body, and is analogous to the manual of electronic instrument, kind of a monitor screen to which sensory, symbolic and cognitive representations are projected by quantum and classical communications. Since the size of the magnetic body is measured using Earth's circumference as a natural unit, the long time lapse results from the finite velocity of light.

The following explanation is a variant of the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths. The basic sensory representations are realized at the level of the sensory organs and entangled with magnetic body whereas symbolic representations are either shared as mental images by or communicated classically to the magnetic body. This differs from the original scenario in which sensory representations were assumed to result by classical communications from brain to the magnetic body.

1. Communications from brain to magnetic body

One must consider two kinds of communications from body to magnetic body corresponding to positive energy MEs generated by at least brain and negative energy ME sent by magnetic body to at least sensory organs. The assumptions are following.

(a) Negative energy MEs bound state entangle the magnetic body with the sensory representations realized at the level of sensory organs, and constructed using back projection from brain and possibly also from higher levels. Fusion and sharing sensory mental images is involved. Also the classical communication of memories to magnetic body could be involved with the build up of sensory and symbolic representations at the magnetic body. In both cases sensory representations are memories with the same time lapse determined by the length of the MEs involved, a fraction of second typically if the magnetic body is of an astrophysical size. During sensory and motor imagination magnetic body entangles by negative energy MEs with some higher level of CNS.

(b) Symbolic representations in brain can entangle with the sensory representations entangling in turn with the magnetic body so that CNS defines tree like structure with roots corresponding to sensory organs and branches and leaves corresponding to the higher levels of CNS. Direction of attention selects some path along this tree somewhat analogous to the path defining computer file in some subdirectory.

(c) Symbolic representations of the perceptive field can be projected to the magnetic body using also classical signalling by positive energy MEs with phase velocity in a good approximation equal to the light velocity. For instance, if perceptive field contains something important, classical signal to the magnetic body could induce the generation of negative energy MEs turning attention to a particular part of perceptive field. Projection to the magnetic flux tubes of the Earth's magnetic field is possible. The spatial direction of the object could be coded by the direction of ME located in brain whereas its distance could be coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results. Field pattern could be realized the coding of information to bits in some time scale, perhaps even in the time scale of millisecond associated with the memetic code. Positive energy MEs generated by brain realize the representation and this implies time delay. In the original model it was assumed that the direction and distance of the object of perceptive field are coded as direction and distance at the magnetic body. The representations are expected to be rather abstract, and it might be enough to perform this coding at the level of magnetic bodies associated with the sensory organs.

2. Libet's findings

Libet's experiments [**?**] about the strange time delays related to the passive aspects of consciousness serve as a continual source of inspiration and headache. Every time one reads again about these experiments, one feels equally confused and must start explanations from scratch. The following explanation is based on the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths [K82].

The basic argument leading to this model is the observation that although our brain changes its position and orientation, the mental image of the external world is not experienced to

move: as if we were looking some kind of sensory canvas inside cortex from outside so that the motion of canvas does not matter. Or equivalently: the ultimate sensory representation is outside brain at a fixed sensory canvas. In this model the objects of the perceptive field are represented on the magnetic canvas. The direction of the object is coded by the direction of ME located on brain whereas its distance is coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results.

According to the summary of Penrose in his book "Emperor's New Mind" these experiments tell the following.

(a) With respect to the psychological time of the external observer subject person becomes conscious about the electric stimulation of skin in about .5 seconds. This leaves a considerable amount of time for the construction of the sensory representations.

(b) What is important is that subject person feels no time delay. For instance she can tell the time clock shows when the stimulus starts. This can be understood if the sensory representation which is basically a geometric memory takes care that the clock of the memory shows correct time: this requires backwards referral of about .5 seconds. Visual and tactile sensory inputs enter into cortex essentially simultaneously so that this is possible. The projection to the magnetic canvas and the generation of the magnetic quantum phase transition might quite well explain the time lapse of .5 seconds.

(c) One can combine an electric stimulation of skin with the stimulation of the cortex. The electric stimulation of the cortex requires a duration longer than .5 seconds to become conscious. This suggests that the cortical mental image (sub-self) is created only after this critical period of stimulation. A possible explanation is that the stimulation generates quantum phase transition "waking up" the mental image so that threshold is involved.

(d) If the stimulation of the cortex begins (with respect to the psychological time of the observer) for not more than .5 seconds *before* the stimulation of the skin starts, both the stimulation of the skin and cortex are experienced separately but their time ordering is experienced as being reversed!

A crucial question is whether the ordering is changed with respect to the subjective or geometric time of the subject person. If the ordering is with respect to the subjective time of the subject person, as it seems, the situation becomes puzzling. The only possibility seems to be that the cortical stimulus generates a sensory mental image about touch only after it has lasted for .5 seconds.

In TGD framework sensory qualia are at the level of of sensory organs so that the sensation of touch assignable to cortical stimulation requires back-projection from cortex to the skin. The mental images generated by direct stimulation of cortex could be called cognitive this is created first and takes some time. If the construction of cognitive mental images about cortical stimulation and the formation of back projection takes at least about.5 seconds the observations can be understood. Genuine sensory stimulus starts to build cortical mental image almost immediately: this mental image is then communicated to magnetic body.

For instance, assume that the preparation of cognitive mental image at cortex takes something like.4 seconds and its communication to magnetic body about.1 seconds and that back projection is possible only after that and takes roughly the same time to the sensory organs at skin and back. This would explain the change of time order of mental images.

(e) If the stimulation of the cortex begins in the interval $T \in [.25 - .5]$ seconds *after* the stimulation of the skin, the latter is not consciously perceived. This effect - known as backward masking - looks really mysterious. It would be interesting to know whether also in this case there is a lapse of.5 seconds before the cortical stimulation is felt.

If the construction of cognitive mental image about direct stimulation of cortex takes about.4 second, it does not allow the buildup of cognitive mental image associated with the stimulation of skin. Hence the stimulation of skin does not create conscious cognitive or sensory mental image communicated to magnetic body.

2.3   First attempts to telate sensory sanvas idea to neuroscience

The challenge to relate sensory canvas hypothesis to the general qualitative features of EEG and to what is known about its evolution. The general knowledge about neural correlates of consciousness could also provide constraints for the model of how sensory representations are constructed. One could also try to find clear tests and even existing evidence for the hypothesis that there indeed are also other than neural correlates of consciousness (MEs projecting to the sensory canvas are obviously the candidate in present case).

There seems to be a general consistency of predictions of sensory canvas hypothesis with what is known about EEG. Mention only the evolution of EEG as the emergence of decreasing EEG frequency scales; the disappearance of alpha, beta and gamma bands from EEG during sleep; the existence of narrow coherent EEG sub-bands in all EEG bands; and also the complex fractal like coherency structures of EEG difficult to understand if EEG has a purely neural origin.

Brain is active also during sleep. Sensory canvas hypothesis encourages to think that, besides making possible consolidation of long term memories, this activity could serve the purposes of higher level multi-brained magnetic selves representing collective levels of consciousness receiving abstract non-sensory input from several brains at theta and delta frequencies. Of course, interaction could occur also in reverse direction and among other things explain the creative insights often achieved during sleep.

Computer metaphor would suggest that motor actions and sensory representations are basically identical procedures in TGD framework: only the final representation of the data file constructed by brain is different. As found, this is not quite the case: there is time reversal involved. Motor action is like precognitive recall whereas sensory experience is like geometric memory recall.

The considerations below rely on various review articles [E4], [?, ?] about the recent situation concerning the understanding of EEG. Also the article [?] about neural correlates of consciousness, and the article [?] suggesting that primary sensory area V1 is crucial for conscious vision have been very useful in attempt to develop more concrete views about how sensory representations are constructed. I do not hesitate to admit that the model to be discussed is nothing more than a first attempt to relate the general idea of sensory canvas to the complex neuro reality and is severely restricted by my very limited knowledge about neuroscience (I am grateful for Gene Johnson for his patience while trying to teach me some basic facts about conscious brain).

2.3.1   Anatomical Structure Of The Cortex And Sensory Canvas Hypothesis

The anatomical structure and evolution of cortex inspires definite hypothesis about how brain constructs and realizes sensory representations at magnetic sensory canvas and how magnetic sensory canvas builds up motor actions. In order to avoid confusions I want to stress that sensory representations generated by brain are assumed to be symbolic representations assigning meaning to the raw sensory input and do not involve qualia, which in TGD Universe are most naturally assignable to the sensory organs.

Do primary sensory areas serve as gateways to the fundamental sensory canvas?

Is there single cortical magnetic body or several of them? Do various sensory areas define a hierarchy of magnetic bodies serving as sensory canvases ("sensory" is somewhat misleading here)? There are several arguments supporting the view that primary, and possibly secondary and tertiary sensory areas, but not necessarily higher areas, should be accompanied by separate magnetic bodies.

(a) Computer metaphor encourages to consider the hypothesis that sensory representations and motor outputs have essentially the same character just like printout and monitor picture are different outputs of a same file in the case of a computer. First (with respect to the subjective time!) a rough sensory sketch is generated and then more and more details are added and the primary areas activate the final sensory representation just as in the case of motor output. As in the case of motor actions, higher levels of cortex simply select the activated sensory representation to be experienced consciously by us (binocular rivalry). The sequence of quantum entanglements proceeding from the magnetic body down to the magnetic bodies of sensory organs selects what is experienced consciously by us. There is probably a hierarchy of experiencers each characterized by particular selections.

(b) The intention for motor activity is realized as p-adic MEs connecting magnetic body by entanglement sequence to motor organs and induces directly action at this level (buy now-let others pay principle and precise targeted realization of intention). This quantum communication like aspect is accompanied by classical communications from magnetic body to cortex and in terms of nerve pulse patterns from cortex to lower levels. Intention can be also initiated at higher level than motor organs and in this case motor imagination is in question.

(c) Mental images are entangled with the mediation of the negative energy projector MEs along along magnetic flux tubes connecting magnetic bodies together. Hierarchical sequences of mental images result in this manner, and sensory qualia become associated with various higher level mental images. MEs can be thought of as representing radiation propagating in the wave channel represented by the magnetic flux tube and being reflected repeatedly. MEs need not be only simple cylindrical prototype MEs but can be also curved: this means that the number of reflections need not be too high. Magnetic flux tubes are essentially guides for MEs so that they do not "lose their way".

(d) The motor-sensory analogy might provide also other new insights. For instance, basic elements making possible several potential motor actions might exist simultaneously as sub-selves representing imagined basic modules of motor activity at the level of cortex. The sequence of quantum entanglements would then select the desired motor action, much like the sensory percept is selected in the sensory rivalry. This would be like building a program from a set of active modules selecting some subset of them or selecting one downwards path in a branching tree. The magnetic sensory representations associated with primary sensory organs without the higher level cognitive and symbolic associations could be seen as the counterparts of reflex actions.

Neural correlates of visual consciousness and motor-sensory analogy

The study of the neural correlates of visual consciousness reviewed in [**?**] allows to study the reasonability of the primary sensory areas as gateway to sensory canvas hypothesis and its variants.

(a) Evolutionary argument suggests that both primary sensory organs and various sensory areas are accompanied by magnetic bodies providing increasingly abstract symbolic and cognitive representations for the sensory input. The neurons at the higher sensory areas indeed become increasingly complex and have increasingly wider receptive fields. In particular, in the case of vision the neuronal receptive fields at V4 and higher areas are also dynamical and determined by the attentional level. Color/orientation information and the information about motion are treated separately in parvo and magno cellular pathways in V1, V2 and V3 but not in V4 (for the organization of the visual pathways see [**?**]). These observations encourage the view that sensory areas define a hierarchy of separate magnetic bodies giving rise to more and more integrated conscious higher level representations of the sensory input. These representations define hierarchy of selves using the same brain and body.

(b) The standard assumption about feed-forward hierarchy of the sensory areas leads to difficulties. For instance, in binocular rivalry of two competing visual stimuli feed to

right and left eye, only the other stimulus is experienced at time. V1 and also V2 and V3 however contain neural representations of both stimuli. It has been also found that during the binocular rivalry the co-varying neural activities (seen by fMRI) in the extrastriatal visual cortex and in prefrontal cortex correlate with the subjective percept (rather than real stimulus) unlike the activity in V1 which represents both stimuli [?]. The manner to understand this is that quantum entanglement sequences starting from the magnetic body proceed down to sensory organs and select from V1, V2 and V3 only the second stimulus.

(c) It is known that neural activity in parietal and frontal regions is involved with the change of the dominating stimulus and that the activity in visual areas is not enough for visual consciousness [?]. Thus the presence of neural representations of both stimuli in V1 but conscious experience of only one stimulus would support the view that neuronal activity is *not* enough to generate our conscious experience. If the hierarchy of entanglements proceeds from our magnetic body to frontal lobes and from there downwards it is easy to understand why the activity in frontal lobes is essential for selecting the consciously experienced stimulus. Obviously the sensory-motor loop would have counterpart in much longer length scales.

(d) V1 seems to be necessary for visual consciousness. Pascual-Leone and Walsh have studied the visual hallucinations induced by transcranial magnetic stimulation [?]. The stimulation of V1 generates static and colored impressions whereas the stimulation of V5/MT generates moving non-colored phosphenes (in accordance with the fact that "where" type information processing is color blind and "what type" information processing at lowest levels is motion blind). This picture is consistent with the idea that the fundamental visual representations are realized at retinal magnetic bodies. The back-projections in question would be essential for the "qualiafication" of imagination during dreams and hallucinations.

(e) The study also demonstrates that the stimulation of V1 *after*, rather than before, the stimulation of regions V5/MT sending feedback to V1 can prevent the generation of hallucination. Even more, [?] describes a case in which patient has lost visual consciousness when V1 is not intact. There is indeed a strong neural feedback to V1, V2 and V3 from the higher visual areas V5/MT and area V1 is activated simultaneously with MT in macaque. These findings are in conflict with what one might expect if sensory processing proceeds in strictly feed-forward manner. The necessity of V1 for our visual consciousness is obvious if entanglement sequences go through V1 down to the level of retinas. Feedback would also make possible "coloring" of the sensory map during ordinary wave-up experience. Perception would be creative act already at the level of sensory organs.

(f) The timing of the interactions in the visual areas provides further hints about how sensory representations are constructed. According to [?] that early activation of V1 by magnocellular neurons in LGN occurs 20 ms earlier that the activation by parvocellular neurons. At this time also the feedback from V5/MT arrives to V1. This suggests that sensory map is constructed by making first a rough sketch using the sensory input from the magnocellular pathways (motion and position). For about 20 milliseconds later follows the coloring of the sensory map as well as the association of the higher level features to the map. This order is is consistent with the fact that highly developed parvocellular pathway is a newcomer in the evolution and that the information involved is not so vital for survival. Thus V1 would act as an effective "active blackboard" as has been suggested [?] and by the sensory-motor analogy in TGD framework.

2.3.2 EEGAnd Sensory Canvas Hypothesis

The general qualitative features of EEG seem to conform with sensory canvas hypothesis and it seems possible to make relatively concrete suggestions for EEG correlates of sensory qualia, cognition and long term memories.

Why the endogenous magnetic field corresponds to .2 Gauss?

For years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking Ca^{++} cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for Ca^{++} is .2 Gauss and thus slightly smaller than the minimum value .3 Gauss of B_E. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of B_E at distance 1.4R, R the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [K35]. Number theoretical arguments suggest a general formula for the allowed values of Planck constant [K37] $h_{eff} = nh$ with n a product of two integers n_1 and n_2. The values of integers for n_i which the quantum phase is expressible using only iterated square root operation are number theoretically preferred and correspond to integers n_i expressible as $n_i = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \to h_n = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \to nL(k)$ and $B \to B/n$.

$B_E = .5$ Gauss corresponds to flux quantum for $L(169)$ for ordinary value of Planck constant. $B = .2$ Gauss would correspond to a flux tube radius $L = \sqrt{5/2} \times L_e(169) \simeq 1.58 L_e(169)$, which does not correspond to any p-adic length scale as such for $h_{eff} = h$. $k = 168 = 2^3 \times 3 \times 7$ with $h_{eff} = nh$, $n =_F 1 = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 18 \ \mu$m, size of a large neuron. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux h_5. Note that $n = 5$ is the minimal value of n making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [K3].

Evolution as emergence of lower EEG frequency scales: dark matter hierarchy

Sensory canvas hypothesis combined with the scaling law suggests an entire hierarchy of sensory canvases. One must however keep mind open for the possibility that the flux tubes of Earth's magnetic field define only single sensory magnetic canvas.

A firm prediction is that evolution should correspond to the emergence of higher level selves characterized by decreasing EEG frequency scales. There are two hierarchies involved. Dark matter hierarchy and p-adic length scale hierarchy and both presumably correspond to evolutionary hierarchies.

Dark matter hierarchy correspond to a hierarchy of values of Planck constant coming for the most general option as ratios and products of two integers. The model for the hierarchy of generalized EEGs [K35] assigns to preferred levels of dark matter hierarchy a typical time scale identifiable as typical time span of memories. The hypothesis about evolution proceeding as the emergence of higher and higher levels of dark matter hierarchy at the level of personal consciousness is very natural.

Evolution as emergence of lower EEG frequency scales: p-adic length scale hierarchy

p-Adic length scale hierarchy defines a hierarchy at each level of dark matter hierarchy and one can ask whether also the emergence of increasingly longer p-adic length scales characterizes evolution.

1. Cerebellar, retinal, and cortical rhythms

The p-adic time scales assignable with the basic rhythms associated with cerebellum, retina, and cortex increase in this order and are consistent with the hypothesis that higher evolutionary levels corresponds to longer p-adic time scales.

(a) The fact that the dominating rhythm in cerebellum is about 200 Hz supports the view that it corresponds to shorter p-adic length and time scale than cortex. The fact that cerebellum is responsible for the finer details of motor action is consistent with shorter p-adic time scale.

If one assumes that 200 Hz rhythm is analogous to sensorimotor rhythm of 13 Hz (Na^+ cyclotron frequency) then scaling then the magnetic field at the field quanta involved should be $\simeq 16$ times stronger than B_{end}. Since B_{end} most naturally corresponds to the p-adic length scale $k = 169$ and magnetic flux $2h_5$, this field could correspond to $k = 169 - 8 = 161 = 7 \times 23$ (scaling down of thickness of flux sheets flux sheets) or $k = 169 - 4 = 165 = 5 \times 53$ (scaling down of the radius of the flux tube). The work of [I25, I26] provides support for the hierarchy of magnetic flux sheets of various thicknesses associated with chromosomes and favors $k = 161$ option.

(b) The micro-tremor of retina corresponds to 80 Hz frequency and would relate naturally to 40 Hz thalamocortical resonance frequency if the magnetic field in question corresponds to transversally scaled down magnetic flux sheets having $k = 167$ instead of $k = 169$. Note that $k = 167$ corresponds to the Gaussian Mersenne $(1 + i)^{167} - 1$.

(c) Primary sensory areas are dominated by 40 Hz frequency. Lowest frequencies such as hippocampal theta are in turn associated with long term memory which corresponds to high level mental function distinguishing sharply between humans and other species.

2. Why the interpretation in terms of spin flip frequencies does not work?

The original interpretation of cerebellar rhythm was in terms of some magnetic spin flip frequency. Representative examples of spin flip frequencies near cerebellar 200 Hz are $f_s(Na) = 222$ Hz, $f_s(Al) = 218$ Hz and $f_s(Mn) = 208$ Hz, $f_s(Co) = 199$ Hz and $f_s(Sc) = 204$ Hz. Co is obviously the best candidate.

The spin flip frequencies in EEG range (see the table 4) are $f_s(Cl) = 82$ Hz and $f_s(Rb) = 81$ Hz (80 Hz micro-tremor in retina); $f_s(K) = 39$ Hz and $f_s(Y) = 41$ Hz (both very near to 40 Hz thalamocortical resonance frequency); $f_s(Ag) = 34.2$ Hz, $f_s(Rh) = 26.6$ Hz (27 Hz resonance frequency in dog's cortex); $f_s(Ir) = 17$ Hz (narrow band in EEG [**?**]), $f_s(Au) = 14$ Hz (the sleeping spindle frequency).

These interpretations are however excluded in the dark matter based view since the ions are assumed to be ordinary ions topologically condensed to dark matter space-time sheets defining λ^k-fold coverings of M^4 so that spin flip photons would be ordinary ones and their energies would be extremely low and much below the thermal threshold. Of course, one must be very cautious with this kind of statements since the ideas about dark matter are still just a collection of rules.

3. p-Adic length scale hierarchy as abstraction hierarchy

This picture suggest an abstraction hierarchy in which EEG frequency scale of projecting EEG MEs correlates with the abstractness of the feature associated with the point of sensory map. For instance, sensory qualia could correspond to gamma frequencies, in particular frequencies near 40 Hz; cognitive features to beta frequencies whereas alpha and theta and delta frequencies to the generation of the long term memories making possible the historical self. The frequencies involved with long term memory recall are expected to correspond to the time span of the memory characterized by the level of the dark matter hierarchy.

4. Objection against p-adic evolutionary hierarchy

If evolution corresponds to emergence of increasingly longer p-adic time scales in EEG, then the naïve application of ontogeny recapitulates phylogeny principle (ORP) suggest that

gamma, beta, alpha and theta bands should emerge in this order during the development. This is not the case.

(a) According to [**?**], the wake-up EEG of infants before 3 months age consists of "fast" background activity. At three months posterior delta rhythm appears at 3-4 Hz and gradually shifts to 6-7 Hz during the first life year. According to [**?**], binding related 40 Hz oscillations are evident at the age of 8 months. Also the contrast sensitivity of vision improves rapidly to adult level at this age: this conforms with the hypothesis that EEG is essential for the construction of the sensory representations.

(b) According to [E2], [E2], for infants the counterpart of the alpha band appearing in darkness is the occipital rhythmic activity in the range $5.2 - 9.6$ Hz with peak frequency at about 7 Hz and increases gradually. The frequency band $6.0 - 8.8$ Hz with gradually increasing peak frequency at about 7 Hz is activated during visual attention and seems to be the counterpart of sensory-motor rhythm of about 13 Hz of adults. It would be interesting to know whether the sensorimotor rhythm is eventually established via a continuous shift of this band or not.

A direct correlation between body size and frequency scale of the sensory-motor frequency band suggests itself. This might be understood if magnetic flux tubes in the somatosensory part of the sensory canvas get gradually stretched during the growth so that the increasing distances of the body extremities from head are coded by increasing magnetic transition frequencies.

This picture seems to contradict the idea about p-adic evolutionary hierarchy. In TGD framework one must however seriously consider the possibility that the lowest EEG bands relate with the higher level collective and multi-brained sensory representations. These higher level selves could be especially alert during sleep since the entire information processing capacity used for the sensory and motor activities during wake-up state would be freely available. This suggests also a resolution of the objection against p-adic evolutionary hierarchy.

The work of Jaynes inspires the idea about child as a small bicameral nursed by the higher collective levels of consciousness. The location of the sensory motor and alpha rhythms in theta band could indeed be seen as an indication for a kind of magnetic nursery provided higher level magnetic selves and their presence would not corresponds to the infant's consciousness but to the consciousness of the "magnetic nurse". Rather interestingly, according to Jaynes [**?**] sitting in mother's lap can induce EEG in infants not possessing stable EEG yet. An interesting question is whether mother's EEG shows a correlation with that of infant and whether it deviates from ordinary EEG in theta band.

The TGD based model of EEG to be discussed in detail later predicts that EEG consists of two copies so that ordinary alpha band has a scaled down copy around 5 Hz. The scaled down copy of EEG is predicted to dominate during sleep. The 7 Hz rhythm in the infant EEG could be interpreted as the scaled down counterpart of the sensorimotor rhythm identifiable in terms Na^+ cyclotron frequency. Infants would be in a state of consciousness analogous to sleep state as far EEG is considered: this of course conforms with the magnetic nursery hypothesis.

EEG rhythms in contrast to evoked and event related potentials

Evoked and event related potentials are believed to be associated with the neuronal activities generated by the sensory stimuli and it seems that they must be distinguished from the narrow frequency bands associated with the sensory and cognitive representations. Indeed, both evoked potentials associated with simple stimuli and event related potentials accompanying more complex stimuli have temporal structure which clearly reflects the propagation of nerve pulses along various parts of brain and one can assign to the peaks of the evoked potentials various a anatomical correlates in the neural pathways involved [**?**].

The time-scale systematics for the evoked and event related potentials conforms with the idea of self hierarchy. For instance, brain stem responds to simple auditory stimuli like clicks

in time scale is 10 ms: the corresponding frequency is 100 Hz, which is the dominating EEG frequency in brain stem. For cerebellum the corresponding rhythm is about 200 Hz and cerebellum indeed takes care of micro-temporal regulation of motor actions. For higher regions of brain the time scale of event related potentials is typically about 100 ms: this correspond to the time scale of 10 Hz and time scale of memetic code. For instance, at V4 activity starts 100 ms after the onset of the visual stimulus and is peaked around 135 ms.

A good example of an event related potential (ERP) is P300, which is a large positive amplitude ERP following an improbable target in the sequence of repeated target stimuli: P300 occurs with the latency of 300 ms for young adults and for simple stimuli. P300 is preceded by a negative potential called N2 which presumably corresponds to the conscious detection of the target stimulus whereas P300 probably represents the use of this information to update the model about world. N2 contains also information about novelty of the stimulus and the difference of N2 for standard stimulus and novel stimulus is called mismatch negativity.

Coherence of EEG and sensory canvas hypothesis

If the EEG measured at skull relates closely to the sensory representations, it must inherit high coherence from the high coherence of the sensory landscape. Also fractal like hierarchy is predicted. At higher frequencies associated with sensory representations in shorter length scales, coherence should be restricted in shorter range. Indeed, according to [**?**], the coherence length for EEG at skull is present and measured by using 10 cm as a natural unit. This coherence could reflect the correlations between neural activities in various parts of brain but it is not at all obvious whether the timing of neural ionic currents can be so sharp that destructive interference cancelling the correlations EEG level does not occur.

According to [**?**], very complex structures of coherence in bands around 3, 5 and 7 Hz and 13, 15 and 17 Hz are definitely inconsistent with simple dipole models for the generation of EEG patterns. The findings are however consistent with the view that several distant regions of cortex can project features to the same point of a sensory map and that the coherence reflects the coherence of the sensory map. Coherence regions could naturally correspond to the objects of the perceptive field. The high coherence in the band $4-5$ Hz during mental calculations [**?**], which certainly represent abstract information processing and involve also long term memory in an essential manner, supports the view that abstract long term memories correspond to lowest EEG bands at 3, 5 and 7 Hz. According to [**?**], also increase of coherence between prefrontal and posterior cortical association areas have been reported during working memory retention in the range $4-7$ Hz.

The coherence lengths for EEG inside cortex are generally much shorter and complex patterns are encountered. Coherence length of order 2 cm is associated with cortical EEG structures which Freeman introduces as basic units of EEG activity [E4] and calls mesoscopic level of sensory processing. Note that also retina has same size as the mesoscopic structures. Perhaps it is not accident that this length scale corresponds to the highest ionic cyclotron frequencies in Helium period.

EEG synchrony and negentropic entanglement

If one accepts the vision about life as something in the intersection of real and p-adic worlds 40 Hz EEG synchrony can be interpreted as a correlate for the generation of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) between cortical neurons. Before proposing this interpretation let us first describe the experimental findings of a finnish neuroscientist Antti Revonsuo [**?**].

1. Findings

The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [**?**]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of

random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. There could be also some time lapse between the unified percept and the report about it but probably this cannot explain the entire lapse. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [**?**]. Note that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [K35].

That the change in activity is associated with the emergence of a new percept suggests that the temporary increase of the EEG power could be assigned to the communications of the forming percept to the magnetic body.

2. Interpretation in terms of generation of negentropic entanglement

A fresh view about what really happens during 40 Hz synchrony came with the realization that negentropic entanglement is possible in the intersection of real and p-adic worlds. The generation of negentropic entanglement between two sub-selves means that the corresponding mental images are fused [K106, K59]. The process is experienced by the fusing sub-selves as an expansion of consciousness whereas consciousness is lost when when bound state entanglement is generated. Also the meditative states begin with enhanced 40 Hz activity and the interpretation would be same. Quite generally, the generation of negentropically entangled neuron groups could be a correlate for the emergence of a new idea or a new holistic pattern emerging from a chaos. Synchronous firing would be a natural correlate for the synergic state resulting in this manner. The paradoxical looking reduction of the oxidative metabolism associated with 40 Hz firing could be seen as a signature of reduced dissipation when dissipating ensemble of neurons forms a single quantum coherent system.

What could then be the interpretation of the 300-500 ms time scale and synchronous firing in TGD framework?

(a) If one assumes that only brain is involved, one must answer whether the new percept emerges after such a long time period. One would naïvely expect that negentropic entanglement immediately gives rise to the percept. Negentropic entanglement however means that a quantum superposition of several alternative percepts is involved. In the beginning the new percept is present with only small probability so that one would only know that the moment of eureka is quite near (this is indeed the experience that one has) and in the final situation it dominates but not completely since it requires conscious effort to preserve the percept.

(b) Also magnetic body should be involved in TGD framework. The natural question is "Why this synchronous neuronal firing?". The natural answer would be that it allows to communicate the new percept as a consequence of a generation of negentropic entanglement to the magnetic body. The frequency scale of 40 Hz corresponds to a time scale of 25 milliseconds and corresponds to a length scale involved is about $.75 \times 10^7$ m, a good candidate for the size of the part of the magnetic body involved. This time scale is much shorter than 300-500 seconds. If the layer of the magnetic body in question corresponds to the fundamental 100 millisecond time scale assignable to electron as is natural in case of sensory percepts, the time lapse could be essentially due to the communication. If one takes the time scale literally the value of Planck constant which is about 3 to 5 larger than its standard value would suggest itself. Of course, the development of the percept from a fuzzy inkling to the final eureka could involve several communication loops between brain and magnetic body so that the interpretation as a lapse due the slowness of communications need not be inconsistent with the first interpretation.

(c) The time scale 300-500 ms could characterize the duration of negentropic entanglement but this is not necessarily the case since negentropic entanglement would be un-necessary after the percept has been represented symbolically so that one knows what is lurking behind the chaos.

Narrow EEG bands and sensory canvas hypothesis

Sensory canvas hypothesis predicts the existence of narrow EEG bands corresponding to the magnetic transition frequencies varying in the range determined by the thickness range for the magnetic flux tubes involved with the sensory representation. The most natural candidates for the magnetic transition frequencies are cyclotron frequencies and their harmonics. There is indeed evidence for this kind of bands [?].

(a) The best known band is alpha band around 11 Hz and has width of order 1 Hz. From this one can conclude that the relative variation of the magnetic field along magnetic flux tubes and thus magnetic flux tube area in the radial direction is roughly 10 per cent so that the radius would vary about 3 per cent. The fact that alpha band at 11 Hz becomes active when eyes are closed is consistent with the interpretation that alpha band corresponds to cyclotron frequencies of bosonic ions and to the motor control by rather than sensory communications to the magnetic body. The activation of the alpha band is also associated with the generation of meditative and "creative" states of mind. Hence one cannot exclude the possibility that alpha band activation corresponds to the projection of some information to the possible multi-brained sensory/cognitive representations associated with higher level collective selves.

(b) Besides alpha band Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as sub-bands at 13, 15 and 17 Hz in beta band [?]. That beta disappears when eyes are closed conforms with the interpretation of these bands as being associated with sensory communications to the magnetic body. Hence these bands might be associated with the assignment of cognitive features to the points of the sensory canvas. Indeed, the evolutionary hierarchy sensory representations→ cognitive representations→ long term memories involving time like entanglement and making possible historical self, suggests this.

(c) 40 Hz band has a width of about 8 Hz, contains several cyclotron frequencies, is associated with the primary sensory areas and disappears during sleep. This suggests that also this band is involved with the projection of the sensory qualia to the sensory canvas. The information about narrow sub-bands of EEG during hypnagogic states (the state between wake-up and sleep involving sensory hallucinations), during the schizophrenic hallucinations and hallucinations generated by sensory deprivation, and during lucid dreaming could provide interesting constraints on the possible sensory quale-EEG frequency correlations.

(d) A well motivated guess is that 3, 5 and 7 Hz bands do not correspond directly to the sensory qualia experienced by our magnetic body. Hippocampal theta band (which actually extends from about 4 to 12 Hz) could contain these narrow bands and be involved with the assignment of abstract features, such as concepts and verbal associations and emotions, to the sensory map crucial for the memories. The fact that alpha and theta waves are important during this period suggests that alpha and theta frequencies are involved with the generation of episodal memories.

Whether the same frequency must be present during memory recall as during the generation of the memory, depends on the model of memory recall. According to the simplest model, memory recall means that an object in the sensory canvas of the geometric past is activated and temporal quantum entanglement mechanism allows us to share the experience. This does not require that the EEG frequency involved with sensory projection is generated in the brain which remembers. Of course, the formation of memory about recalled memory could generate this frequency.

2.3.3   How To Test The Sensory Canvas Hypothesis

In this subsection some tests for the new vision about sensory canvas hypothesis are proposed and some astrophysical phenomena possibly supporting the basic assumptions behind the new view are considered. The magnetospheric sensory representations associated with Mother Gaia, as opposed to the sensory representations realized at the personal magnetic body, are discussed in [K53].

Some simple tests

One could try to disturb the magnetic flux tubes or MEs responsible for the projection of the visual map to the external world *outside* the body somehow. If the visual experience is modified dramatically, one has an experimental argument supporting the new view. One could perhaps induce also magnetic quantum phase transitions outside the body by stimulating the super-conductors at magnetic transition frequencies and perhaps generate in this manner visual hallucinations. One could generate weak magnetic fields of roughly the same strength as the fields associated with the magnetic canvas and thus superposing with them. Slow modulations of the magnetic fields in these flux tubes might be possible so that cyclotron frequency scale changes and the objects of the perceptive field would be experienced to either contract or expand. Unfortunately (from the point of view of empirical testing), if sensory images are of order ME wavelength $L = c/f$, the sensory images might be extremely stable against perturbations.

One could also study what happens for the vision if the magnetic materials in brain or retina are not present in normal amounts. Or what happens when there is external magnetic field perturbing the magnetic field of Earth inside retina or cortex so that the compass defining the inertial reference frame does not function properly. Does this lead to a sensations associated with dizziness? Could the removal of Earth's magnetic field induce this kind of sensations or affect the visual experience? Probably this is not the case. The general model for EEG predicts that the magnetic flux quanta carrying dark matter responsible for sensory representations and motor control are present even if Earth's magnetic field is cancelled.

Tests for place coding

The hypothesis that EEG frequencies in narrow EEG bands code for the distance of an object of perceptive field can be tested. If subject person directs attention to a moving object of the perceptive field, the peak frequencies inside the narrow EEG bands responsible for the place-coding should shift. The detection of EEG activity in V1 when percept changes in binocular rivalry would support the existence of strictly non-neural correlates of visual consciousness. Negative energy MEs are responsible for the entanglement, and one must ask what it is to detect negative energy MEs. MEs generate coherent light and phase conjugate laser waves at ELF frequencies are what comes in mind first. It is not at all obvious to me how one could observe these. The breakdown of second law in appropriate time scale might be one correlate for the presence of negative energy MEs.

How to test the hypothesis that primary sensory representations occur at the level of sensory organs?

That retinas are involved with the attention is known for some time: directing the attention to an object of the visual field does not necessarily imply directing the gaze to the object [**?**]. The amplification of the back-projections from frontal lobes to the part of retina in question is enough, and if the feedback exceeds a critical value the direction of the gaze is changed. This suggests that the mental image of the object of the perceptive field is realized at the retina and corresponding magnetic body and directing of attention to it feeds metabolic energy to this mental image. If the fundamental visual representation occurs at the level of retinas, the selection of the visual percept in the visual rivalry might be detectable at the level of retinas.

80 Hz frequency is known to be associated with retinas, and one can wonder whether this would determine the size of the magnetic body associated with retina (the size would slightly below Earth radius!). It would be worth of testing whether the pattern of 80 Hz activity associated with retinas correlates with the selection of the sensory percept say in the case of sensory rivalry: certainly this is not what standard neuroscience would suggest but would be worth of testing.

2.4 Could brain be represented as a hyperbolic geometry?

There are proposals that neuronal systems in brain could have hyperbolic geometry [**?**] (`http://tinyurl.com/ybghux6d`) in the sense that neurons could be mappable to a 2-D lattice like structure representable in terms of to 2-D hyperbolic geometry H^2. A concrete identification as a lattice-like structure in H^2 would not be in question.

2.4.1 A concrete representation of hyperbolic geometry cannot be in question

The tessellations of P^2 represented as Poincare disk have large density of points near the boundary. The concrete geometry of the cortex could very roughly correlate with the geometry of near the boundary of Poincare disk or even boundary sphere of 3-D Poincare ball representing 3-D hyperbolic space H^3. A rather abstract representation based on statistical properties of the network formed by the neurons would be in question. If a genuine geometric representation as a tessellation of hyperbolic space exist it must be realized somewhere else than brain.

To see what is involved, note that the line element of Poincare disk is given by

$$ds^2 = d\eta^2 + sinh^2(\eta)d\phi^2 \ \ .$$

to be compared with the line element of ordinary disk given by

$$ds^2 = d\rho^2 + \rho^2 d\phi^2 \ \ .$$

For given neuron the size of the radial coordinate η of Poincare disk would correspond roughly to the number of connections it has, kind of popularity. For large values of radial coordinate η the circles of Poincare disk have radius proportional to η and circumference proportional to $sinh(\eta)$ increasing exponentially for large values of η whereas for ordinary disk both radial distance circumference would be proportional to ρ.

For the neurons of cortex, in particular pyramidal neurons, the image points would have large distance from the origin of hyperbolic space. The image points for neurons resembling each other would have small distance with respect to the angular coordinate of the Poincare disk. Since similar neurons can have large distances from each other at the level of brain, the representation must involve a map taking them close to each other.

2.4.2 Hyperbolic geometry and its tessellations

The standard representations for 2-D hyperbolic geometry are 2-D Poincare plane (`http://tinyurl.com/y8tnklz6`) and Poincare disk (`http://tinyurl.com/y8bcd6cv`). Poincare disk is claimed to be natural representation space for the lattice like structure of neutrons. These lattice structures of H^2 are known as tessellations.

Remark: There is a painting of Escher visualizing Poincare disk. From this painting one learns that the density of points of the tessellation increases without limit as one approaches the boundary of the Poincare disk.

The group $SL(X)$, $X = C, R$, consists of matrices $[a, b; c, d]$ with $a, b, c, d \in X$ satisfying $ad - bc = 1$. The modular group $SL(2, Z)$ acts subgroup of both $SL(2, C)$ and $SL(2, R)$. $SL(2, C)$ *resp.* $SL(2, R)$ forms a double covering of Lorentz group $SO(1, 3)$ *resp.* $SO(1, 2) = SL(2, R)$. $SL(2, C)/SU(2) = SO(1, 3)/SO(3)$ defines 3-D hyperbolic geometry H^3 realized as $a = \sqrt{t^2 - x^2 - y^2 - z^2} = constant$ hyperboloid of future light-cone M_+^4 having $SO(1, 3)$ as isometries. $SL(2, R) = SO(1, 2)$ acts as isometries of H^2 realizes as hyperboloid of M_+^3. $SL(2, C)$ *resp.* $SL(2, R)$ acts as complex *resp.* real Möbius (conformal) transformations $z \rightarrow (az + b)/(cz + d)$, $ad - bc = 1$, of complex plane *resp.* upper half plane.

The modular group $SL(2, Z)$ acting as the subgroup of $SL(2, R) \subset SL(2, C)$ consists of matrices $[a, b; c, d]$ having integer valued elements satisfying $ad - bc = 1$. Alternative definition identifies the elements differing by sign (https://en.wikipedia.org/wiki/Modular_group) is a basic example of infinite discrete sub-group.

Modular group is representable as a free product $Z_2 * Z_3$ with generators S *resp.* T subject to relations $S^2 = I$ and $(ST)^3 = I$. Modular group has braid group B_3 of 3 braids as a universal covering group. Modular group has an infinite number of congruence subgroups $\Gamma(N)$ as subgroups. The diagonal elements of $\Gamma(N)$ satisfy $a \ mod \ N = d \ mod \ N = \pm 1$ and $c \ mod \ N = d \ mod \ N = 0$ so that the matrices are equal to $\pm I$ modulo N. There is also a hierarchy of subgroups $\Gamma_0(N)$ for which matrices are upper triangular matrices modulo N.

In TGD one has also p-adic length scale hierarchy with preferred p-adic primes $p \simeq 2^k$. Therefore the groups $\Gamma(p^n)$ are of special interest in TGD framework.

If replaces N with an extension of rationals, one obtains huge hierarchy of subgroups expected to be relevant in TGD framework. One can define the notion of integer also for the extensions of rationals. Algebraic integer is defined as a root of a monic polynomial $P_n = x^n + ...$ with integer coefficients. Also the counterparts of the groups $\Gamma(N)$ can be defined, in particular those associated with $N = p^n$.

H^n, $n = 2, 3$ allows infinite number of tessellations as left coset spaces $G \backslash H^n$ of $H^n = SO(1, n)/SO(1, 1)$. G is here some infinite discrete subgroup $G \subset SO(1, n)$ of $SO(1, n)$ such as $\Gamma(N)$. For ordinary sphere S^2 the analogs of tessellations are finite lattices and correspond to Platonic solids - tetrahedron, octahedron and cube, and icosahedron and dodecahedron. tessellations would therefore define hyperbolic analogs of Platonic solids.

The groups $SL(2, Z)/Z_N$ are finite groups. For $N = 3$ one obtains tetrahedral group and $N = 5$ gives icosahedral group. Both groups play central role in TGD inspired model of genetic code [L12, L73] but their origin has remained unclear. $\Gamma(N)$ is a normal subgroup $SL(2, Z)$ so that the coset space is group too: $SL(2, Z)/\Gamma(N) = SL(2, Z_N)$. One can represent the elements of group algebra $G(SL(2, Z))$ of $SL(2, Z)$ as entangled elements in the tensor product of $G(SL(2, Z)/\Gamma(N))$ and $G(SL(2, Z_N))$. Number theoretic state function reduction as a "small" state function reduction (SSFR) for elements of $G(SL(2, Z)))$ would project them to unentangled products of elements of $G(SL(2, Z)/\Gamma(N))$ and $G(SL(2, Z_N))$. Maybe genetic code could relate with $\Gamma(N)$ with $N = 3$ and $N = 5$.

2.4.3   Could magnetic body provide a concrete geometric representation for the tessellation of hyperbolic space?

In TGD framework magnetic body (MB) having an onion-like structure and carrying dark matter as ordinary matter labelled by effective Planck constant $h_{eff} = nh_0$, where n corresponds to the dimension of extension of rationals serving as a kind of IQ. Various quantum scales, in particular quantum coherence length are expected to be proportional to n so that algebraic extensions of rationals define an evolutionary hierarchy with levels labelled by the dimension of extension. Space-time surface for given value of n can be regarded as a covering spaces with n sheets related by the action of Galois group of Galois extension acting as symmetry.

The question is whether one could generalize the hypothesis [?] (http://tinyurl.com/ybghux6d) in TGD framework. In the sequel such a generalization replacing 2-D hyperbolic

space with its 3-D counterpart and assuming that the hyperbolic tessellation is associated with MB of brain or of its subsystem considered. This generalization reduces to P^2 if one restricts P^3 to subspace P^2 and restricts $SL(2,C)$ ($SO(1,3)$) as symmetry to cylindrical symmetry $SL(2,R)$ ($SO(1,2)$). Cylindrical symmetry is natural to magnetic flux tubes and cylindrical magnetic flux sheets so that P^2 option might be more natural.

The notion of MB is extremely general and makes sense in all scales, and one can consider the possibility that the hyperbolic tessellations could provide a kind of universal for the MB of system responsible for cognitive representations.

2.4.4 Could regions of brain be mapped to tessellations of 3-D hyperbolic space defined by magnetic body?

The question is whether some 3-D lattice-like structures formed by neurons of brain or its sub-system could correspond to tessellations of 2-D or 3-D hyperbolic space H^3 realization as cognitive representations at the MB of brain having hierarchical onion-like structure correlating with hierarchical structure of brain. The tessellation would be defined by an infinite discrete subgroup G of $SL(2,C)$ such that elements are algebraic integers in the extension of rationals. The unit cells of the tessellation would be labelled by elements of G and would therefore define cognitive representation.

One can consider two basic options. Brain or its substructure as 3-D structure is mapped

(a) either to a tessellation of H^3 at which $SL(2,C)$ acts as isometries,

(b) or to a cylindrically to a tessellation of H^2 at which $SL(2,R)$ acts as isometries represented as upper half-plane or as Poincare disk where the action is as conformal transformation. One can consider also mapping to a complex plane compactified to Riemann sphere at which $SL(2,C)$ acts: now the action is however not as isometries but conformal transformations.

The interpretation could be in terms of symmetry breaking selecting time axis and spin quantization axis as direction of cylinder.

Some basic facts

Consider first some basic facts about the possible role of 3-D hyperbolic space and its tessellations in TGD.

(a) 3-D hyperbolic space H^3 representable as hyperboloid $t^2 - x^2 - y^2 - z^2 \equiv t^2 - r_M^2 = a^2$. a has interpretation as light-cone proper time and in TGD inspired cosmology it corresponds to cosmic time. 2-D hyperbolic space could be seen as subspace of H^3. Now infinite discrete subgroups of $SO(1,3)$ would define tessellations as lattice-like structures. They would serve as 3-D analogs of Platonic solids. I have proposed [K58] that they could explain the astrophysical objects a located along lines with redshifts coming as multiples of a basic redshift in terms of lattice-like structures in cosmic scales.

(b) Brain region itself cannot correspond in any manner to a region of H^3 represented as $a = constant = a_0$ hyperboloid. MB of brain region might however do so. The mapping of brain region to the hyperboloid $a = a_0$ could be mediated by gravitational magnetic flux tubes which can be radial since the Kähler flux vanishes in good approximation and there is no conserved monopole flux. Only the cognitive representation as discrete points in extension of rationals would correspond to points of the hyperboloid.

If MB participates in cosmological expansion assignable to CD, its size would scale up like a as also the cognitive representation associated with the tessellation, whose points would be labelled by discrete infinite subgroup G - say congruence group $\Gamma(N)$ for extension of rationals. In ZEO this means that the part of tessellation inside CD would approach to the boundary of CD (or cd). The finite size of CD would however prevent the expansion to values of $a > T$, T is the size of CD define as the maximal radius of the

intersection light-cones involved. It would also prevent MB from reaching the boundary of CD. One cannot therefore exclude cosmic expansion of MB.

(c) One can challenge the assumption about cosmic expansion of MB. Quite generally, all known astrophysical objects participate in cosmological expansion by receding from each other as the cosmic redshifts show but do not experience cosmological expansion themselves. TGD solves this paradox by the assumption that cosmic expansion takes place as quantum phase transitions in which expansion occurs in rapid jerks, which correspond to reductions of length scale dependent cosmological constant Λ by a power of 2 if p-adic length scale hypothesis is accepted [L77] .

There is evidence that even Earth has experienced this kind of expansion during Cambrian Explosion, which would have increased the radius of Earth by factor 2 [L62]. This would have been also a giant step in biological evolution as the multicellular life developed in the Earth's interior would have bursted to the surface of Earth and oceans would have formed. An interesting question inspired by the fractality of TGD Universe is whether one could see also the biological growth and development of organs and organelles as sequences of this kind of phase transitions.

This situation might hold true also for MB so that also it should evolve by rapid jerks as the value of Λ is reduced.

(d) In TGD space-times are surfaces in $M^4 \times CP_2$. In zero energy ontology (ZEO) they are 4-surfaces in causal diamond (CD), where one has $= cd \times CP_2$, where cd is diamond-like intersection of future and past directed light-cones.

For light-cone M_+^4 one has a natural slicing is by using the hyperboloids $a = constant$. This slicing would define a natural time coordinate as analog of cosmic time. The usual linear Minkowski coordinates define a second natural natural slicing by $t = constant$ sections, where t is the linear Minkowski time.

One can define the standard hyperbolic coordinates of M_+^4 by the line element

$$ds^2 = da^2 - a^2(d\eta^2 + sinh^2(\eta)d\Omega^2) \ .$$

$d\Omega^2 = d\theta^2 + sin^2(theta)d\phi^2$ is the line element of unit sphere S^2. η is the hyperbolic angle identifiable as analog of ordinary angle and having expression

$$tanh(\eta) = \frac{r_M}{t} \equiv \beta$$

having an interpretation as velocity $\beta = v/c$ n radial direction satisfying $\beta \leq 1$: one has $t = acosh(\eta)$ and $r_M = asinh(\eta)$.

About the precise correspondence between 3-D surfaces and H^3

What could the precise correspondence between 3-D surface giving rise to a cognitive representation of MB and tessellation of H^3 be?

(a) The space-time surface representing MB is not hyperbolic space itself but could in some sense have discrete subgroup of $G \subset H^3$ as its symmetries: a possible interpretation would be as cognitive representations [L84, L74] consisting of points of H with coordinates in extension of rationals defining the adele [L52, L51]. The lattice-like structure associated with 3-surfaces could be mappable to this kind of hyperboloid for some value of a.

Could the part of MB representing sub-system of brain in question be seen as an intersection of the with $t = T$ section of M_+^4 with the slicing of M_+^4 by $a = constant$ hyperboloids such that magnetic images of neurons as points of the tessellation of H^3 defining cognitive representation would belong to the intersection? For $t > T$ the 3-D structure would be preserved in good approximation.

(b) The usual time=constant snapshot in M_+^4 satisfying $t = T$ intersects the hyperboloids with $0 \leq a \leq T$. The condition $t = acosh(\eta) = T$ gives $a = T/cosh(\eta)$ so that a indeed varies in this range. This gives for the radial M^4 coordinate $r_M = asinh(\eta) = Ttanh(\eta)$ giving $r_M \leq T$.

It seems that this projection is 3-D analog of Poincare disk as a "Poincare ball" of radius $r_M \leq T$ with at least analog of hyperbolic geometry. At least the density of intersections with hyperboloids increases as one approaches light-cone boundary since the density of hyperboloids increases.

(c) A tessellation of H^3 corresponds to the points $\{(asinh(\eta_n), \Omega_n)\}$. The lattice-like structure in E^3 for $t = T$ would correspond to points (r_M, Ω) in $\{Ttanh(\eta_n), \Omega_n\}$. The difference from the representation hyperbolic geometry as H^3 is that instead of $r_M = asinh(\theta_n)$ for H^3 one has $r_M = Ttanh(\eta_n)$ for the analog of Poincare disk. For small values of η one has $sinh(\eta) \simeq tanh(\eta)$ but not for large values so that E^3 is compressed to Poincare ball B^3.

Neurons with large number of connections would correspond to points of tessellation with large values of η_n and similar neurons even if far away from each other would be mapped near to each other at spheres $\eta_n =$ constant surfaces (spheres for H^3 or circles for H^2).

The discrete geometries for the magnetic image of neural sub-system as tessellations would naturally correspond to discrete subgroups of $G \subset SO(1,3)$ as analogs $G\backslash H^3$ of Platonic solids. As found, there is infinite number of them and concordance groups $\Gamma(N)$ ore of special interest. One obtains also their 2-D variants as 2-D planar slices consistent with the symmetries just like one can have 2-D lattices as sub-lattices of 3-D lattices in E^3.

Remark: The elements of subgroup $G \subset SL(2,C)$ for given extension of rationals provide natural coordinates for the unit cells of tessellation, and can be used instead of $\{\eta_n, \Omega_n\}$.

(d) The system could have a finite size due to finite light-velocity if it has resulted in an event analogous to Big Bang like event (TGD predicts a hierarchy of cosmologies within cosmologies and cd is geometrically analogous to Big Bang followed by Big Crunch). This option does not however look plausible at the level of visible bio-matter. At the level of MB this could be make sense and correspond to the emergence of a new onion-like layers to MB bringing in new scale of quantum coherence as CD.

In the case of MB one can estimate the T from the assumption that EEG corresponds to communications between brain and particular layer of its MB. Schumann frequency 7.8 Hz corresponds to wavelength of $\lambda = 2\pi R_E$, R_E Earth radius. EEG alpha band is around 10 Hz and corresponds to a slightly shorter wave length lengths. If this frequency is realized as cyclotron frequency the corresponding part of MB should be of the order of Earth size. This would give $R \sim R_E$ and $T \leq R/c \leq .1$ s. The part of neuronal system considered could be the above described intersection corresponding to time $t = T$. After this no expansion would take place and the 3-D analog of Poincare ball would be preserved.

Note that if MB would participate in cosmic expansion, one would expect that the frequency scale of EEG scales down like $1/a$, which is not observed. Different bands of EEG could however correspond to different values of $a = a_0$ defining different layers of MB.

The neuronal network has been assumed to be accompanied by flux tube network with flux tubes parallel to axons defining the "small" part of MB with size of order body size [L42, L61]. How the topology of this network correlates with the topology of the "large" part of MB with layers having size scales even larger than Earth size? Could the "small" networks at the level of biological body be representations of the "large" networks at the level of MB - or vice versa.

The higher level representations would re-organize the nodes of "small" flux tube networks by various criteria such as the number of connections to other nodes. Similar nodes - even

distant ones - would correspond to points near to each other. Therefore similar neurons could be treated as coherent units with coherence induced from that at higher level. Synchronous firing would be the signature for nearness at the higher level. The hierarchy of layers of MB would perform basically classification of the objects of the system at the lowest level.

There is a huge number of possibilities for the cognitive representations corresponding to various values of N (in particular powers preferred prime p) labeling $\Gamma(N)$, to hierarchy of extensions of rationals and the values of T possibly identifiable as roots of polynomials defining representation of layer of MB in M^8. Therefore one can hope that this vision could provide universal view about the anatomy of MB in relation to that of biological body (in very general sense).

The interpretation of the hyperbolic tessellations of neurons in terms of ZEO, $M^8 - H$ duality, and cognitive representations

This picture suggests an interesting connection to TGD based view about quantum measurement theory [L86], which actually extends physics to a theory of consciousness. Causal diamonds (CDs) have a key role in ZEO and hyperbolic geometry is very naturally associated with them. The notions $M^8 - H$ duality [L82, L80] could provide an explanation for the special value $t = T$, and tessellations could correspond to a particular cognitive representation [L84].

(a) In zero energy ontology (ZEO) replacing ordinary ontology of quantum theory the notion of causal diamond (CD) plays a central role. CDs for a length scale hierarchy and CDs have sub-CDs. Space-time surfaces for given CD have ends at the upper and lower boundary of CD. In this picture the appearance of hyperbolic geometry at the level of MB would be very natural.

(b) $M^8 - H$ duality [L82] states that space-time surfaces could be regarded either as algebraic surfaces in M^8 or as preferred extremals of action in $H = M^4 \times CP_2$ reducing to minimal surface satisfying infinite number of additional conditions. Otherwise the consistency of dynamics in H dictated by partial differential equations with algebraic dynamics in M^8 dictated by algebraic equations would not be possible.

One can say that space-time surfaces are roots of an octonionic polynomial obtained as an algebraic continuation of a real polynomial with rational coefficients to octonionic polynomial. This in the sense that either imaginary or real part of P in quaternionic sense vanishes and gives rise to 4-D surface in the generic case.

(c) A special prediction of M^8 picture is that besides 4-D surfaces as roots of algebraic equations also 6-D special brane-like solutions with topology of 6-sphere S^6 are possible. For these solutions both real and imaginary parts vanish. These solutions have counterparts in H, and their intersection with cd is $t = r_n$ ball, where r_n is the root of P.

(d) I have called the moments $t = r_n$ "very special moments in the life of self" identified as evolution of zero energy state of self by "small" state function reductions (SSFRs) as analogs of weak measurements. Also the size of CD increases in this process in statistical sense and corresponds to the increase of clock time as a natural correlate of subjective time defined by the sequence of SSFRs.

(e) Could the state of neuron system at $t = T$ correspond to $T = r_n$ as a root of polynomial P? Could these special moments correspond to rapid jerks in the cosmological expansion so that also the development of living organism would involve a sequence of them increasing the value of Λ. Presumably these jerks would occur at the level of MB and possibly induce those at the level of biological body. At the level o MB they could also correspond to a phase transition like events in the evolution of consciousness involving scaling up the size of MB.

To summarize, the tessellations of H^3 or $E^1 \times H^2$ suggest a universal cognitive representations realized at the MB of the system. One would have hierarchy of p-adic length scales and

extensions of rationals giving rise to hierarchies of tessellations defining cognitive representations at corresponding layers of MB. Living matter would be only a special case. In living matter EEG would define important hierarchies of tessellations but also other frequency ranges would do so.

2.4.5 Empirical support for MB as a carrier of information about state of BB

If the view about hyperbolic brain and body is true, an abstract plan of brain and BB would be realized at MB. There are several findings supporting this view and in the following two examples are described.

Salamander recovers after shuffling of its brain

In the lab, the neurons of the brain of a salamander were shuffled like a pack of cards. The salamander however recovered and preserved its memories (identified as learned behaviors) [**?**]. In [K76, K78] this finding was considered as a support for the view that the brain is analogous to a hologram (TGD Universe can be seen as a conscious hologram [K14]). It seems, however, clear that a single neuron cannot represent the information content of the entire brain. However, if memories are represented by the images of neurons at the level of the MB, the shuffling of neurons has no effect on memories as the experiment indeed demonstrated. Neurons would be analogous to RAM in computer science.

A chordate able to regrow all of its organs if dissected into three pieces

The popular article "Polycarpa mytiligera can regrow all of its organs if dissected into three pieces" `https://cutt.ly/SndWg8l` tells about an extraordinary biological discovery.

The creature known as Polycarpa mytiligera is a marine animal commonly found in Gulf of Eilat that is capable of regenerating its organs. The surprising discovery was that the animal can regenerate all of its organs even when dissected into three fragments.

Such a high regenerative capacity has not been detected earlier in a chordate animal that reproduces only by sexual reproduction. In the experiment, the researchers dissected specimens in a method that left part of the body without a nerve center, heart, and part of the digestive system. Not only did each part of the creature survive the dissection on its own, all of the organs regenerated in each of the three sections.

This is highly interesting challenge for TGD. The information about the full animal body was needed for a full generation. How it was preserved in dissection? Was genetic information, as it is understood in standard biology, really enough to achieve this?

(a) In TGD inspired quantum biology magnetic body (MB) carrying dark matter as $h_{eff}/h_0 = n$ phases is the key notion. h_{eff} is an effective Planck constant defining the scale of quantum coherence. n is dimension of extension of rationals defined by a polynomial defining space-time region, and serves as a measure for algebraic complexity and serves as a kind of IQ. MB with high IQ defined by n serves as the master of BB controlling it and receiving information from it. The layers of MB also define abstracted representations of BB.

(b) If BB suffers damage, the information about BB is not lost at MB and MB, which carries abstracted representations about BB and able to control BB, could restore BB partially. Healing of wounds would be the basic example. A more dramatic example about healing was discovered by Peoch: the neurons of the salamander brain can be shuffled like cards in a package but the animal recovers.

Indeed, since nothing happens to the MB of salamander or Polycarpa Mytilera, recovery is in principle possible. The new finding gives additional support for MB as a carrier of the biological information.

One can also make questions about the recovery process itself. Could recovery be seen as a self-organization process of some kind?

(a) In the TGD framework, quantum measurement theory relies onzero energy ontology (ZEO) and solves its basic problem. The basic prediction is that in the TGD counterparts of ordinary state function reductions ("big" SFRs or BSFRs) time reversal takes place. In small SFRs (SSFRs) identifiable as analogs of "weak" measurements, the arrow of time is preserved. ZEO makes it also possible to understand why the Universe looks classical in all scales although BSFRs occur in all scales at the dark onion-like layers of MB controlling the lower layers with ordinary biomatter at the bottom of the hierarchy.

(b) Time reversed dissipation after BSFR looks like self-organization from the perspective of the outsider with a standard arrow of time, called it briefly O, and would bea basic self-organization process in living systems. In dissipation gradients disappear but in time-reversed dissipation they appear from the perspective of O.

(c) This makes possible also self-organized quantum criticality (SOQC), which is impossible in standard thermodynamics because criticality by definition means instability. The change of the arrow of time changes the situation from the perspective of O since the time reversed system tends to approach the criticality. Homeostasis would rely SOQC rather than on extremely complex deterministic control programs as in the computerism based picture. Change the arrow of time for a subsystem and let it happen. Very Buddhist approach to healing!

(d) The change of the arrow of time would be also central in the healing processes and also regeneration.

2.5   DMT experiences and hyperbolic geometry

I received a link to a highly inspiring talk about a modelling of DMT induced experiences in terms of 2-D and more generally 3-D hyperbolic geometry. The title of the talk (see `https://zpr.io/7Bzbagjrk7LE`) was "DMT and Hyperbolic Geometry"". The talk was by a person using the name "Algekalipso" and I understand that the person in question is Andres Gomez Emilsson. The organization in question is Qualia Research Institute (`https://cutt.ly/fG05D9W`). There is also article by Emilssson (`https://cutt.ly/YG05Qrk`) with essentially the same content.

2.5.1   Can one characterize DMT experiences by using temperature like parameters

The question posed in the beginning of the talk was whether there could exist parameters analogous to temperature allowing a general qualitative understanding of the nature of the DMT and more general psychedelic experiences. The proposal was that the DMT experience could be characterized by two parameters.

(a) The first parameter characterizes how "hyperbolic" the visual field is and is identifiable as the curvature of the hyperbolic space. The idea is that during a DMT trip the experienced 3-space is not Euclidean but hyperbolic. This kind of geometry has been proposed as an effective statistical geometry of the brain in which functionally similar neurons distant from each other are close to each other [L98].

In the TGD framework, this effective geometry could correspond to a real hyperbolic geometry of 3-D hyperbolic space playing a key role in TGD and assignable naturally to the magnetic body (MB). Besides ordinary visual input also the projection of objects of H^3 to the usual Euclidean space E^3 would be experienced so that the experience would be "multiverse" experience.

In the TGD Universe, the space-times are minimal surfaces apart from singularities analogous to frames of soap films [L132] and their basic aspect is local saddle point property possessed also by hyperbolic spaces. Maybe DMT experiences make it possible to visually perceive 3-surfaces as objects in H^3. Also the usual vision corresponds to hyperbolic vision but with a small value of the H^3 curvature.

(b) The second parameter would characterize the complexity of the experience and could in the TGD framework correspond to algebraic complexity associated with the extension of rationals determined by the polynomial determining a given space-time region by $M^8 - H$ duality [L95, L96].

The value $h_{eff} = nh_0$ of the effective Planck constant, which can be larger than h, would correspond to the dimension n of the extension of rationals and serve as a universal IQ. Dark matter would correspond to phases of ordinary matter with $h_{eff} \neq h$.

As the IQ increases, the experience transforms from simple to complex and eventually chaotic since the experiencer is not able to make sense of it. Under some assumptions this would relate to the formation of Julia set type fractals.

The model also leads to a progress in the interpretation of TGD. In particular, a geometric interpretation of p-adic length scale hypothesis [K64, K55] suggesting that p-adic length scale is accompanied by much shorter length scale of order CP_2 length scale finds an interpretation: p-adic length scale would correspond to the Euclidian scale defined by a hyperbolic length scale naturally emerging for hyperbolic tessellations.

2.5.2 TGD based model for DMT experiences

I have already earlier developed a TGD based model [L98] for the finding that the brain seems to obey an effective statistical geometry which is hyperbolic in the sense that neurons which are functionally near to each other have a short distance in this geometry. In the sequel a TGD based model for DMT experiences relying on hyperbolic geometry and based on the ideas already outlined is developed.

About hyperbolic spaces

First some mathematical background.

(a) Hyperbolic 3-space H^3 is a generalization of 1-D hyperbola of 2-D space-time as a curve defined by condition $t^2 - x^2 = a^2$ but with its metric being induced from the 2-D Minkowski metric $ds^2 = dt^2 - dx^2$. By performing all possible rotations of this 1-D hyperbola one obtains H^3.

(b) In particle physics H^3 corresponds to mass shell $E^2 - p^2 = m^2$ and in cosmology to cosmic time identifiable as $a^2 = t^r - r^2$ in $M^4 \subset M^4 \times CP_2$. a defines Lorentz invariant cosmic time and is therefore analogous to absolute time invariant under Lorentz boosts which do not affect the tip of the light-cone. It is not invariant under translations however.

In the TGD framework H^3 has a central role and plays a key role also in the model of the brain involving the notion of magnetic body (MB). One could say that cognitive and sensory representations are realized at the intersection of MB with H^3.

(c) The value of cosmic time a characterizes the curvature of H^3. The curvature is proportional to $1/a^2$ and the smaller the value of a, the larger the curvature and "hyperbolicity". As a decreases, one approaches the analog of the Big Bang with infinite curvature. As a increases, one approaches flat E^3 in an infinite future. Cosmic evolution proceeds from the Big Bang to the future whereas DMT trip would be a travel towards the moment of Big Bang. One can of course ask whether trips could also be in the opposite time direction.

(d) The lecture (see also the written version) contains a nice description of hyperbolic geometry. In particular, the volume of a ball in H^3 increases exponentially as a function of its radius and this means that H^3 has a lot of volume. This might be very relevant for memory storage. This can be easily understood from the visualization in terms of real hyperboloid.

(e) The counterpart of plane E^2 of E^3 in H^3 is 2-D hyperbolic space H^2 and Poincare sphere gives a good view about what the projections of the tessellations of H^2 look like when projected to E^2. The radial size for the basic unit of tessellations decreases with the distance from the origin whereas the region around the origin looks like E^2.

Note that one particular tessellation, known as icosa-tetrahedral tessellation, plays a key role in the TGD based view about genetic code implied by the notion of bioharmony [L100], which relies on icosahedral and tetrahedral Hamiltonian cycles [L120].

(f) The hyperbolic geometry H^2 embedded locally in E^3 has the saddle property meaning that in one direction the observer is at the bottom of the valley and in another direction at the top of the hill. This property has analog also at the level of abstract geometry: geodesic lines diverge very rapidly since the curvature scalar is negative: for spheres they converge.

(g) By their negative curvature, H^3 and H^2 allow tessellations (analogs of lattices in E^3 and E^2) which are not possible in E^3. For instance. 7-polygons are possible. The number of tessellations is infinite whereas in E^2 only 17 wall papers are possible.

(h) Hyperbolic analogs of plants are mentioned as fractals.

A possible interpretation of DMT experiences

DMT experiences could reflect both the relationship between the geometries of hyperbolic 3-space and Euclidian 3-space represented as 3-surfaces of Minkowski space and the algebraic complexity assignable to the tessellations of H^3.

1. DMT trip as travel backwards in cosmic time

It was already mentioned that the proper time parameter a and algebraic complexity characterized by extension of rationals could characterize DMT experience. The increased complexity in turn means approach to apparent chaos since it is not possible to comprehend too high complexity. The following description is what I understood from the representation of Emilsson. I have not personally made DMT trips except spontaneously decades ago. This experience was so impressive that I got a passion to understand conscious experience from a quantum physics point of view.

(a) For small DMT does, the visual experiences correspond to patterns in plane $E^2 \subset E^3$, which can be regarded as plane $H^2 \subset H^3$ for large value of a and thus small curvature. The lattives of E^2 (17) called wallpapers serve as a background for the visual field. As if one would be perceiving two different worlds simultaneously. The lattices can be dynamical and pulsate. This kind of experience was part of the "Great Experience" decades ago.

(b) As the DMT dose increases, the value of a decreases and one moves towards the Big Bang, so to say. In TGD and TGD inspired theory of consciousness, causal diamonds (CDs), identified as intersections of future and past directed light-cones, could be seen as correlates of perceptive fields [L86, L129] which in TGD are 4-D so that also memories could be seen as analogs of sensory perceptions. CD is analogous to a Big Bang followed by a Big crunch. The CDs form a fractal hierarchy.

The visual field becomes more and more hyperbolic. What we would see is the projection of the patterns of $H_a^2 \subset H_a^3 \subset M_+^4$ to $E_t^2 \subset E_t^3 \subset M_+^4$, where a is cosmic time and t is the linear Minkowski time.

(c) At the next step the 2-D patterns in H^3 are replaced by patterns in H^3 as hyperbolic analogous of curved surfaces in E^3 and one can say that the dimension of the visual field becomes 3.

(d) In TGD Universe space-time surfaces are minimal surfaces [L132] and analogous to 4-D soap films spanned by frames appearing as singularities where minimal surface property and also the determinism of field equations fail so that the frames are space-time correlates as seats of non-determinism. The saddle property of minimal surface could explain the appearance of the "hyperbolic plants" which Emilsson lists as part of DMT experience.

Do we really see a hyperbolic world or does the visual perception reflect only the statistical geometry of the brain? The TGD proposal is that these two views reflect real space-time surfaces. One can of course argue that since conscious experience itself is associated with quantum jumps in the TGD framework so that the experience is about becoming rather than about being in the physical sense.

2. Algebraic complexity of the experience as a second parameter

The second parameter discussed in the talk was meant to characterize what was called valence as a measure for the "degree of bliss" of the experience. TGD counterpart would be algebraic complexity associated with the extension of rationals defined by the polynomial defining the space-time region. The value of $h_{eff}/h_0 = n$ as dimension of extension would serve as the parameter [L95, L96] For large values of n the situation becomes too complex to comprehend or remember and the bliss is lost.

In the TGD framework more complex systems can be engineered as functional composites of polynomials and this leads to the increase of h_{eff}. One can interpret this also as a construction of many-particle states with each polynomial, which represents a particle-like entity. When a fixed polynomial is iterated functionally, one obtains a fractal known as Julia set so that the connection with fractals is quite concrete [L99, L133, L134].

To sum up, the reports of Emilsson suggest a very concrete connection between DMT experience and TGD based views of space-time and number theoretical vision about quantum theory explaining dark matter as $h_{eff} = nh_0$ phases. DMT perception would be perceptions of both ordinary and dark matter simultaneously.

2.5.3 Possible implications for the interpretation of TGD

The proposed picture involving in an essential manner both H^3 and E^3 suggests some highly non-trivial implications concerning the physical interpretation of TGD.

H^3 is ideal for information storage and holography

The hyperbolic radial distance r_H in H^3 from origin is given by $r_H = aarsinh(r_E/a) \simeq alog(r_E/a)$, where r_E is the Euclidean distance in E^3. r_H depends logarithmically of r_E slowly. The area $S = 4\pi a^2 r^2$ of the hyperbolic sphere of radius u projected to Euclidean sphere with r increases as function of u as $S \simeq 4\pi a^2 exp(2u/a)$. One can imbed a tree graph (say) m ranches in the node much more effectively than in the Euclidean case. One can think of the tree graphs a simple model for a neural network consisting of layers such that n:th layer has m^n nodes for

If a given node requires fixed area ΔS, the solid angle $\Delta\Omega$ required by a node decreases as $1/r^2$ whereas in E^3 it remains constant, the number of these areas at sphere increases as $S/\Delta S = 4\pi exp(2u/a)/\Delta S$. In the Euclidean case it increases as $S/ = 4\pi r^2/\Delta S$. This means that the geometric information storage capacity of H^3 is exponentially larger. Therefore the idea that the 3 surfaces associated with H_a^3 could serve as information storage is very attractive.

H^3 and the origin of p-adic length scale hypothesis

p-Adic prime assignable to a region of the space-time surface is identified as the largest ramified prime associated with the polynomial defining the region of the space-time surface.

p-Adic length scale hypothesis states that the physical preferred p-adic primes correspond to p-adic primes $p \simeq m^k$, where m is a small integer: $m = 2$ is the most important case.

I have proposed that there are two scales involved. The small p-adic length scale associated with m and the exponentially larger p-adic length scale proportional to $\sqrt{p}$. The origin of these scales has remained a mystery.

Could the small scales correspond to the radial scales r_H and large scales to radial scales r_E?

(a) H_3 allows tessellations playing a key role in TGD framework and the size scale of the cell of the tessellation defines a natural length scale unit $\Delta r_H = aX$, which could define the small scale and scales would be expressible in terms of this unit.

(b) In E^3 the natural scale would correspond to Euclidean lattices with constant cell size Δr_E. For $r_H = \Delta r_H$, $r_E = asinh(r_H/a) \simeq aexp(r_H/a)$ would give $r_E \simeq aexp(nX = am^{\Delta X/log(m)}$.

(c) $r_E = L_p = \sqrt{p}R$ would give $\sqrt{p}R = am^{\Delta r_H log(a)/alog(m)}$. p-Adic length scale hypothesis $p \simeq m^k$ requires $X = klog(m)/2log(a/R)$.

Note that there would be a logarithmic dependence of the p-adic length scale on the a, which would have an interpretation as a renormalization of the p-adic length- and mass scales.

2.6 Support for the magnetic densory canvas hypothesis

Magnetic sensory canvas hypothesis is certainly the craziest idea inspired by TGD inspired theory of consciousness. The effects of Lithium on brain function lend support for the notion of magnetic body. The effects of atmospheric and magnetospheric electromagnetic phenomena to conscious experience would also support the sensory canvas hypothesis. If sensory organs are the seats of primary sensory qualia, the possibility that atmospheric phenomena could induce extrasensory percepts is excluded. Sensory percepts based on back-projection mechanism might be however possible. Taos hum is a strange anomaly which might also relate to the magnetic body and dark matter at it.

2.6.1 Invisible magnetic fields as a support for the notion of monopole flux tube

Physicists studying a system consisting of a layered structure consisting of alternate superconducting and spin liquid layers have found evidence for what they call invisible magnetic fields. The popular article is published in Scitechdaily (`https://cutt.ly/XVmeOXj`) and tells about research carried out by Prof. Beena Kalisky and doctoral student Eylon Persky in Bar-Ilan University. The research article is published in Nature [D38] (`https://cutt.ly/wVme7pu`).

First some basic notions.

(a) The notions of spin liquid and charge-spin separation are needed. Popular texts describe charge separation in a way completely incomprehensible for both layman and professional. Somehow the electron would split into two parts corresponding to its spin and charge. The non-popular definition is clear and understandable. Instead of a single electron, one considers a spin liquid as a many-electron system associated with a lattice-like structure formed by atoms. The neighboring electrons are paired. There are a very large number of possible pairings. In the ground state the spins of electrons of all pairs could be either opposite or parallel (magnetization). Pairing with a vanishing spin is favoured by Fermi statistics.

If the opposite spins of a single pair become parallel and this state is delocalized, one can have a propagating spin wave without moving charge. If one electron pair is removed and this hole pair is delocalized ,one obtains a moving charge +2e without any motion of spin.

(b) When a superconductor of type II is in an external magnetic field with a strength above critical value, the magnetic field penetrates to the superconductor as vortices. Inside these vortices the superconductivity is broken and electrons swirl around the magnetic field. This is how the magnetic flux quanta become visible.

In the layered structures formed by atomic layers of spin liquid and superconductor, magnetic vortices are created spontaneously in the superconducting layers. In the Maxwellian world, magnetic fields would be created either by rotating currents or by magnetization requiring a lattice-like structure of parallel electron spins. In the recent case spontaneous magnetization should serve as a signature for the presence of these magnetic fields.

Surprisingly, no magnetization was observed so that one can talk of "invisible" magnetic field.

In the bilayered structure 4Hb-TaS$_2$, the superconductivity is anomalous in the sense that the critical temperature is 2.7 K whereas in bulk superconductor 2H-TaS$_2$ it is .7 K. There is also a breaking of time reversal symmetry closely related t the presence of the magnetic flux quanta. The magnetic flux quanta survive above critical temperature 2.7 K up to 3.6 K and their life time is very long as compared to the electronic time scales (12 minute scale is mentioned). Therefore one can talk of magnetic memory.

The proposal is that a spin liquid state known as a chiral spin liquid is created and that the invisible magnetic field associated with the chiral spin liquid penetrates to the superconductor as flux quanta.

Could TGD explain the invisible magnetic fields?

(a) TGD predicts what I called monopole flux tubes, which have closed, rather than disk-like , 2-D cross sections and carry monopole flux requiring no current nor magnetization to generate it.

This is possible only in the TGD space-time, which corresponds to a 4-surface in 8-D space $H = M^4 \times CP_2$, but not in Minkowski space or in general relativistic space-time in its standard form. The reason is that the topology of the space-time surface is non-trivial in all scales.

The possibility of closed monopole flux tubes without magnetic monopoles, is one of the basic differences between TGD and Maxwell's theory and reflects the non-trivial homology of CP_2.

(b) Monopole flux tubes solve the mystery of why there are magnetic fields in cosmic length scales and why the Earth's magnetic field B_E has not disappeared long ago by dissipation [L24].

(c) Electromagnetic fields at frequencies in the EEG range corresponding to cyclotron frequencies have quantal looking effects on brains of mammalians at the level of both physiology and behavior. The photon energies involved are extremely low.

In the TGD based quantum biology they can be understood in terms of cyclotron transitions for "dark" ions with a very large effective Planck constant $h_{eff} = nh_0$ in a magnetic field of .2 Gauss, which is about 2/5 of the nominal value .5 Gauss of the Earth's magnetic field B_D. The proposal is that B_E involves a monopole flux contribution about $2B_E/5$ [K51].

The estimate for the invisible magnetic field was .1 Gauss so that the numbers fit nicely.

The findings suggest that the spin liquid phase atomic layer involves the monopole flux tubes assignable to the Earth's magnetic field and orthogonal to the layer. They would not be present in the superconducting layer but would penetrate from spin liquid to the superconductor.

2.6.2 Lithium And Brain

My friend Samppa told about positive effects of lithium on brain. I have proposed years ago that these effects could be explained by cyclotron frequency hypothesis and I decided to search

for web about the recent situation. Lithium has been used for more than 50 years as a mood stabilizer in manic depression. During last years Lithium has been studied intensively and found that it can be used also in treatment of schizophrenia and many other brain disorders. The popular and somewhat hypeish article "Lithium promotes longevity-mood and love" at `http://tinyurl.com/ns9ksms` tells about various applications of lithium. Even statistical evidence that lithium reduces violent crime is represented.

Basic findings

To my view the importance of these apparently rather specific effect is that it lends support for the notion of magnetic body.

(a) Lithium is found to increase the volume of grey matter (see the artcle "Lithium-induced increase in human brain grey matter" at `http://tinyurl.com/gu2s4ps`) and it is accumulated in white matter (axons) (see the article "Lithium in brain" at `http://tinyurl.com/zm9a4gm`). Lithium also enhances axonal growth and myelinination.

(b) The higher concentration of lithium in drinking water is found to reduce mortality and suicide rate. It has been also found that higher lithium concentration increases the life span of bacteria (see `http://tinyurl.com/z73ayq4`).

(c) Lithium might also help in Altzheimer's disease and other neurodegenerative diseases such as Parkinson's and Huntington's disease. Lithium is found to inhibit neuro-atoptosis (death of neurons). Lithium's neuroprotection may result from its inhibition of protein GSK3, which in turn prevents neuroatoptosis regulating survival and differentiation.

(d) Lithium is found to increase neurogenesis helping the healing of brain injuries (see artcle "Inactivation of Glycogen Synthase Kinase 3 Promotes Axonal Growth and Recovery in the CNS" at `http://tinyurl.com/hlfbkvz`). Lithium has also positive effect on memory. Lithium affects various signalling proteins and pathways. Indeed, lithium has been claimed to serve as "brain food" (see `http://tinyurl.com/zhe5ckf`).

(e) Disruption in the blood-brain barrier is proposed to be a missing link between brain and body flammation in bipolar disorder [?] (see `http://tinyurl.com/ya9tqzj8`). According to the abstract of the article:

The blood-brain barrier (BBB) regulates the transport of micro- and macromolecules between the peripheral blood and the central nervous system (CNS) in order to maintain optimal levels of essential nutrients and neurotransmitters in the brain. In addition, the BBB plays a critical role protecting the CNS against neurotoxins. There has been growing evidence that BBB disruption is associated with brain inflammatory conditions such as Alzheimer's disease and multiple sclerosis. Considering the increasing role of inflammation and oxidative stress in the pathophysiology of bipolar disorder (BD), here we propose a novel model wherein transient or persistent disruption of BBB integrity is associated with decreased CNS protection and increased permeability of proinflammatory (e.g., cytokines, reactive oxygen species) substances from the peripheral blood into the brain. These events would trigger the activation of microglial cells and promote localized damage to oligodendrocytes and the myelin sheath, ultimately compromising myelination and the integrity of neural circuits. The potential implications for research in this area and directions for future studies are discussed.

The mechanism of lithium-brain interaction is still unknown: mechanisms like altered mitochondrial function, inflammation, dysregulated dopaminegic/glutamatergic systems have been proposed. It is said that lithium helps to cure multisystem disorder rather than disease (reader can try to figure out what this might mean!). In any case, the effect of lithium seems to be on gene expression and it would seem that lithium only makes possible natural healing mechanisms to operate rather than providing single healing mechanism.

TGD view about Lithium's role

In TGD framework organism-environment pair of standard biology is replaced with the triplet magnetic body - organism -environment [K76, K75, K74]. Magnetic body uses biological body as sensory receptor and motor instrument. This suggests that the re-establishment of communications of brain with some level of the magnetic body is how lithium causes its positive effects. The disorders caused by the lack Lithium and other biologically important ions would be something totally new from the perspective of standard neuroscience. The standard idea that some kind of neuronal receptors or some information molecules are underpresented or over-represented would not be enough. Magnetic body would take care of healing in much more effective manner than more or less random tinkering of bio-molecular concentrations.

(a) The basic hypothesis is that communications between biological body and magnetic body correspond to sending sensory input from the cell membrane to magnetic body as generalized Josephson radiation and receiving control command from magnetic body controlling gene expression as cyclotron radiation [K77, K78, K35].

The control commands from magnetic body would rely on signals having carrier waves with cyclotron frequencies associated with dark variants of biologically important ions and assignable to dark magnetic bodies forming an onionlike scale hierarchy with sizes of order cyclotron frequency in endogenous magnetic field $B = 2B_E/5$, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field. The size scale assignable to 10 Hz frequency would be of order Earth size.

The sensory communications to magnetic body from cell membrane based on generalized Josephson frequencies associated with cell membrane regarded as generalized Josephson junction. The frequencies of radiated dark photons would be differences of cyclotron frequencies at the two sides of the junction plus relatively small contribution corresponding to the ordinary Josephson frequency determined by the membrane potential. Nerve pulse activity would thus induce frequency modulations of the carrier wave: kind of whale's song (or human speech) would be in question. Also amplitude modulation and even modulation of the polarization of radiation can be considered.

The value of Planck constant is large and EEG frequencies correspond to energies in the energy range of biophotons assumed to result in the transformation of dark photons to ordinary ones visible and UV photons. These energies correspond to excitation energies of biomolecules so that magnetic body could induce chemical reactions.

The gravitational Planck constant $\hbar_{gr} = GMm/v_0$ (here M and m denote masses connected by magnetic flux tubes carrying dark gravitons and $v_0/c < 1$ defines a velocity parameter - some natural velocity in the system) introduced originally by Nottale [E3] is identified with the effective Planck constant $h_{eff} = n \times h$ emerging in TGD framework from the fractal hierarchy of isomorphic sub-algebras of super-conformal algebras of various kinds (generalizations of ordinary conformal algebras) serving as symmetries of quantum TGD [**?**].

If M corresponds to large central mass and m to a mass of charged particle (elementary particle, ion, molecular ion,..), one obtains that cyclotron energies proportional to h_{eff}/m do not depend on mass number at all so that cyclotron energy spectrum is universal (and corresponds to that of bio-photons in visible and UV where also molecular transition energies are). The additional prediction is that each charged dark particle is at its "personal" dark magnetic flux tube. Instead of being a random chemical soup, dark living matter is highly organized, somewhat like library containing each book at its own self! It is difficult to exaggerate the importances of this implication.

(b) The most important biologically important ions include H^+, Li^+, Na^+, Cl^-, K^+, Ca^{++}, Mg^{++}. If some of these ions are absent, the communications to the corresponding layer of the magnetic are not possible and this part of magnetic body cannot control the corresponding parts of brain. The generation of these ions could be based on charge separation causing also the formation of exclusion zones (EZs) of Pollack [L14] as protons are transformed to dark protons at dark flux tubes outside EZ.

It is known that lithium ions accompanying lithium carbonate Li_2CO_3 dose intefere with ion transport processes (sodium pump) pumping Na^+ ions from cell interior (see

`http://tinyurl.com/y9u4uorr`). This suggests that also Li ions give rise to dark generalized Josephson currents through the cell membrane.

(c) Electron corresponds to 6×10^5 Hz, proton to 300 Hz, and lithium cyclotron frequency is 50 Hz and could be assigned to the limbic brain. Mg^{++} corresponds to 26 Hz, Ca^{++} to 15 Hz, Na^+ to 13 Hz, Cl^- to 8.5 Hz, K^+ to 7.5 Hz, etc... Iron and Cobolt would have cyclotron frequencies near 10 Hz of alpha band. The cyclotron frequencies for ^{6}Li and ^{7}Li are 50 Hz and 43 Hz.

Also higher harmonics of cyclotron frequencies are present and I have proposed that the magnetic field strength has spectrum, which corresponds apart from scaling to the frequency spectrum of biophotons, so that this picture is oversimplified. For instance, in retina 80 Hz frequency appears and would require stronger magnetic field unless it corresponds to higher harmonic.

(d) Magnetic fields oscillating at 50 Hz frequency are known to have biological effects [K77]. The size of the corresponding magnetic body part would be obtained from the wavelength $\lambda = 2\pi R$ (R denotes the radius of Earth) of the lowest Schumann frequency 7.8 Hz as $L = (7.8/50) \times R = .98 \times R$. This suggests that dark magnetic flux tubes assignable with Earth are involved: not however that the field strength is $2B_E/5$.

Quite recently (towards end of 2016) I learned that in 1986, scientists at Cornell University examined the effects of the two isotopes of Lithium on the behavior of rats (see `http://tinyurl.com/zyy3b4l`). Pregnant rats were separated into three groups: One group was given lithium-7, one group was given the isotope lithium-6, and the third served as the control group. Once the pups were born, the mother rats that received lithium-6 showed much stronger maternal behaviors, such as grooming, nursing and nest-building, than the rats in either the lithium-7 or control groups.

The naïve guess is that EEG amplitude at 50 Hz is enhanced thanks to ^{6}Li dose. It is found that the increase of lithium carbonate level for patients increases EEG delta and theta intensities and slow down alpha frequency (see `http://tinyurl.com/z88okg7`): unfortunately there is no mention about 50 Hz. The simplest interpretation is that improved communications at 50 Hz induce healing and indirectly improve communications also at lower frequencies. The slow down of alpha frequency remains to be understood. The precise values of cyclotron frequencies are controlled by magnetic body by varying flux tube thickness (flux quantization and conservation implies correlation of field strength with the thickness of the flux tube). Typical variation is about 10 per cent.

(e) A naïve dimensional guess is that the size scale of the part of the magnetic body corresponding to particular part of brain is proportional to its size. The naïve scaling argument would suggests that lithium scale is few centimeters. One must of course take this kind of estimates with extreme caution. The most primitive parts of CNS such as spinal chord and brain stem would correspond to highest frequencies in EEG and also above it, and the most advanced parts such as cortex or its sub-structures to the lowest frequencies such as at 10 Hz alpha frequency: lower frequencies would not correlate directly with our conscious experience but could correspond to large structures giving rise to collective levels of consciousness.

To sum up, lithium could help by re-establishing the connection to the lithium part of the magnetic body so that it could fix the part of brain involved. This would take place by control commands controlling gene expression.

50 Hz electric oscillation wakes up brain

Thanks for Ashton Martin for very interesting link (`http://tinyurl.com/wfbooaq`) related to neuroscience. The popular article tells about the work of Michelle Redinbaugh *et al* [**?**] (`http://tinyurl.com/uwfvatr`). The researchers have conducted experiment on monkeys in anaesthesia and conclude that the activation of central lateral thalamus by 50 Hz electric oscillations may enable consciousness. Activation of the central lateral thalamus and deep layers of the cerebral cortex drives pathways in the brain that carry information between the parietal and frontal lobe in the brain, the study suggests.

From TGD point view the conclusion is too far fetched and reflects the naïve "consciousness-module" thinking. The fining is however very interesting from the view point of TGD inspired theory of consciousness and quantum biology.

(a) The wakeup from anaesthesia happened using 50 Hz electric stimulation of central lateral thalamus.

(b) In TGD framework magnetic body (MB) carries dark matter as phases of ordinary matter with effective Planck constant $h_{eff} = n \times h_0$, which can be very large. n serves as a kind of IQ and MB serves as a master using biological body (BB) - in particular brain - as slave. EEG and it scale variants serve as a tool for communication to and control by MB. EEG photons are dark with large h_{eff} and can transform to bio-photons in visible and UV energy range and thus affect molecular transitions.

(c) MB has layered structure with cyclotron frequencies of biologically important ions associated with the control by MB in "endogenous" magnetic field $B_{end} = .2$ Gauss identifiable as monopole flux part of Earth's magnetic field with nominal value $B_E = .5$ Gauss. B_{end} explains the findings of Blackman and others about the effects of ELF radiation on brain and also why EEG correlates with consciousness and brain state. Without MB sending of EEG radiation to outer space would be horrible waste of energy resources.

(d) For ^{7}Li the cyclotron frequency for B_{end} is 50 Hz. Litium is known to have healing effect on depression and heal axonal infection. Depression and other problems could be due to the lack of communications to MB or control by MB. This would be due to a lack of magnetic flux tubes containing cyclotron B-E condensate of biologically important ions. MB could not take care of BB.

(e) Interestingly, the rate of lightnings in Earth's atmosphere is 50 Hz (`http://tinyurl.com/rb2l737`) and corresponds to a very strong peak in the em resonance spectrum of Earth including also Schumann resonances at 7.8, 14, 20, 26, 33, 39, 45 and 59 Hz (`http://tinyurl.com/r2dge5y`). TGD inspired theory of consciousness predicting self hierarchy and that the MB of Earth - Magnetic Mother Gaia - is also a conscious entity, suggests a connection.

(f) The finding suggests that some layer of MB of thalamus region producing dark cyclotron radiation at cyclotron frequency of Li manages to wake up this brain region in presence of irradiation. How?

    i. The model of water memory based on MB and water as a poly-phase involving dark magnetic flux tubes with $h_{eff} = n \times h_0$ suggests that 50 Hz frequency generates in water flux tubes with cyclotron frequency of 50 Hz which act as receiving and sending antennas.

    ii. Water would detect this frequency by tuning the thickness of the flux tubes to tune cyclotron frequency to 50 Hz: this is possible for monopole flux tubes not allowed by Maxwellian ED: flux is conserved and changing the thickness changes the cyclotron frequency. The antennas can send and receive 50 Hz radiation. The 50 Hz antennae generated by oscillation em field would be able to receive the cyclotron radiation from MB and wake up.

    iii. The flux tubes can also tune to the cyclotron frequencies associated with the MBs of invader molecules and this would make possible to generate "fake" molecules as MBs of water clusters. This would explain water memory, and give rise to basic recognition mechanism of immune system. Also homeopathy would be real effect and be based on the build-up of "fake" variants of molecules as flux tube antennae tuned to cyclotron frequency spectrum of MB of molecule. This requires metabolic energy feed to increase the value of h_{eff} at magnetic flux tubes and the agitation of water would provide this energy.

Magnetic sensory canvas hypothesis is certainly the craziest idea inspired by TGD inspired theory of consciousness. The effects of atmospheric and magnetospheric electromagnetic phenomena to conscious experience would support the sensory canvas hypothesis. If sensory organs are the seats of primary sensory qualia, the possibility that atmospheric phenomena

could induce extrasensory percepts is excluded. Sensory percepts based on back-projection mechanism might be however possible.

2.6.3   Atmospheric And Ionospheric Phenomena And Sensory Canvas Hypothesis

The sounds claimed to be generated by auroras and meteors and the correlation of UFO reports and ET experiences with tectonic activity provide some clues in the attempt to develop magnetic sensory canvas hypothesis. Also various anomalous visual percepts and OBE experiences provide challenges for the model.

The sounds generated by auroras

There are claims that auroras generate audible sounds [F15] (for the quantum model of auroras see [K18]). These sounds have not been detected by acoustic means. Of course, it might be only a matter of time when this is done.

A particular example of microwave hearing [I31] could be in question. The microwave MEs generated in auroras could propagate like massless particles along ELF MEs to brain, and induce cortical perturbations modulated by ELF frequencies serving as modulating frequencies and determining the pitch of the sounds heard. The perturbations would be analogous to electric stimulation of cortex inducing sensory percepts by back-projection mechanism. The cortical perturbations would generate auditory sensations by the back-projection mechanism. Higher Schumann resonances are in the audible range and could also be mediated along the flux tubes from the magnetic body or magnetosphere to brain and induce audible sounds by the back-projection mechanism.

The TGD based model of hearing relies heavily on classical Z^0 fields and auditory canvas could be actually Z^0 magnetic. Since all classical fields are expressible in terms of CP_2 coordinates, magnetic storms are expected to be accompanied by their Z^0 magnetic counterparts.

The sounds generated by meteors

so some further evidence for the sensory canvas hypothesis. Since 16th century it is known that also meteors produce audible sounds. What is mysterious that there is no time lag due to the propagation through the atmosphere. The explanation is that it is very low frequency em waves which propagate to Earth and generate sounds by interacting with the objects at the surface of Earth. Joined by the International Leonid Watch - Croatia (ILWC) project, a group of scientists presented the first instrumental detection of elusive electrophonic meteor sounds. In November 1998, the researchers from the Croatian Physical Society and the University of Kentucky organized an expedition to Mongolia to observe the anticipated Leonid meteor shower and shed some light on the phenomenon [F10].

The complete data analysis revealed two electrophonic sounds that provided several important clues about the nature of this longstanding astronomical mystery. It became clear that sounds were created when the meteors were crossing night-time ionosphere (the heights involved are in 85-110 km). The electrophonic sounds seem to be produced inside the measuring apparatus suggesting that electromagnetic energy is transformed to sound at this stage. The existing theories cannot however completely explain the phenomenon. The energy of the meteor does not seem to be high enough to invoke the electric fields needed to explain the electronically recorded sounds: only one percent of the electric energy is estimated to be transformable to acoustic form but the required conversion ratio seems to be 100 percent and perhaps even higher than this. The frequencies are much lower than the expected range 20-20.000 Hz range for sferics, which by the way is the range of audible sounds, not an accident in TGD universe. The fundamental frequencies are in the region 37-44 Hz but are consistent with the psychophysical correlate of the sound (deep "pop").

Magnetic mirrors as carriers of the electromagnetic perturbations might allow a better understanding of the phenomenon. What is intriguing that the frequencies are in the range 37-44 Hz: this frequency range is the same as associated with the average value of the thalamocortical resonance frequency of 40 Hz. This frequency range should be associated with the sensory representations on the magnetic canvas. It is known that sounds near 40 Hz induce strong effect in EEG. The first hypothesis is that the interaction of these em fields with brain generates the perceived sound. On the other hand, in TGD framework these sounds are represented ultimately in the magnetic sensory canvas: thus the intriguing possibility is that the consciously perceived sounds are in fact generated by the direct perturbations of the magnetic or Z^0 magnetic auditory canvas and are genuine ESP effects.

The recorded electrophonic sounds could be induced by electromagnetic perturbations propagating along magnetic mirrors at multiples of the fundamental frequency $f = c/L$ determined by the length L of the magnetic mirror and the mirrors might not only channel the electromagnetic energy very effectively but even act as resonators amplifying the em fields. In fact, in one of the models analyzed in [F10], the electric fields on the surface of Earth must have the same strength as the electric fields created by the meteor in its immediate vicinity in order to explain the data! If the electric fields are channelled along the magnetic mirrors associated with the magnetic sensory canvases to the surface of Earth, the frequency spectrum is automatically in the "thalamocortical" range instead of the expected $20 - 20.000$ Hz range for the sferics and one can understand why only few meteors generate electrophonic sounds. Notice that magnetic mirrors of length shorter than Earth's circumference would give rise to higher resonance frequencies than Schumann frequencies: the required length of the mirror would be roughly 1.26 Earth radii for 40 Hz frequency.

One can imagine tests for the sensory canvas hypothesis and for the possible ESP character of the heard sound (in the sense that the heard sound is induced cortically rather than received from environment).

(a) One could construct acoustic amplifier in 37-44 Hz range so that human perceiver could hear both the direct ESP sound and the sound generated by the amplifier. This would mean hearing two "pops", such that the interval between them is determined by the time used to the sensory processing and propagation of the sound from the external source. In fact, in the introduction of [F10] it is mentioned that "many witnesses heard sounds even before they heard the noise inside the house". Assuming that the sounds are both heard and electronically detected, a neurophysiological model for the time lapse from the sensory input to the conscious percept would allow to test whether the consciously perceived sounds can have non-ESP origin. If the lag is too small, ESP interpretation is supported.

(b) The human perceiver could use ear plugs. If "pop" is heard also in this case, the only possible interpretation (excluding fraud) is that the sounds are generated either by the neuronal activity stimulated by the interaction of the ELF em perturbation with brain, that the sound is generated in body as physiophonic sound [I41], or that a genuine ESP is in question. The phenomenon of physiophonic sound discovered by Antonio Meucci in 1842 means the amplification of external sounds or electromagnetic signals by musculature and their feed directly to the neural circuits (ears could be closed) and is a rather convincing explanation for the heard sounds. The possibility of fraud could be eliminated by excluding the possibility of the direct visual perception of the meteor and finding whether the heard sounds coincide with the electronically detected sounds.

UFOs, ETs and magnetic perturbations

Persinger has proposed a model explaining the encounters of extraterrestrials as hallucinations caused by the perturbations of Earth's magnetic field induced by the liberation of the tectonic energy at the lines of tectonic activity [**?**]. The model is based on well-established statistics about the effects of the perturbations of Earth's magnetic field on consciousness collected in mental hospitals. The lines of the tectonic activity are also accompanied by well

established luminous phenomena which suggests that the model could be naturally combined with the explanation of UFOs as this kind of luminous phenomena.

The most obvious guess is that a beam of visible light or ions emerges from the region where the tectonic energy is liberated. If this beam somehow produces a localized ball lightning type phenomenon it could be interpreted as UFO. If the direction of the beam varies randomly the resulting UFO performs random butterfly like motion and in principle the velocity of motion can be super-luminal since a signal velocity is not in question. The motion would resemble that of a flicker's light spot in a roof. Many UFO candidates have indeed found to move in this manner and this is quite a challenge in the attempts to understand the technology used.

1. Why a light spot rather than beam of light is observed?

The challenge is to explain why a localized pseudo UFO rather than a beam of light is observed.

(a) One could consider the possibility that a radial spray of electric flux emanates from the site of the tectonic activity and electrons accelerate in this field until they gain the energy needed to ionize the molecules of the atmosphere and produce visible light. The analog of vacuum discharge would be in question. The problem is that the drifting velocity is achieved very rapidly so that the model works only if the density of molecules of the atmosphere decreases sufficiently fast as function of height. This is not the case.

(b) Suppose that the spot of tectonic activity emits dark microwave photons including frequencies $f > 5$ GHz. In this case visible light could result via the de-coherence of the dark microwave photons to ordinary photons. The fraction of ordinary visible photons in the beam would behave as $1 - exp(-h/h_0)$ and at some critical height the beam would become visible as the visible photons scatter from the molecules of atmosphere.

(c) Pseudo UFO could be a kind of a mini aurora produced by exactly the same mechanism as auroras. Similar mechanism could apply also to ball lightnings and other exotic luminous phenomena. The super-conducting magnetic flux tubes associated with the stream of magnetic flux assumed to emanate from the site of tectonic energy liberation would intersect with the magnetic flux tubes of Earth's magnetic field (or those emerging from the brain or body of the perceiver of ETs). This would lead to a reconnection process in which magnetic flux tubes having a local U-shape are generated. The inertia of the super-conducting ions (perhaps protons and electrons) would induce the leakage of the ions to the non-super-conducting atmospheric space-time sheet. This in turn would lead to a further ionization and the molecular electronic transitions would generate the visible light as in the case of auroras. Also electric fields could be involved as in the case of auroras. U-shaped structures would occur at definite height. By measuring the local electromagnetic fields one could perhaps test whether the orbit of the pseudo UFO correlates with the variation of the hypothesized stream of magnetic flux emerging from the site of the tectonic activity. The pseudo-UFO character could be tested by finding what kind of radar echoes the luminous region generates (if any).

2. What about ET reports?

The aurora mechanism could explain also the hallucinations as real encounters with other selves of the predicted self hierarchy rather than ETs. The tectonic activity could cause a similar perturbation of the personal sensory canvas and perhaps its temporal fusion with other sensory canvases, perhaps even with higher multi-brained sensory canvases possibly present. This would obviously induce genuine ESPs. The generalized motor response coming from the sensory canvas would be also involved but primary percept would occur before it. Brain would probably do its best to interpret the situation using concepts provided by the cultural background. Angels, spirits, demons, ETs, etc.. would be various narratives for the same phenomenon.

Also Schumann resonances are excited during tectonic activity and could correlate strongly with the experiences about encounters of ETs: this explanation is consistent also with option

b). Similar mechanism might be behind hypnagogic experiences occurring at the boundary between wake and sleep. EEG is dominated by frequencies near the lowest Schumann frequency 7.8 Hz during hypnagogy and this might mean that the entanglement with other sensory canvases occurs with an enhanced probability.

Krishnamurti has told very movingly about experiences of literally being another one. Perhaps also other identification experiences, such as shamanic identification with animals, rely on the same mechanism. Also I have had strange hypnagogic experiences of being a totally different person for a moment. This picture would suggest that magnetic transition frequencies associated with the flux tubes of the magnetic sensory canvas emanating more or less vertically from the head code for the personal content of consciousness whereas Schumann frequencies relate with the transpersonal contribution to consciousness possibly present always and giving rise to a third person bird's eye of view about own person and amplified during hypnagogic experiences or by strong perturbations of Earth's magnetic field.

Anomalous visual percepts and sensory canvas hypothesis

Sensory canvas hypothesis means that at the level of magnetic body we see using ELF– rather than visible light. Of course, if primary sensory qualia are at the level of sensory receptors, this seeing has the character of imagination. Even in this case brain could use back-projection to the sensory receptors assign sensory qualia with the imagination like perception. This would occur during dreaming and what is regarded as hallucinations.

The model of EEG [K35] however leads to the conclusion that the Josephson radiation from cell membrane corresponds to dark photons with EEG frequencies and bio-photon energies so that they can transform to bunches of EEG photons or to bio-photons with ordinary value of Planck constant. This model predicts correctly the frequencies of maximal sensitivity for the four kinds of photoreceptors and a good guess is that this radiation could explain large number of various anomalies in which low frequency radiation has biological effects.

One can also consider the possibility of "vision" as a sensory experience of the magnetic body based solely on the ELF input from brain and body having no correlate with the visible light entering into the retina or even with neural activity. The de-coherence of (for instance) dark ELF photons with frequencies above alpha band level of the dark matter hierarchy to ordinary visible photons could be responsible for this vision.

Even genuinely three-dimensional vision in which own body is seen as it would be seen by the external world suggests itself. The dropping of ions from the atomic space-time sheets to the magnetic flux tubes so that they end up to high n cyclotron states decaying via the emission of photons at frequencies which are harmonics of the cyclotron frequency would generate the projector MEs needed for the sensory representation of the physical body or part of it as seen by the environment. 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.

There is some evidence for this kind of anomalous vision.

(a) Yogis have reported altered states of consciousness in which they see their own body three-dimensionally, that is simultaneously from all directions. This might have interpretation as ELF vision involving a feedback from magnetic sensory canvas to brain to "qualiafy" the percept. An alternative interpretation is that the visual experience is visual experience of some other self which is shared by quantum entanglement.

(b) Becker tells in his book "Cross currents" [**?**] about a young cancer patient who told that he can see the interior of his own body. The patient could also locate the remnant of the tumor correctly. If sensory receptors are necessary for visual qualia, the needed

data must be received from somewhere by brain, and be projected to the retinas like during dreaming. The simplest option is that body parts can in some sense "see" each other. In particular, brain can "see" body parts (note that bacteria possess a primitive IR vision based on micro-tubules). Bio-holography provides support for the body as a hologram. For instance, an electric stimulation of ear during Kirlian imaging of a finger tip creates a Kirlian photo from which it is possible to abstract a hologram of ear (see [I61] and [K42]). One can also imagine that magnetic body "sees" and the mechanism is the transformation of dark EEG photons to visible photons.

(c) Also the OBE experiences, for instance those associated with NDEs, could have an analogous interpretation. The sensory input from eyes would be absent but brain would give feedback to visual receptors to "qualiafy" the input which it might receive from other levels of self hierarchy. If even the input from neural activity is absent during NDEs so that the visual experience should be determined by the background ELF component emanating from the brain and body. The third person perspective associated with OBEs might be always present but be masked by the strong sensory input or by the absence of feedback to visual receptors. It is possible to have experiences about contact with deceased by a therapy based on rhythmic eye movements [**?**, **?**]. The function of eye movements might be to establish a feedback to certain brain regions serving as receivers of input from magnetic bodies of deceased or from magnetosphere. I have developed a detailed model for various kind OBE experiences in [K101].

(d) I have proposed thousand and one explanations for the beautiful flow visible when I close my eyes in a calm state of mind. During my "great experience" this background flow was accompanied by extremely vivid visual hallucinations. An additional item to the long list of explanations is following. The information characterizing the flow enters from or via brain to the visual receptors and is in this manner "qualiafied".

What has been said about magnetospheric third person aspect applies also to other senses. Interestingly, I often wake-up partially and realize that I hear my own snoring as an outsider (quite a dramatic experience!). Sometimes I have had an experience which might be interpreted by saying that the hearing in the first perspective is superposed with the hearing in the third person perspective. The third person hearing has a time lag so that a kind of double breathing results.

2.6.4   Taos hum

Taos hum (see this) is an experimentally well-established anomalous phenomenon which has escaped rational explanations (in the article [I41] 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 thus provide an application for the sensory canvas hypothesis.

The TGD based model for EEG [K35] 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 photons as manifestations of one and same thing. Taos hum might be perhaps understood in terms of this kind of Josephson radiation at microwave 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.

Also other interpretations might be considered and the most recet idea suggests a connection with quantum gravitation,

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 gigantic amplification by the physical (and em!) 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 its 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.

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.

1. Microwave hearing

During the collaboration with Joaquim Fernandez related to the construction of a a model for so called Fatima miracle [H3] I learned about the phenomenon of microwave hearing [I31] in which microwaves generate an audible sensation. There is evidence that microwave hearing does not involve ears as receivers of the primary signal [I15] 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 that back-projections cannot induce physical pain, the presence of the painful tactile sensations means that microwaves 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!

2. 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 [I41]. 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.

3. 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.

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 [K48] pose strong constraints on the model of taos hum.

Taos hum as sensitivity to alien control commands

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 would 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 [K42, K48].

(a) 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 Ca^{2+} waves and nerve pulse are examples of the physiological responses resulting in this manner.

(b) 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.

(a) In the healthy situation em immune system takes care 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.

(b) 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.

4. Taos hum and microwave hearing

The identification of the audible sensation associated with taos hum is in terms of microwave hearing explains 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.

5. 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.

6. 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.

7. An explanation for 40-80 Hz modulation

The model of biological evolution and evolution of nervous system based on dark matter hierarchy [K35] 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.

8. 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 [K83]. 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.

9. 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.

Is hum possible in other sensory modalities?

The model of hum based on magnetic sensory canvas suggests that the effect is involved with all sensory modalities. Tactile sensations, in particular pain, are certainly involved. It was already mentioned that hum experiences can involve also perceptions of white light in the horizon in the direction from which hum came. In the model explaining the sensation of hum as being caused by the muscular sound, this sensation could result as a kind of cross-modal association accompanying very intense auditory sensation. In the model explaining the effect as ESP the presence light sensation could be understood as visual aspect of the ESP.

My personal experiences provide a candidate for the counterpart of taos hum in visual field. While closing eyes in a calm state of mind, I see a strange and complex flow consisting of small dots: for the first time I had this experience during my great experience roughly 15 years ago. The effect is easiest to achieve with lightly closed eyes but appears after some time also with tightly closed eyes. For lightly closed eyes the flow is more complex whereas for tightly closed eyes there is just a sink in the middle representing what I would call "third eye", which is present practically always. Vortices and spiral vortices (compare with the whirling winds associated with hums) are typically involved and flow can have also weak coloring.

Could this flow be the visual counterpart of the taos hum? The very fact that the experience is pleasant and the appearance of diffuse white light during taos hum suggests that this interpretation need not be quite correct.

(a) The effect is caused by the de-coherence of dark microwave photons or perhaps dark EEG photons above alpha band to visible photons (during calm states of mind alpha band is very strong).

(b) This effect is strongest when the eyes are only lightly closed. Perhaps ELF em waves from some source could provide the input to the retina which is magnetic structure and generate the visual sensation somehow (note that rotating non-colored Benham top can generate sensations of color). The de-coherence of dark ELF photons to ordinary visible photons could be the mechanism.

(c) I have proposed an interpretation for the flow in terms of the magnetic flux tube structure emerging from the retina. One can however wonder why just single central vortex rather than two? Could it be that pineal gland, which is also a magnetic structure and contains retinal pigments and is "third eye" in rather literal sense, could be responsible for the "third eye" component of the flow, and that during eyes lightly closed conditions turbulent retinal and single vortex like pineal contributions superpose? Could pineal vision be based on the de-coherence of EEG waves above alpha band to ordinary visible photons?

What is perhaps remarkable that the ability to have the flow experience has stabilized during last year or two, which is also the period during which various hum symptoms have developed. However, I experience the flow also when the computer is off: as a matter fact, I experienced the flow for 15 years ago when I did not work with computers.

The recent TGD view of Taos hum

The ideas discussed in this section were inspired by my latest experience with taos hum which I first did not interpret as such.

1. Personal experiences about hum

While learning about taos hum, I suddenly realized that I am perhaps not an objective outsider at all! I cannot tolerate the humming noise of the refrigerator: in order to sleep at all I try to insulate myself from the kitchen by cloth (I do not have door between) and use pillows on my ears in order to get rid of this extremely irritating sound. Even this is not enough and I wake-up very often during night-time. I also used to have terrifying experiences in which the noise of the refrigerator started to increase in volume and my body started to float and was attracted by the refrigerator as if it were a conscious creature wanting to fuse with, or rather steal, my consciousness (by the way this suggests that magnetic selves strongly interacting with my magnetic body might be really involved). I can also hear sounds, such as cracks from wall, as amplified to completely abnormal intensity (in fact I have always had abnormally sensitive ears).

I suffer also from almost intolerable hum of my computer at day-time and only while learning about taos hum, I realized that similar mechanism might be at work also here (note however that taos hum is strongest during night time, between 9 P.M. and 9 A.M.). Remarkably, the hum amplifies when I become conscious of it: I can work long times without noticing its presence at all. Neither am I aware of the refrigerator at daytime. To complete the picture, two years ago I began to suffer from chronic pain in head, neck and back which are due to strong muscle tensions. These pains correlate very strongly with working at the computer terminal. I have believed that this is due to the bad working ergonomy and poor quality of eye glasses. However it turned out that this was not the reason of pains. I have even suffered from temporal dizziness when pains have been worst and even lost my consciousness once: strangely enough, I heard before the loss of consciousness a strange whirling wind to blow (sic!), and realized only later that weather had been completely calm.

It seems that all these symptoms fit with those of a hum patient. Now only the source of radio waves would be my own computer and would act also at daytime via direct radio wave magnetic mirror bridges connecting the oscillating circuits of the computer to my musculature. When I am not aware of the noise, my brain does not project sensory input from muscles to the auditory canvas and I am saved from the hum sensation. I however feel the pain coming from the body all the time.

On basis of what has been said, it would seem that there is high time to consider the possibility that the electric pollution of environment is gradually making our life increasingly intolerable. One cannot even exclude demon like conscious virus like entities generated by the electronics and computers and fighting for survival with us.

This was however not the full story yet. I suffered from taos hum in my previous hometown. After I moved to my recent hometown, I believed that I had got rid of this problem. But also here I have been tormented from time to time by an unpleasant sensation of sound. Always at night and summertime. The sound source did not move. As if someone were keeping the car idling or even screaming the car engine to drive his fellow men to the brink of rage.

What gave the stimulus to write an article was that after a long period the experience came back at winter time and lasted for several hours. Once again I tried to figure out what it could be. The interpretation as hallucinations didn't seem likely. Another interpretation was as sensory memories. Such are possible and can be induced by electrically stimulating the temporal lobes. For example, some previously experienced pain due to some real cause can be chronically repeated as a sensory memory.

Then I suddenly realized that it was my old friend Taos hum! The reason why I had not realized this from the beginning was that in my new hometown my friend has been much more aggressive and created the impression of intentional bullying so that the unavoidable first impression was that some-one is terrorizing his neighbors by gassing his car at night-time.

2. Taos hum and quantum gravitation

The latest experiences with taos hum led to an identification of new pieces, which seem to fit the puzzle of taos hum.

If taos hum corresponds to microwave hearing, the natural question is what the range of the carrier frequencies is and whether there are some special carrier frequencies.

(a) In quantum biology based on TGD quantum gravity is essential [L138, L135]. Nottale's hypothesis [E3] is generalized and assigns macroscopic and even astrophysical quantum coherence to classical gravitational fields created by astrophysical objects.

In the Earth's gravitational field, the gravitational Compton wavelength is $\Lambda_{gr} = GM_E/\beta_0$, where the velocity parameter satisfies $\beta_0 = v_0/c < 1$. Λ_{gr} and the corresponding frequency f_{gr} do not depend on the mass of the particle (Equivalence Principle). For $\beta_0 = 1$ one has $\Lambda_{gr,E} = .45$ cm. It corresponds to the microwave frequency $f_{gr,E} = 67$ GHz. This would be some kind of universal clock frequency of quantum biology.

(b) I have considered also the possibility that computers [L149, L148, L154] could acquire some characteristics of a biological organism, if their clock frequency is higher than this frequency, because then the statistical determinism would no longer apply. In fact, the corresponding wavelength associated with the Sun is half the radius of the Earth and corresponds to the frequency $f_{gr,S} = 50$ Hz which is EEG frequency, which inspires many questions.

(c) For biomolecules, microwave frequencies play an essential role. Microwaves are associated with many strange effects such as ball lightning and light balls that have often been interpreted as UFOs. The creation of crop circles [K32, K33] [L154] could be based on the same mechanisms as the explosion of a tomato in a microwave oven, which can be also used to produce this kind of light balls. There are also reports of lightballs in the act of building a crop circle.

(d) Could the amplitude modulation of the radiation with gravitational Compton frequency $f_{gr,E}$ of the Earth produce the taos hum?! The modulating frequencies are in the EEG range and quite low, which brings in mind the gravitational magnetic body of the Sun with $f_{gr,S} = 50$ Hz.

(e) What would give rise to the impression of an idling diesel engine? Could it correspond to some kind of random noise but what about the impression of deliberate gassing? What comes to mind is a boxer who is in a state of maximal alertness ready to attack at any moment. This suggests a quantum critical state in which bursts of metabolic energy are randomly occurring. Note that the carrier frequencies would be microwave frequencies and by a factor of 67 higher than in the Frey effect, which has been associated with the microwave hearing.

There is also another important microwave frequency. The maximum for the frequency distribution of the cosmic microwave background is at the frequency 160 GHz and to wavelength .2 cm. This frequency is roughly twice the gravitational Compton frequency for Earth. This is close to the upper limit of microwave frequencies of 300 GHz. Is it a coincidence that these two frequencies are so near to each other?

3. Taos hum and TGD based generalization of stochastic resonance

Stochastic resonance [D26] [?] occurs in the brain [D43] and its quantum analog serves as a candidate for the mechanism behind the perception of taos hum.

Consider first the classical variant of the stochastic resonance, which I have considered in [K83].

(a) Classical stochastic resonance is an amplification mechanism for a signal represented as an amplitude modulation of a carrier wave with a basic frequency f acting as a harmonic perturbation of a bistable system, which is also subject to a white noise. In the recent case the message could correspond to the amplitude modulated signal with frequency f in the microwave range. $f = f_{gr}$ is an interesting option. One might say that the system manages to extract the energy of the noise, which creates the question whether the mechanism conforms with the second law of thermodynamics.

(b) In the resonance, the signal frequency f must be one half of the average frequency $f(spont)$ for the jumps between two states of the bistable system: $f = f(spont)/2$. This condition has a simple physical interpretation: the height of the potential barrier separating the two potential wells varies periodically with a period which is half of the period defined by f, and the best opportunity to get to another potential well is to hop when the potential barrier is lowest possible.

(c) For the mechanical analog system the rate $f(spont) = r_0 A$ is proportional to an "Arrhenius factor" $A = exp(-\Delta V/D)$, where ΔV is the height of the potential barrier and D characterizes the intensity of the white noise. $f(spont)$ is also proportional to a factor $r_0 = \omega\omega_b/\gamma$ where ω is the frequency of small oscillations at either bottom of the symmetric potential well, ω_b is the analogous quantity at the top of the barrier (for harmonic oscillator potential one would have $\omega = \omega_b$), and γ characterizes the linear dissipative force (overcritical damping is assumed).

(d) Thus, when the white noise has a correct intensity, a weak harmonic perturbation with a given frequency is amplified in the sense that the Fourier expansion of the system's time development regarded as jumps between the two states contains a peak at the multiples of the frequency of the amplitude modulated harmonic perturbation. Neuroscientists refer to this phenomenon as phase locking. The peaks for the higher multiples of the input frequency f are exponentially suppressed. The notion of stochastic resonance makes sense also in the quantum context: now quantum tunnelling would replace the jumps induced by the stochastic noise.

Could stochastic resonance generalize to a quantum situation but with the ordinary ontology of quantum theory replaced with the zero energy ontology (ZEO) of TGD [K123]? What would be new is the identification of the ordinary quantum jump as a "big" state function reduction (BSFR) in which the arrow of time changes. One can consider two interpretations.

(a) Consider first the TGD analog of the standard interpretation. The jump between the potential wells corresponds to a quantum tunnelling as a transition of states with the same arrow of time and therefore involves two subsequent BSFRs. In stochastic resonance, the frequency $f(spont)$ for these tunnellings should satisfy $f = f_{spont}/2$. Each period $T = 1/f$ would correspond to two pairs of BSFRs. In the TGD framework, this interpretation looks too complicated.

(b) For the second option, a single BSFR defines the counterpart for the hopping between two potential wells and 2 BSFRs define quantum tunnelling. Bistability has nothing to do with the details of the dynamics and is universal and corresponds to the two arrows of time. $f(spont)$ is identified as the rate for BSFRs rather than their pairs and characterizes external perturbations.

In the stochastic resonance, the rate $f(spont)/2$ for a pair of BSFRs would be equal to the carrier frequency f so that quantum tunnelling is in synchrony with the driving frequency f and each period corresponds to a quantum tunnelling. The intensity of the noise could be used to induce this synchrony.

This synchronization mechanism applies to all transitions and to all frequencies f but $f = f_{gr,E}$ would be in a special role since $f_{gr,E}$ defines a universal gravitational Compton frequency of the Earth. For instance, EEG could involve this mechanism and the halves of the EEG period would correspond to different arrows of time as I have indeed proposed in [K83] on basis of observations of brothers Fingelkurts [?]. As already noticed, the gravitational Compton frequency $f_{gr,S} = 50$ Hz of Sun is EEG frequency and EEG frequencies appear as modulation frequencies in Taos hum.

2.7   Evidence for quantum brain

The recent findings suggest quantum coherence in the brain scale. The quantum coherence would make itself visible in the magnetic resonance imaging (MRI). The findings are described in the popular article in Scitechdaily (`https://cutt.ly/ONtnxwZ`). The research article

"Experimental indications of non-classical brain functions" by Christian Matthias Kerskens and David Lopez Perez [**?**] is published in Journal of Physics Communications (`https://cutt.ly/ONtnEKz`).

The system studied is the brain and cyclotron resonance of protons in "brain water" is involved. The goal was to find whether there exists evidence for macroscopic quantum entanglement. The work was based on the proposal that some quantum coherent, non-classical, third party, say quantum gravitation, could mediate quantum entanglement between protons of brain water. NMR methods based on so-called multiple quantum coherence (MQC) act as an entanglement witness.

The work of Kersens and Perez was inspired by a theoretical work of Bose et al in which a possible method allowing to witness quantum gravity by spin entanglement [B11](`https://cutt.ly/CNhF2Ev` was discussed.

In the sequel, the proposal of Bose et al for generating entanglement by quantum gravitational interaction between mesoscopic objects is first discussed. A superposition of two locations for the objects is required. It is assumed that it is possible to correlate the locations with spin values. Entanglement would be generated by different phases, which evolve to different pairs of components of objects and measurement of spin would demonstrate the presence of entanglement.

Mechanisms generating quantum coherence in scales of at least 10^{-4} meters and giving rise to a superposition of locations are needed but are difficult to imagine in the standard view of quantum gravitation.

In TGD, the mechanism would be different. Gravitational Planck constant $\hbar_{gr} = Gm/v_0$ associated with Earth-test particle interaction could generate quantum coherence in even brain scale and gravitational Compton length $\Lambda_{gr} = GM/v_0 \simeq .45$ meters, where $v_0 \simeq c$ a velocity parameter characterizes the lower bound for the quantum gravitational coherence scale. The analogs of magnetized states assignable to microscopic objects of size scale 10^{-4} meters take the role of spins and spin-spin interaction generates the entanglement, which is detected by measuring the spin of either object just as in the case of ordinary spins.

2.7.1 Could spin entanglement be used as a witness for quantum gravitation

The basic idea of the two [**?**] and [B11] is that quantum gravitation can be witnessed by the entanglement induced by it.

2.7.2 Could quantum gravitation generate spin entanglement for quantum superpositions of locations?

In the article "A Spin Entanglement Witness for Quantum Gravity" of Bose et al [B11](`https://cutt.ly/CNhF2Ev` a detailed proposal how the quantum gravity could generate entanglement in scale $d \sim 10^{-4}$ meters.

(a) The masses $m_1 = m_2 = m$ considered are of order 10^{-14} kg and would correspond to a water blob of size about 10^{-5} m with mass of order $m \sim 10^{-3} m_{Pl}$. The masses m_i would be at a distance $d \sim 100$ μm, which corresponds to the size of a large neuron having mass about Planck mass. One has $\alpha_{gr} = Gm^2/\hbar \sim 10^{-6}$. So that the interaction energy at distance d would be $Gm^2/d \simeq 10^{-8}$ eV, which is much below the thermal energy.

(b) The idea is that although the gravitational interaction energy is quite too small, quantum gravitational interaction between masses m_i could be detectable via a generation of quantum entanglement. The additional assumption, bringing in mind the Orch-OR hypothesis, is that superpositions of 2 locations are possible for the masses and the separation scale Δx is of order $d/10$. The mechanism causing this superposition is not discussed. What comes into mind is gravitational double well potential.

(c) One considers a situation in which each mass is a superposition L+R of locations for the center of mass. One assumes that it is possible to assign to the locations L and R opposite spins so that the measurement of spin would perform a state function reduction inducing a localization to either R or L configuration.

The distance of the masses has the scale d. One assumes that the masses behave like quantum coherent objects describable by a scalar field, and assumes that they fall freely in the gravitational field of Earth for a time of order of a few seconds.

(d) The mathematical model assumes standard perturbative quantization of the gravitation using quantum field theory in Minkowski space. The situation is assumed to be static so that only the component g_{tt} of the metric and radiation part of the gravitational field matters in the description of the interaction.

(e) The initial state is an unentangled product of states but their mutual quantum gravitational interactions LR and RL corresponding to distances $d + \delta x$ and $d - \delta x$ of masses generate different phase factors. After this, these analogs of photon beams superpose again and interference takes place. The predicted difference of the phase angle is of order 10^{-4} and might be measurable with recent technology.

2.7.3　　NMR as a witness for quantum gravitational entanglement

The experiment carried out by Kerskens and Perez [**?**] was not based on interferometry but on nuclear magnetic resonance imaging (MRI).

It is far from clear that the ordinary NMR signals can contain quantum correlations of the spectrum in the hot and wet brain environment. Therefore a witness protocol, which eliminated the "classical" background from known sources was used.

To achieve this, the "classical" sources of entanglement had to be eliminated. This was achieved by irradiation of the brain region with a radiation inducing cyclotron transitions to higher energy state so that the situation would become saturated and one would have a statistical dynamic equilibrium. In a statistical sense, the temporal patterns associated with the transitions from a higher state to a lower state causing cyclotron radiation patterns visible in MRI would be absent. In this back-ground the presence of "non-classical" sources of cyclotron emission would be visible. This source could correspond to a formation of pure entangled state which would decay by emitting cyclotron radiation.

What was found, was a periodic pattern in MRI with a frequency of heart beat, interpreted in terms of evoked membrane potentials. This pattern is too weak to be visible in the ordinary MRI. What looks surprising is that the frequency was that of heart beat; one would expect some resonance frequency of EEG, say 10 Hz. Premumably, the the possible evoked potentials due to the heartbeat were intentionally chosen as as a target of attention.

The finding fits very nicely with the TGD view of brain and quantum biology, in particular the TGD view of genetic code [L73, L142, L120, L141].

(a) In the simplest model, sequences of dark protons (ordinary protons with effective Planck constant $h_{eff} = nh_0$, which can be very large) at the flux tubes of the magnetic body associated with DNA would realize genetic code as sequences of dark proton triplets. Besides dark nucleotides, also dark codons and dark genes as quantum coherent dark 3N-protons would be possible and characterized by very large value of h_{eff}.

Also dark photon triplets would realize codons and give rise to dark genes as sequences of dark codons: 3N-photons. Communications between dark genes and would occur using dark 3N-photons by dark 3N-resonance. The 3N-frequency would serve as an address somewhat like in LISP and the modulation of frequency scale would create a sequence of resonances analogous to sequence of nerve pulses.

EEG would closely relate to the dark photon radiation between the magnetic body and brain. Also generalizations of EEG to other frequency ranges are suggestive.

(b) The dark magnetic flux tubes would be associated with water and its numerous thermodynamic anomalies and exceptional role in biology, could be understood by the presence of a dark phase involving long gravitational flux tubes carrying dark protons with $h_{eff} = h_{gr}$.

The required values of h_{eff} are huge, and this led to a connection with the Nottale hypothesis of gravitational Planck constant $\hbar_{gr} = GMm/v_0$, $v_0 \leq c$ is a velocity parameter. One would have $\hbar_{eff} = \hbar_{gr}$. The value of velocity parameter can be estimated from various applications. It would have a spectrum with the largesty value $v_0/ \simeq 1$ in the case of Earth with $M = M_E$.

(c) TGD leads also to an identification of B_{end}. TGD predicts monopole flux tubes (CP$_2$ homology is non-trivial) distinguishing TGD from Maxwellian electrodynamics. $B_{end} = 2B_E/5$ is identified as the monopole flux part of the Earth's magnetic field. The monopole flux tubes would carry dark matter and since they have huge quantum coherence scales, would naturally control ordinary biomatter. The control would involve frequency modulation by the variation of the thickness of the monopole flux tubes which would affect the field strength by the conservation of the monopole flux. The variation of the frequency scale would induce at the end of the receiver sequences of cyclotron resonance analogous to nerve pulse patterns.

(d) Magnetic body of DNA carrying dark DNA is expected to act as controller of the ordinary biomatter using cyclotron resonance mechanism. In particular, important biorhythms could correspond to cyclotron frequencies. Heartbeat defines one such biorhythm.

DNA nucleotide cyclotron frequencies are about 1 Hz for B_{end} assigned to the monopole flux tubes. Also for DNA sequences, such as codons and genes, the average cyclotron frequency would be around 1 Hz because the nucleotides carry the same charge and charge to mass ratio Ze/m, so that the cyclotron frequency depends only very weakly on the length of quantum coherent dark DNA segment.

(e) The variation of the heart beat frequency could be understood in terms of the variation of the monopole flux tube thickness for dark DNA. This variation would be basic motor action of MB making possible control of biomatter using frequency modulation inducing sequences of resonances manifesting as pulses. Nerve pulse patterns could be one manifestation of this mechanism.

2.7.4 How quantum gravitation could generate spin entanglement in TGD Universe?

One source of theoretical inspiration for the work of Kerskens and Perez [?] was the article "Spin Entanglement Witness for Quantum Gravity" of Bose et al [B11].

Classical interactions, be their gauge or gravitational interactions, cannot generate entanglement whereas their quantum counterparts do so in scales smaller than the scale of quantum coherence.

(a) The first open question is whether quantum gravitation is able to generate quantum coherence in long length scales such as the scale of the brain. The fact that gravitation has infinite range and is unscreened might allow this. This however requires a new view of quantum gravitation.

A gravitational 2-particle interaction or interaction induced by quantum gravitation is needed to entangle the systems. If spins or possibly magnetizations are in question, the entanglement can be detected by spin measurements as done in the experiment. The interaction must be such that it can be distinguished from ordinary magnetic interactions.

(b) If objects with mass above Planck mass behave like quantum coherent particles with respect to quantum gravitation rather than consisting of small quantum coherent units such as elementary particles, the gravitational fine structure constant $\alpha_{gr} = GM_1M_2/\hbar$

between objects satisfying $M_1 M_2 > m_{Pl}^2$ becomes strong and one expects that the situation becomes non-perturbative.

The condition $M_1 = M_2 = m_{Pl}$ is satisfied for a water blob of radius $\sim 10^{-4}$ meters and corresponds to the size of a large neuron [L88, L141]. The gravitational interaction energy $GM_1 M_2/d$ for distance $d \sim 10^{-4}$ m is about 10^{-2} eV and of the same order of magnitude as thermal energy.

(c) In the interferometer experiment a much larger phase difference could be generated in the TGD framework but the problem is that it is difficult to imagine a mechanism for creating a superposition of 2 locations of mesoscopic or even microscopic objects.

(d) It is also difficult to imagine a mechanism creating 1-1 correlation between location and spin direction (analogous to entanglement associated with spin and angular momentum).

The notion of gravitational Planck constant

The basic problem is what makes the quantum coherence scale so long.

(a) In the TGD framework, the non-perturbative character of the situation for $Mm \geq m_{Pl}^2$ motivates a generalization of the Nottale's hypothesis stating that the gravitational Planck constant $\hbar_{gr} = GMm/v_0$, $v_0 < c$ a velocity parameter. $\hbar_{eff} = nh_0 = \hbar_{gr}$ would be associated with gravitational flux tubes to which interacting masses M and m are attached, and would replace $\hbar$ with the gravitational fine structure constant $\alpha_{gr} = GMm/\hbar > 1$ meaning that $Mm > m_{Pl}^2$ is true. One could say that Nature is theoretician friendly and makes perturbation theory possible. This applies also to other interactions.

The gravitational Compton length $\Lambda_{gr} = GM/v_0$ does not depend on the mass m at all. For the mass of order Planck mass assignable to a large neuron one has $\Lambda_{gr} = L_{Pl}/v_0$, which is of order Planck length. Much longer quantum coherence scale is however required.

(b) In the case of the Earth, the basic gravitationally interacting pairs would be Earth mass and particles of various masses. The gravitational Compton length $\Lambda_{gr,E} = GM_E/v_0$ does not depend on the small mass and is about .45 cm for $v_0 \simeq c$ favored by TGD applications. By the way, this scale corresponds to the size of a snowflake [L135].

$\Lambda_{gr,E} \simeq .45$ cm defines a minimum value for the gravitational quantum coherence scale but much larger coherence lengths, say of order Earth radius, are possible. The size scale of the brain or even body would define a natural scale of quantum coherence. For objects with a size of order of a large neuron, the gravitational interaction could be quantal in scales of the brain, and actually in the scales of the magnetic bodies assignable to the organism.

(c) Earth-particle interactions can induce quantum coherence in the scale of the brain and the masses could be taken to be of the order of Planck mass so that they would correspond to water blob with size of 10^{-4}, so that their distance could be larger than d. This raises the hope that the effects of quantum gravitation quantum coherent in cell length scale or even longer scales could be measured although the interaction itself is extremely weak for elementary particles.

(d) For $r = 10^{-4}$ meters, $M = M_E$ would give $E \sim e^2/410^2$ eV ~ 2.5 eV. For $r = 5 \times 10^{-4}$ meters this would give $E \sim .01$ eV, roughly the thermal energy at the physiological temperature.

TGD allows the possibility of detecting gravitational interaction energies for objects of mass of say Planck mass or larger. In fact, the large value of gravitational Planck constant increases the extremely tiny cyclotron energies of ELF photons in EEG range to energies above thermal energy at room temperature [K51, K77, K78] [L142].

A possible TGD based mechanism generating spin entanglement

These considerations suggest a TGD based mechanism for the generation of spin entanglement, which is not directly based on quantum gravitational interaction but on microscopic and even macroscopic qravitionally induced quantum coherence making possible a generalization of the spin-spin interaction as a way to generate entanglement.

(a) Spin should correspond to an analogs of macroscopic magnetization rather than individual spin. Spin-spin interaction between "mesoscopic" defined by quantum coherent particles characterized by $\hbar_{gr}$ and having mass about Planck mass generates the entanglement which can be detected by measuring the "spin" of either particle. As a consequence also the "spin" of the other particles is determined and one has a standard situation demonstrating that the particles were entangled before the measurement.

Large value of the energy due to the large value of $\hbar_{gr}$ could mean that one has a dark Bose-Einstein condensate like state with a large number of ordinary particles, say protons at the gravitational flux tube representing the quantal magnet behaving like spin.

In the TGD framework, Galois confinement provides a universal mechanism for the formation of many-particle bound states from virtual particles with possibly momenta with components in an extension of rationals . The total momentum would have integer components using the unit defined by the size scale of causal diamond (CD).

(b) The dark cyclotron energy $E_c = \hbar_{gr} eB/m = \Lambda_{gr} eB$, $\Lambda_{gr} = GM/v_0$ of a mesoscopic particle whose particles are associated with (touching) the dark monopole flux tubes of the Earth's gravitational field, does not depend on its mass and is large.

The magnetic field created by this kind of particle would correspond in the Maxwellian picture to a field $B \propto \hbar_{gr} e/mr^3$. This would give for the magnetic interaction energy of the mesoscopic particles the estimate $E \sim \mu_1 \mu_2/r^3 = e^2 \Lambda_{gr}^2/r^3$.

2.8 TGD based model for the solar magnetic field, solar cycle, and gamma ray emission

Sabine Hossenfelder gave a link to a popular article (see `http://tinyurl.com/y6mpuggu`) telling about rather shocking new findings about Sun.

2.8.1 Solar surprise: looking sunspots again after decades

There are 5 times more gamma rays than expected and the spectrum has a deep and narrow dip in 30-50 GeV range. Spectrum continues to much higher energies than expected, at least up to 100 GeV. One proposal is that there could be dark matter in the interior of Sun yielding the gamma rays but is unclear how they could get to the surface without experiencing the same fate as the ordinary gammas from nuclear reactions. There is also a correlation with sunspot cycle (see `http://tinyurl.com/aqw2hmz`). Basic data and observations related to correlations with the solar cycle are described in the article [E6] (see `http://tinyurl.com/yxajyzp8` and [E5] (see `http://tinyurl.com/y2qlaaa2`).

(a) Power law spectrum is harder than for cosmic rays: spectral indices are $n = -2.2$ and $n = -2.7$ respectively (one has power law behavior E^n for the flux). The spectral intensity at 100 GeV is very nearly the maximum flux predicted by the model assuming that reflection of cosmic gamma rays explains the gammas.

(b) The spectrum has two components: poloidal component farther from equator and equatorial component largest during sunspot minimum. The equatorial contribution is maximal at solar minimum. The spectral index of the equatorial contribution is harder and higher energies are present. The energy range is maximal during spot minima. Gamma flux is reduced during sun spot maxima.

How the observed gamma rays could be produced in TGD Universe?

(a) Gamma rays cannot cannot be produced by nuclear reactions as ordinary gammas since nuclear energy scale is much below the scale of gamma rays extending to 100 GeV at least. Even the hadronic energy scale is too low. The gamma rays could be cosmic rays having already high energies: the spectral indices are however different. This leaves acceleration of charged particles producing gamma rays as the most plausible mechanism irrespective of whether the charged particles come from solar core or are cosmic rays.

(b) Dark magnetic flux tubes are basic notion of TGD and could serve as the channels along which charged particles could propagate to the surface without losing their energies in collisions. An interesting hypothesis considered already earlier is that solar magnetic field are what I call wormhole magnetic fields [K122] consisting of closed monopole flux tubes with flux and return flux at different space-time sheets connected by tiny wormhole contacts. This would predict that the flow is not evenly distributed but reflects the structure of the flux tube distribution. If the flux tubes have same M^4 projection they cause no effects on test particle and behave like dark energy creating only long range gravitational fields.

Charged particles could accelerate in the electric field of flux tube as they travel along flux tubes and generate gamma rays by some mechanism. The energy would be the increment of Coulomb energy if dissipation is neglected. A simple modification of flux tube type extremals allows the presence of helical magnetic and electric fields along flux tube orthogonal to each other. I have proposed the same mechanism to explain the gamma rays and high energy electrons at MeV energies associated with lightnings [K18]: in standard physics framework dissipative losses do not allow them.

(c) What could be the production mechanism of gamma rays? If flux tubes have sharp kinks, charged particles should experience large deceleration in the kinks and could emit high energy gamma ray in the process. The highly relativistic charge particle itself could leak out (one cannot exclude nuclei from solar core). Large deflection angles however requires transfer of momentum also to flux tube degrees of freedom.

(d) What could be the origin of the tip around 30-50 GeV? If the acceleration takes place in the electric fields assignable to the closed flux tubes assignable to solar dipolar magnetic field, the charged particle could travel several times around the loop giving rise to several energy bands explaining the gap and suggesting several of them. The flux loop would act as a particle accelerator.

(e) The charged particles could be provided by the solar core or they could be cosmic rays. The order of magnitude for gamma ray intensity is 5 times larger than in cosmic ray model, which encourages the identification as cosmic rays (see `http://tinyurl.com/psdp99h`). The origin of cosmic rays is however also a mystery and neutron stars, supernovae, active galactic nuclei, quasars, and gamma-ray bursts have been proposed as sources of cosmic rays.

A possible mechanism producing cosmic rays could be pair-annihilation of pairs of M_{89} pions with mass about 70 GeV [K60] to gamma ray pairs or charged particles with energies 35 GeV. Could the dip observed in the energy range around 30-50 GeV somehow relate to the charged decay products of M_{89} pions accelerating in the electric fields of flux tubes? Could the dip be gap without the decays of M_{89} pions?

In TGD the model for the formation of galaxies, quasars, and active galactic nuclei, and even stars, and planets relies on the formation of looped tangles along long thickening cosmic strings with topology resembling that of dipole magnetic field. Galactic matter would be produced by the decay of the flux tube energy to particles as analog of the decay of inflaton field. This could generate both charged particles and gamma radiation in the solar core and in neutron stars. The acceleration could be much more effective due to the strong magnetic and electric fields involved. Also charged particles can leak out from the flux tubes and cosmic rays could be produced by this mechanism. Cosmic rays could move along the highways defined by the long magnetic flux tubes connecting galaxies.

The understanding of the correlations with the solar cycle requires a model for the polarization flip. One can consider several options but the model based on reconnection splitting dipole loops from the flux tube tangle representing the analog dipole field is the simplest one. The simplest variant of the model requires zero energy ontology (ZEO) and quantum coherence at dark flux tubes in solar length scales and that long galactic string defines wormhole magnetic field with two sheets (type I and II) connected by wormhole contacts separated from each other in the sense that M^4 projections are disjoint.

(a) Let us denote the numbers of dipole loops of type $i = I, II$ by n_i. Assume that in the initial situation one has $(n_I = n_{max}, n_{II} = 0)$. B as maximum value B_{max}. The arrows of time at the two sheets are assumed to be opposite during cycles.

(b) The transition leading $B = B_{max}$ to $B = 0$ would be "big" state function reduction (BSR) changing the arrow of time at sheets of both type I and II. BSR would generate maximum number of new dipole flux loops of type II: $n_{II} \rightarrow n_{max}$ so that one has $n_I = n_{II} = n_{max}$ and $B = 0$.

(c) After that dipole loops of type I begin to split away by reconnections in "small" state function reductions (SSRs) so that n_I decreases. They split further in pieces and leak out from Sun whereas n_{II} remains unchanged since it corresponds to the passive boundary of CD - this is essential. Net B increases until one has $B = -B_{max}$.

(d) Next occurs BSR generating maximum number of new flux loop portions of type I leading $n_I = n_{II} = n_{max}$ and $B = 0$ and same is repeated except that now n_{II} decreases.

(e) One can understand the sunspot cycle in terms of split dipole loops leaving the Sun: their intersection with the solar surface would define sunspot pair and the distance of members of the pair would decrease to zero during the cycle.

The model leads to rather dramatic predictions.

(a) Various magnetic structures are predicted to appear in pairs with members related by an approximate Z_2 symmetry. For the magnetic field of the Sun this symmetry would be naturally inversion symmetry with respect to the surface of Sun. Also reflection symmetry can correspond to Z_2. This symmetry should be universal and the predictions are in sharp contrast with the locality principle of classical physics. One could even understand the mysterious "Axis of Evil" associated as anomaly of CMB and apparently giving special role for solar system (see `http://tinyurl.com/yb6nabw4`).

(b) Also unexpected connections with TGD inspired views about biology and consciousness emerge. Magnetic body (MB) is the intentional agent in living system Z_2 realized as inversion could related the parts of MB in the interior and exterior of Earth: could the idea about intra-terrestrial life introduced originally half-jokingly [K51, K53, K32, K32] make sense - at the level of MBs at least? ZEO based theory of consciousness predicts that conscious entities can have both arrows of time and death means reincarnation with opposite arrow of time. But where do these ghostly selves with opposite arrow of time reside? Could Z_2 - possibly realized as inversion - relate these selves to each other.

2.8.2 How the magnetic fields of galaxies and stars are generated?

To get a general enough perspective about the generation of time dependent B, one must consider the general model for how the magnetic fields of galaxies, stars, and planets are generated.

(a) The magnetic fields of galaxies, stars, and planets would have formed as tangles along cosmic strings thickened to magnetic flux tubes carrying monopole flux. . Tangles would be formed by the flux tubes forming knotty structures with flux tubes defining analog for subset of flux lines of dipole field. The flux tubes can organize in several ways.

Cosmic strings would be wormhole magnetic fields carrying opposite monopole fluxes at space-time sheets connected by wormhole contacts (in principle it is possible to consider

also single-sheeted monopole fluxes). I will talk about sheets of type I and II. If the flux tubes are on top of each other in the sense that M^4 projections are identical, the magnetic field experienced by test particle touching both flux tubes would vanish. The fact that the energy of the flux tubes gives rise to gravitational field can be used to argue that one can talk about dark energy in this case. The flux tubes can be connected by extremely short wormhole contacts at places, where they are on top of each other. If the Euclidian wormhole contacts can have tube-like M^4 projection, they would be also flux tube like.

(b) It is not clear whether the flux tubes of both type I and II are inside the volume bounded by Earth's B or whether second type of flux tubes are outside Earth. This gives rise to several options for how B can be realized as flux tube field and how the time dependence of B is obtained.

(c) One can imagine two options, which apply to both types of fluxes separately. For the most general option (Option I) the incoming flux tube can divide to smaller flux tubes going both to the interior and exterior of the dipole core. The extreme options (Option II and II) are that it flows entirely to the dipole core or divides to flux tubes travelling outside the dipole core (this situation is analogous to hydrodynamical flow past obstacle). It will be found that option II is most attractive one.

(d) Incoming flux long tube at given sheet forms a tangle. Consider first the tangle formed by the incoming long flux tube of given type at fixed space-time sheet, for definiteness restriction the consideration to flux of type I..

    i. For Option I the neighbouring flux portions of the flux tube portions inside and outside dipole core can have random orientations: this would be like random spin system without any magnetization. The average observed field would be random. For Options II and III this kind of situation is not possible.

    ii. The flux tube in the tangle can also arrange like spins in spontaneous magnetization so that neighboring portions of the flux tube are parallel both inside the core and outside it. The flux and return flux would be at different sides of the dipole core. This could give rise to an analog of say dipole field. For instance, dipole core could correspond to a spherical volume bounded by the Earth's surface. The extreme situation would correspond to Option II or III.

(e) For Option I the polarity of observed B could be due to a process analogous to spontaneous magnetization, whose degree can vary. The degree of magnetization would be determined by the ratio of the incoming fluxes going to the interior and exterior of the dipole core. The total flux Φ flowing inside dipole core is $\Phi = (p_1 - p_2)\Phi_{in}$, where p_i are the fractions of incoming fluxes going inside the dipole core and outside it. If the ratio equals to unity the net B vanishes in long enough scales. For Options II and II one cannot have time varying B unless the number n_i, $i \in \{I, II\}$ of dipole loops can vary.

Polarization reversal could be a dynamical process. For the analog of hydrodynamical flow the portions of the flow going through the dipole core and its exterior could change, and the fraction of these portions is the parameter determining the strength B. Oscillating B would mean oscillation of this fraction. Also the numbers n_i change and induce change of B.

(f) If the flux tubes of both types are in the volume carrying B, more possibilities arise for Option I since the flux tube portions of type I and II can have magnetizations of varying degree and these can be parallel or opposite inside (outside) dipole core.

(g) For Options II and III the magnetization direction cannot vary unless n_i can change and the total average magnetic field would vanish for $n_I = n_{II}$. n_i can however change if dipole loops split away by reconnection. It turns out that option II is the most promising one.

2.8.3 A model of solar magnetic field in terms of monopole flux tubes

The model relies on the notion wormhole magnetic field with flux tubes carrying electric fields, the notion of reconnection, and the theory of quantum measurement based on zero energy ontology (ZEO) [K63] and extending to a theory of consciousness [L54].

Also hydrodynamic analogy, the analogies with ferromagnetic hysteresis cycle, spontaneous magnetization, and de-magnetization, the analogy with the Meissner effect explaining solar spots as magnetic flux branching from the dipole axis of solar magnetic field, and Lenz principle (induction law) stating that magnetic field generates ohmic current in turn generating magnetic field opposing the change of the magnetic field , are used as guidelines.

(a) One can argue that the magnetic fields in question correspond to flux tube portions carrying monopole flux. The empirical support for the hypothesis comes from the fact that monopole fluxes need no currents to generate them. Cosmology is indeed full of long range magnetic fields whose presence is mystery in Maxwellian electrodynamics.

(b) Interaction of two kinds of magnetic fields would be involved. The first magnetic field identified as solar magnetic field, call it B, is assumed to have flux tubes wormhole magnetic field carrying monopole fluxes. No current is needed to create the magnetic flux: something impossible for ordinary Maxwellian fields. Note also that the cross section of flux tube is closed 2-D surface. One could call B topological magnetic field. Mathematically B could be seen as an analog of the external magnetic field H generating as a response total magnetic field as a sum of H and magnetization M.

Second magnetic field, call it B_1 would be Maxwellian and generated by Faraday induction. By Lenz principle it opposes the change of the magnetic flux associated with B and has roughly the same direction. B_1 would correspond to M. In the proposed framework the induced currents j would generate B_1 and it would be regarded as secondary rather than primary field.

Remark: The flux tubes of B_1 would be obtained from closed string like objects with CP_2 projection which geodesic sphere S^2 by replacing S^2 with disk D^2, by deforming to get flux tube, and gluing it to a large background space-time sheet along D^2. The current creating B_1 would be associated with the boundary of D^2.

One cannot of course exclude the Maxwellian option for B.

(a) The portion of flux tubes of B identifiable as analog of the dipole core of Maxwellian dipole field would consist of particles with magnetic moment whereas for monopole flux no magnetic moment is needed. Magnetic moment could be due to spin or orbitals motion.

Remark: One could wonder whether quantum-classical correspondence (QCC) requires that the monopole flux has as quantum counterpart magnetization representable in terms of fermions.

(b) The contribution of the spin to magnetic field is rather small so that the idea about spontaneous magnetization at flux tubes defining dipole does not look promising. Note however that the large value of h_{eff} together with proportionality of $\mu \propto \hbar_{eff}/m$ could change the situation. Macroscopic quantum coherence making possible quantum states with macroscopic radius for the orbits could be considered and would conform with the idea that the flow of currents generates B. B could be of course generated also classically.

2.8.4 Are wormhole magnetic fields really needed?

The additional assumption is that wormhole magnetic fields involving two space-time sheets connected by wormhole contacts appear in the volume containing B. More generally, fundamental magnetic fields would be wormhole magnetic fields. This additional hypothesis is

necessary in the recent model of elementary particles and p-adic fractality suggests that the property holds true also astrophysical scales.

(a) In elementary particle scales monopole flux tubes associated with wormhole magnetic fields must be closed and involve return flux along second space-time sheet. If the two space-time sheets have same M^4 projection, the test particle touches both sheets and experiences essentially no gauge fields. At QFT limit one would have no fields. Therefore the M^4 projections of the flux tubes at the two sheets must be disjoint in order that one has normal magnetic field in operational sense.

The energies of both flux tubes however sum up and the wormhole flux tube pair has long range gravitational interactions. The attractive interpretation is that if the volumes in which the sheets have same M^4 projection, the energy of flux tube pair corresponds to dark energy. The portions giving rise to tangles in which the flux sheets have separate projections give rise to ordinary matter. This would give rise to galaxies, stars, and planets and even smaller objects in various scales. Flux tubes would thicken and their energy would decay to ordinary and dark matter.

(b) Wormhole magnetic fields could define pairs of systems. The understanding of the geometric correlates for the hierarchy of Planck constants have already led to the realization that many-sheeted space-time means that one space-time surface can be regarded as n_1-fold covering of CP_2 and n_2-fold covering of M^4 such that one has $h_{eff}/h_0 = n = n_1 n_2$ holds true. For n_1-fold covering of CP_2 the sheets can be disjoint regions of M^4. Although the regions are disjoint, they are physically closely correlated. This is classical correlate for macroscopic quantum coherence coded also by the large value of n.

For $n_1 = 2$ one obtains the simplest pairs. Also even values of $n_1 = 2m_1$ are of course and would describe a pair of structures with m_1 components. The components would be most naturally flux tubes fusing to larger flux tube fractally.

(c) This view becomes understandable if one takes CP_2 coordinates or $M^2 \times CP_2$ coordinates as a coordinate system so that the roles of space-time and fields are changed or partially changed. At the level of wormhole contacts the change of the roles of M^4 and CP_2 is necessary. For string like objects $M^2 \times S^2$ replaces M^4. This corresponds to that part of TGD, which does not allow description in terms of GRT.

Playing with the ideas generates questions and new ideas, not always realistic. At this time the question is following.

(a) Could the Euclidian region associated with wormhole contact and connecting wormhole throats at the two sheets connect two disjoint, even distant regions of M^4? If so, the wormhole contact would be analogous to Einstein-Rosen bridge except that it has Euclidian signature of the induced metric.

Could one identify the wormhole contact as a space-time correlate for entanglement or prerequisite for it? There would be no signal involved since in Euclidian space-time regions one cannot talk about propagation. Euclidian flux tubes are in central role in p-adic mass calculations [K55] but they are extremely short.

I have assumed that time-like flux tubes can serve as correlates of entanglement. Could one can think that Minkowskian flux tubes would allow classical signalling and Euclidian flux tubes would serve as classical correlates for entanglement. Could both aspects be involved with quantum communications?

Remark: One can obtain Euclidian space-time region from piece of M^4 by performing a large enough deformation in CP_2 directions and also this could give rise to Euclidian induced metric. One can also have cosmic string with piece of M^2 as string world sheet and deformed such that one has flat E^2. The deformation of this string world sheet would represent Euclidian flux tube.

(b) Here one must be however extremely cautious. Hitherto I have regarded shortness of flux tubes as obvious, and might have been right. One cannot however exclude the possibility that also Euclidian wormhole contacts are involved but they do not seem to be necessary: one could have wormhole magnetic fields with wormhole contacts only in

the regions where M^4 projections overlap. All depends on the properties of preferred extremals.

2.8.5 How to understand the solar cycle?

Sunspot cycle (see `http://tinyurl.com/y2qlaaa2`) has period of 22 years and consists of two 11 year half-periods during which opposite polarity of B. The understanding of the mechanism causing the flip of the polarity looks the most difficult part of the problem - at least from TGD point of view. Each half cycle starts from a situation in which the dipole part of B vanishes and sunspots appear at opposite sides of equator at symmetrically related positions at mid-latitudes (about 30 degrees from equator).

Sunspots (see `http://tinyurl.com/y2qlaaa2`) carry intense magnetic fields (fields strength is about 2 Tesla in the vicinity of Sunspot according to Wikipedia) and they have lower temperature than surroundings due to the magnetic pressure. During the half-cycle Sunspots drift towards equator and maintain their polarity. The diagrammatic description of the time evolution at the solar surfaces is known as butterfly diagram. The natural interpretation is that the sunspots at opposite sides are connected by flux loops.

During the cycle the dipole field with opposite polarity as compared to previous cycle is generated and towards the end of the cycle there is a period in which no sun-spots are observed: they would be near equator if present. The spots could be present but the density of elementary flux tubes could be too low to give rise to average field strength enough to cause an observable reduction of temperature.

Polarity reversal of B

What could be behind polarity reversal. First some guiding ideas.

(a) An analogy with ferromagnetic hysteresis circuit suggests itself. B generates B_1 having opposite direction. When the value of B_1 is critical it induces a phase transition in which the direction of Kähler flux is changed at flux tubes. Second half of the 22 year sunspot cycle would start. The ohmic current j generated by B would change and this would induce the magnetic turbulence accompanying solar spots.

This analogy is not quite complete since the generation of B with opposite sign occurs slowly whereas the vanishing of magnetic field isa fast process. De-magnetizing phase transitions seems therefore a natural analog for the dis-appearance of B.

(b) What the analog of spin flip means is highly non-trivial question when the size of the analog of spinning particle is of the size scale of Sun. Quantal and topological effect in solar scales could be in question and involve both TGD view about space-time and fields as well as hierarchy of Planck constants as description of dark matter. The model to be described in the sequel applies universally in TGD Universe and leads to quite dramatic and testable implications.

Consider next general TGD inspired ideas relating to the change of the polarity of B in TGD framework. A general model based on the formation of flux tube tangle as a representation of the say dipole field looks like a safe starting point and provides also a general model for the change of the polarity. An essential element is the distribution of incoming flux of long cosmic string like object to fluxes going through the interior and exterior of the dipole core and return back through exterior and interior. The fractions going through interior and exterior determine the strength of observed B. Whether both kinds of flux tubes are present or not, depends on model.

The first model, call it Model I, is classical. Now one could do using only single flux tube type, say type I, which however must divide to flux tubes travelling both inside and outside the dipole core.

(a) The decay of B would correspond to option I involving the change of fractions p_1 and $p_2 = 1 - p_2$ of the flux tube portions going through the dipole core reducing the parameter $p_1 - p_2$ to zero. The permutations of flux tube portions inside and outside core must lead to $p_1 - p_2 = 0$ and one expects that this process continues and changes the sign of $p_1 - p_2$ and therefore induce polarization reversal. The duration of the process taking $p_1 - p_2$ to zero is rather short as compared to the duration of the half-cycle. The duration of the sunspot minimum is about 10 per cent of that for the entire half cycle. In the hydrodynamical analogy the process would be redistribution of the incoming flow and could be modelled phenomenologically as a change of flow resistances associated with the two channels involved.

(b) This model does not involve reconnection process and does not provide any obvious explanation for the appearance of sunspots nor for the reconnection process associated with the reversal of the polarization of B. Therefore Model I is not promising.

Second model, call it Model II, is quantum mechanical and involves ZEO in an essential manner and one could assume that incoming flux tube enters to the dipole core entirely (option II).

(a) Dipole winding number n_i characterizes the situation for a given type of flux tube. The larger the value of n_i, the larger the dipole strength. n_i could change by reconnection process in which entire dipole loop reconnects and snips away. This followed by further splitting to flux loops would correspond to the emission of magnetic loops from the Sun.

The opposite process would correspond to a fusion of flux loop with a long flux loop but looks thermodynamically implausible. Also a fusion of a short flux loop with long flux loop and the growth of the reconnected part to large dipole loop looks implausible.

(b) Could ZEO based quantum TGD allowing temporary time reversals come in rescue? At dark space-time sheets one can indeed imagine the possibility of time reversals. Ordinary matter would be controlled by dark matter with larger value of $h_{eff}/h_0 = n$ serving as an IQ in TGD inspired theory of consciousness, and would be forced to follow the leader in conflict with its thermodynamical instincts. Could the process involve "big" state function reduction (BSR) and could the dominance of flux tubes of type I and II correspond to different arrows of time at the level of dark flyx tubes? Reconnections for flux loops of say type II would occur in time direction opposite to the standard direction of time but second law would hold true in generalized sense.

(c) The simplest option is that all incoming flux enters to the interior of the dipole core ($p_{2,I} = 0$ identically) or to its exterior ($p_{1,I} = 0$) identically. The first looks more plausible. The integers n_i, $i = \{I, II\}$ characterize the numbers of dipole flux loops carrying magnetic fields with opposite polarizations. Dipole strength is proportional to $n_I - n_{II}$. The arrows of time at the two sheets are assumed to be opposite for flux tube of type I and II.

(d) Consider now a model for the first half-cycle.

   i. Assume for definiteness that in the initial situation one has ($n_I = n_{max}, n_{II} = 0$). B as maximum value B_{max}.

   ii. The transition leading $B = B_{max}$ to $B = 0$ would be "big" state function reduction (BSR) changing the arrow of time at sheets of both type I and II. BSR would generate maximum number of new dipole flux loops of type II: $n_{II} \to n_{max}$ so that one has $n_I = n_{II} = n_{max}$ and $B = 0$.
   This transition is clearly a quantum analog of spontaneous magnetization in sector II. Could one say that a spontaneous magnetization already present in sector I induces opposite spontaneous magnetization in sector II?
   Quantum classical correspondence (QCC) inspires the question about there is in the fermionic sector genuine spontaneous magnetization involving fermion spins. Could a formation cyclotron condensate of spin zero Cooper pairs with members at flux tubes of type I and II and having opposite spins accompany this process?

iii. After that dipole loops of type I begin to split away by reconnections in "small" state function reductions (SSRs) so that n_I decreases. They split further in pieces and leak out from Sun. Net B increases until one has $B = -B_{max}$. This process is analogous to gradual decay of magnetization.

iv. What looks strange that n_{II} would remains unchanged during this process. In ZEO this makes sense: it would corresponds to the passive boundary of causal diamond (CD). One would have two CDs having common portion of boundary, call it δCD. Since the arrows of time are opposite, $\delta CD \subset \delta CD_{II}$ would be passive and experience generalized Zeno effect whereas $\delta CD \subset \delta CD_I$ for CD_I would be active experiencing gradual decay of magnetization in the sequence of "small" state function reductions (SSRs).

v. Topologically one can understand the sunspot cycle in terms of split dipole loops leaving the Sun: their intersection with the solar surface would define sunspot pair and the distance of members of the pair would decrease to zero during the cycle.

(e) The model for the second half-cycle is identical. First occurs BSR generating maximum number of new flux loop portions of type I leading $n_I = n_{II} = n_{max}$ and $B = 0$ and same is repeated except that now n_{II} decreases.

The classically highly counter-intuitive aspect of this picture is that dipole loops would appear in BSR as quantum leap in astrophysical scales. There would be no continuous time evolution generating additional dipole loops. Their dis-appearance by reconnections would correspond to classical time evolution. If one performs time reversal for thermodynamic intuition, there is nothing mystical involved.

Model II looks to me more promising -if not even the only possibility - although conservative colleague can criticize it for the speculative new physics features: these features are however basic elements of new physics predicted by TGD.

Sunpots as intersections of split dipole flux loops with the Earth's surface?

How could sunspots be understood in the picture suggested by Model II?

(a) BSR would induce the cancellation of B. Sunspots should emerge after the cancellation and serve as a signature of BSR inducing change of the arrow of time at flux tube space-time sheets. The usual statement is that the density of the elementary flux tubes composing the the split flux loop is high enough the average magnetic pressure lowers the temperature so much that the solar spot becomes visible.

Could the local reduction of temperature inside sunspots, something not expected in the naïve thermodynamical thinking be forced by the change of the arrow of time at dark flux tubes? One would have leveling of temperature differences but in opposite time direction induced by dark flux tubes having arrow of time opposite to the standard one: by dark flux tubes of type I during first half-cycle and flux tubes of type II during second half-cycle.

(b) The appearance of sunspots would relate naturally to the reconnection process leading to the disappearance of the dipole loops Do the snipped flux loops, which can split further to pieces eventually leaving Sun, intersect its surface at the sunspots so that the formation of sunspot and its disappearance would correspond to a splitting of closed dipole loop by reconnection and further splitting to smaller loops.

The motion of sunspots towards equator would correspond to the outwards motion of the split flux dipole loop and solar spots would represent its intersection with solar surface. This also explains why the number of sunspots is gradually reduced during the half-cycle.

(c) The fact that sunspots emerge first at latitudes $\pm\pi/6$ means that the split dipole flux loop intersects Earth's surface at positions with distance $h = R_E/2$ from equator. Since the distance is reduced after that, the outward motion of the loop requires that dipole core has height smaller than R_E.

Also in the case of Earth's magnetic field an analogous quantum picture might apply [L24] and solar spots might have "Earth spots" as magnetic anomalies. What is fascinating that the reversals of the Earth's magnetic field would be quantum processes in the scale of entire Earth and the magnetic field would go to zero instantaneously. What this means for living systems is an interesting question to ponder.

Does the polarity inversion involve spatial inversion?

Assume that the flux tubes correspond to monopole flux tube, which defines two-sheeted wormhole magnetic field. There is a strong temptation to assume that the members of the pairs defined by portions of flux tubes of given type (I or II) in the interior and exterior of dipole core are related by an approximate symmetry. If so, one would have doubles or mirror pairs of systems. What kind of symmetry polarity inversion for the solar B could correspond?

(a) Assume that the two flux tube sheets of wormhole magnetic field have M^4 projections with empty intersection. Polarization reversal could permute the positions M^4 projections of the two sheets of flux tubes turning the direction of the magnetic flux. If the space-time surface representable as a map from CP_2 to M^4, the flip could be understood as a reflection in CP_2 degrees of freedom permuting the M^4 images and represented also as a reflection or inversion in M^4. In adelic physics [L51, L52] Z_2 has interpretation as subgroup of Galois group.

(b) Could the solar magnetic field be doublet structure mapped to itself under Z_2? The identification of the pair as being formed by symmetry related parts of the flux dipole tubes in the interior of Sun and outside it is what comes naturally in mind. The symmetry could be realized as inversion with respect to the surface of Sun mapping inside and outside to each other. Inversions are indeed symmetries of Maxwell's theory, gauge theories, and of twistor Grassmannian approach. Also for $n_1 = 2m_1$ m_1 could correspond to a subgroup of CP_2. One would have double of bundles formed from m_1 flux tubes: dipole flux tuve consisting of m_1 elementary flux tubes.

(c) The symmetry involved need not always be inversion. It could be also spatial reflection. The possibility of higher values of $n = n_1 n_2$, $n_1 = 2m_1$ suggests the possibility of long range correlations between m_1 pairs in astrophysical scales manifesting themselves quite concretely.

(d) The representability of the group permuting flux tubes as finite discrete subgroups of $SO(3)$ acting as symmetries of Platonic solids would be very natural, and one can ask whether the appearance of Platonic solids in biology reflects this. This might allow to get some idea about why icosahedral model of harmony in terms of Hamiltonian cycles leading to the notion of bio-harmony predicts correctly genetic code [L12].

2.8.6   Trying to understand solar gamma ray spectrum in TGD Universe

One can try to understand the observations about gamma rays [E6, E5] (see http://tinyurl.com/yxajyzp8 and http://tinyurl.com/y2qlaaa2) in the proposed picture. Some kind of acceleration mechanism suggests itself strongly.

(a) An electric field associated with flux tubes with helical magnetic field is the simplest option. TGD allows simple deformations of flux tube like solutions [K50] in which Kähler magnetic and electric fields are orthogonal and helical and one can hope that they define preferred extremals.

What about the electric force experienced by a test particle when the flux tubes of type I and II having same M^4 projection? The identification these objects in terms of dark energy would suggests that also the net electric force cancels and this kind of flux tube pair serves as a kind of superconducting wire.

(b) If the flux tubes and gamma rays are dark with large $h_{eff}/h_0 = n = n_1 n_2$, they can propagate without interactions with ordinary matter. The dissipation would be solely due to curvature, in particular the kinks of the flux tube but would not be present at rectilinear portions of the flux tube. Therefore the amount of dissipation would be small.

Forgetting the losses caused by the curvature of the flux tube, there would be maximum energy $E = ZeV$, V the voltage along flux tube section to which the particles such as protons can be accelerated, and this would define cutoff energy for the emitted gamma rays. I have proposed that this kind of model explains also the gamma rays associated with lightnings [K18].

(c) The dip in the spectrum suggests at least two energy scales for accelerated particles emitting gammas as brehmstrahlung and defining the endpoint of the brehmstrahlung spectrum. The explanation that comes in mind is that particles can go through several cycles of acceleration along closed dipole flux tubes and emit gamma rays at kinks. This would give rise to energy bands labelled by the number of acceleration cycle. The possibility of saturation looks plausible. One would have particle accelerator analogous to storage ring. What would be new as compared to LHC would be quantum coherence in the scale of accelerator. For the values of h_{eff} involved the dark particles would have Compton lengths of the order of the size of Sun.

(d) How could the charged particle and gamma rays emerge from the flux tubes? One can start from everyday experience. Car can fall off the road in sharp curve. Now the sharp curve would correspond to a kink in flux tube. By momentum conservation there should be a large exchange of momentum with the flux tube to keep the charged particle at the flux tube and this is improbable for sharp kinks. Since the charged particles are relativistic and gamma rays must be directed to the observer, the change of momentum direction must be large. In any case, this requires a large exchange of momentum with the collective flux tubes degrees of freedom. It is quite possible that several gamma rays are emitted at the kink. The charged particle can also leak out.

A proper description of the situation might be in terms of dark cyclotron states. If the TGD view about dark matter as $h_{eff}/h_0 = n = n_1 n_2$ phases is true on can treat the bundle of flux tubes as single quantum coherent entity. In particular, the solar spots could be identified as this kind of quantum coherent flux tube bundles and n_2 could correspond to the number of elementary flux tubes.

(e) The sharp kinks appear at two places. Near the North pole where dipole field lines/flux tubes make a sharp kink. Due to differential rotation the flux tubes associated with the dipole contribution follow the rotation of equator and develop tentacles. The shape of strongly flattened square implies instability against splitting of the tentacles and decay to flux loops by reconnection. This part of the magnetic field decays and leads to magnetic turbulence. Also in the standard picture differential rotation is expected to induce reconnections of field lines. The kinks at the ends would induce emission of gammas and leakage of charged particles. Even single gamma ray could be enough.

Gamma radiation indeed has two components. Polar component is roughly constant and the equatorial component having sharp maximum during sunspot minimum.

Spectral index is different for the energy distributions for cosmic rays and gamma rays from Sun: solar distributions are harder. Also the equatorial distribution is harder than polar distribution. One expects that the distribution depends on the energy of the gamma ray and on the sharpness of the kink. In the case of polar distribution two gammas is minimum whereas for equatorial distribution single ray can be enough. This softens the polar distribution as compared to equatorial one. Since several loops are possible even the cosmic ray distribution for charged particles can harden.

Where could the charged particles originate?

(a) The basic observation is that flux of gammas is 5 times higher than predicted by the model identifying them as cosmic rays reflected in solar magnetic field fails. Roughly the

same order of magnitude suggests that cosmic gamma rays could be the origin. Spectral distribution does not support this idea.

(b) Charged particles could come from the solar core or along the long thickened cosmic string continuing as flux tubes of the magnetic field. Cosmic string would not accelerate the charged particles but only feed in the particles beams as kind of supra currents. Also cosmic rays could enter the flux tubes as assumed in the original model: in fact, cosmic rays would naturally arrive along the long flux tubes connecting Sun to sources of cosmic rays.

This could explain why the upper bound for gamma ray energies for cosmic rays equals to the maximal detected energy (100 GeV). Instead of being reflected cosmic rays could rotate possibly several times around dipole flux tube and leak out in the kink. The emission of gamma rays at kinks reduces the energy gain for simple loop and for higher number of loops the reduction is larger. Saturation is quite possible.

(c) The origin of galactic rays is still a mystery (see `http://tinyurl.com/psdp99h`). One proposal is that they originate from neutron stars. The proposed acceleration mechanism could be at work in the case of neutron stars so that neutron star could indeed provide the charged particles. As discussed there are also other options.

2.8.7 Surprises about the physics at the boundary of the heliosphere

I learned from interesting results about cosmic rays and behavior of magnetic field at the boundary of heliosphere (see the article "*Voyager Mission Reveals Unexpected Pressure at The Edge of The Solar System*" (see `http://tinyurl.com/y474zww4`). The article "*Pressure Runs High at Edge of Solar System*" (see `http://tinyurl.com/y5t258c8`) gives a more precise description of the findings.

There were two spacecrafts. Voyager2 was inside heliopause ad Voyager1 slightly outside it. They experienced different kind of reduction in cosmic ray flux. I picked up the following piece of text explaining the basic findings.

> The scientists noted that the change in galactic cosmic rays wasn't exactly identical at both spacecraft. At Voyager 2 inside the heliosheath, the number of cosmic rays decreased in all directions around the spacecraft. But at Voyager 1, outside the solar system, only the galactic cosmic rays that were traveling perpendicular to the magnetic field in the region decreased. This asymmetry suggests that something happens as the wave transmits across the solar system's boundary.

Consider first TGD based view about magnetosphere of Sun.

(a) TGD allows two kinds of magnetic fields: those for which flux tubes carry monopole flux and those for which they do not. Monopole flux tubes are impossible in Maxwellian world and solve several problems related to magnetic fields such as the existence of magnetic fields in cosmic scales, and the maintenance problem of the Earth's magnetic field [L24]

One of the latest applications is to the understanding of the weird properties of the magnetic field of Mars identified in the model as consisting of monopole flux tubes [L78] and thus visible only through northern and southern lights involving reconnections of the monopole flux tubes. Also Mercury has unexpectely strong magnetic field and it could correspond to monopole flux tube tangle associated with flux tubes from Sun.

The latest application is to a model of earthquakes and volcanic eruptions [L79] known to be induced by cosmic rays but quite too deep for them to penetrate to the depths required. There is strong correlation with solar minima and it has turned out that the solar minimum corresponds to maximum of magnetic field. There is also a causal anomaly: electromagnetic fluctuations in upper atmosphere precede rather than follow these event. The new view about magnetic fields and zero energy ontology predicting that arrow of time changes in "big" (ordinary) state function reductions explains these

anomalies. Causal anomalies involving change of also thermodynamical arrow of time are a generic signature of macroscopic state function reductions in TGD Universe.

(b) Also a new view about cosmic rays emerges. Cosmic rays would travel along flux tubes of a gigantic fractal flux tube network defining analog of nervous system for the Universe [L85]. This picture leads to a rather detailed model for the formation of galaxies, stars and even planets as tangles along the flux tubes of this network having same topological structure as dipole magnetic field but with flux tubes carrying monopole flux [L68].

(c) In TGD framework heliosphere corresponds to magnetically to U-shaped tentacles from Sun - flux tubes emanating from Sun radially and returning back to Sun and carrying solar wind and also cosmic rays. They look locally like parallel flux tubes carrying opposite magnetic fluxes. Flux tubes would extend to the heliopause and turn back and emit by reconnection narrow rectangle shaped closed flux tubes.By fractality these tentacles appear in all scales and are in crucial role in understanding of bio-catalysis and basic biochemical reactions like DNA replication, transcription of DNA to RNA, and translation of RNA to polypeptides.

(d) Cosmic rays can travel as dark particles along them in TGD sense meaning that they would have effective Planck constant $h_{eff} = n \times h_0$, where h_0 is minimal value of h_{eff}. The flux tubes from Sun would thus bring dark particles along flux tubes. Suppose that the flux of cosmic rays arrive along these flux tubes, perhaps as dark particles.

Next one must translate various words to physical concepts in TGD framework.

(a) Heliosheath (Voyager 2) is expected to be a turbulent boundary region. Magnetic turbulence means that the directions of U-shaped flux tubes coming from Sun are random. This is magnetic counterpart of a boiling liquid.
Closed U-shaped flux tubes from Sun reach the heliopause before reconnection meaning emission of closed flux tubes looking like narrow rectangles travelling in radial direction: the direction of the flux is assumed to be along the radial flux tube and two directions are possible.

(b) The region outside heliopause (Voyager 1) contains two kinds of monopole flux tubes, which need no current for their existence. Those of galactic magnetic field locally parallel to heliopause like in liquid flow around obstacle plus the closed flux tubes as outcomes of reconnection. They are assumed to be narrow rectangle-like objects in radial direction coming from the heliopause. There are also flux quanta of ordinary magnetic field generated by currents.

(c) The wave called global merged interaction region (GMIR) caused by the activity of Sun means reconnections for the U-shaped flux tubes from the Sun at solar surface generating ordinary magnetic fields giving rise to sunspots. This reduces the number of U-shaped flux tubes and therefore also solar wind and the amount of cosmic rays arriving along them. Thus the reduction of solar wind and of cosmic rays both inside and outside heliosphere.

(d) If the local directions of solar flux U-shaped tubes inside heliosheath are random by turbulence the reduction of flux takes place in all directions. It the long sides of closed flux tube rectangles are radial (orthogonal to the dominating galactic magnetic field), the reduction of flux takes place only in directions orthogonal to the galactic magnetic field. This was observed.

(e) The high pressure could be due to the presence of closed flux tubes formed in reconnection and would represent the contribution of solar wind.

2.8.8 About general implications of the pairing hypothesis

If wormhole magnetic fields appear in all scales, flux tube pairs and more general $n_1 = 2m_1$ multiplets of flux tubes decomposing to m_2 pairs should be universal aspect of the dynamics of TGD Universe. In the following the implications are considered only briefly. The basic consequence is of course that Universe becomes in all scales a quantum coherent object and the locality hypothesis of classical physics would be simply wrong.

Elementary particle physics

Wormhole magnetic fields appear already in elementary particle physics. Elementary particles correspond to at least 2-sheeted flux tube structures with wormhole throats containing the boundaries of string world sheets carrying fundamental fermions. I have already earlier considered the possibility that the M^4 projections of the sheets are disjoint.

Remark: In the general case one would have $n_1 = 2m_1$. Color symmetry for quarks could have as a remnant $m_1 = 3m_3$. For leptons m_1 would not be divisible by 3. Since n_1 corresponds to discrete subgroup for $SU(3)$, m_1 could correlate with the triality of $SU(3)$ partial wave defining the color quantum numbers of the particle.

Astrophysics and cosmology

The predictions in astrophysics and cosmology are in strong conflict with the locality principle of classical physics.

(a) The model for magnetic spin flips in solar cycle leads to the conclusion that solar magnetic field could have doublet structure with parts related by inversion with respect to solar surface. Could the entire MB of Sun have copy somewhere. In principle this is an experimental question. The copy would be connected to Sun by wormhole magnetic flux tubes and this suggests long range correlations.

Stars indeed very often appear as binaries (see `http://tinyurl.com/oooagma`). Could these pairs be related by approximate CP_2 symmetry inducing reflection of inversion in M^4? Could the planets of mirror paired stars be related by Z_2? Could there be correlations between the rotation planes for instance.

(b) What about Earth could be invariant under inversion so that the radius of Earth could define the radius remaining invariant under inversion. This could make Earth so special as far as life is considered.

Could Earth have a double in longer length scale? The least science fictive candidate would be another planet.

Mars (see `http://tinyurl.com/mttm7h8`) has radius $.53R_E$, which is the radius that Earth would have had before the Cambrian Explosion according to TGD inspired variant of Expanding Earth model [L62]. Mass is 11 per cent of the Earth's mass. There are indications for life in Mars. Venus (see `http://tinyurl.com/72rz2g2`) has characteristics surprisingly near to those of Earth except that rotation is in opposite direction than for Earth: the rotation period is -243.025 days. The distances from Sun for (Venus,Earth,Mars) triplet are $(.72, 1.00, 1.52)$ AU. Could Venus and Mars form a mirror pair with respect to inversion at radius R_E.

Recently Nasa found an exoplanet christened as Gliese 581d (see `http://tinyurl.com/yxdmpnbj` and `http://tinyurl.com/y2bwco6q`) located in constellation Lyra at distance of only 20.4 light years. The planet is almost exact copy of Earth as far the prerequisites of life are considered. Semimajor axis of the orbit is .22 from that of Earth. Mass is about 6.98 times higher than Earth mass, the radius is $2.20R_E$. The Sun of the planet could be mirror image of Earth: if this is the case, the should be correlations such as common rotation planes.

(c) I have considered [L24] also a model for the changes of the orientation of Earth's magnetic field involving the interaction of monopole flux tubes and ordinary magnetic field via magnetic torques, and the solar model probably generalizes almost as such. Now however the orientation of the magnetic field can vary. This could relate to the fact that the axis of rotation differs from the magnetic axis. Again inversion as an approximate symmetry is suggestive.

(d) The most intriguing finding about CMB spectrum is anomaly known as "Axis of Evil" (see `http://tinyurl.com/yb6nabw4`). The anomaly appears to give for the plane of planetary system of Sun and the location of Sun a greater significance that one might expect by change. This violates the Copernican Principle. The effect resembles selection

of spin quantization axis in quantum measurement of spin performed by the measurer. A possible explanation at the level of space-time is that by $h_{eff}/h_0 = n$ hierarchy disjoint space-time sheets even in cosmic length scales are related by discrete CP_2 symmetries implying correlations.

Biology

The binary structures populating biology might correspond to pairs of monopole flux tubes. The original motivation for the proposal that they are important comes from p-adic length scale hypothesis: primes $p \simeq 2^{k+2}$ and $p \simeq 2^k$, where k and $k+2$ are twin primes, could define structures with size scale $L(k+2)$ decomposing to a pair of structures with size scale $L(k)$ [K19]. The structures of twin pair would form quantum entangled structures.

(a) DNA and RNA double strands are basic examples of these structures. Even single DNA and RNA molecules form mirror pairs with their conjugates and could be connected by long wormhole contacts. This would make them quantum coherent structures making possible the mysterious ability of bio-molecules to find each other in the molecular crowd. Bio-systems would be extremely organized structure rather than a soup of randomly moving molecules. Could this kind of symmetries characterize all molecules that are paired or form higher structures with $n_1 = 2m_1$?

(b) Cell membranes are formed by pair of lipid layers and also these could be twin pair. Epithelial sheets consist of two cell layers. At the level of body and brain there is also a pairing of subs-structures in left and right brain. Pineal gland is a connected structure could itself be a pair. Also brain hemispheres form a pair. Even married (or even non-married!) couple could form this kind of pair and what looks like a random personal relationship could be something much deeper.

(c) All multi-molecular structures in living matter at least could correspond to groups of n_1 disjoint space-time sheets, perhaps magnetic flux tubes. The value of n_1 would serve as a measure for the scale of coherence and complexity.

(d) Inversion corresponds to the inversion of the polarity of the Earth's magnetic field but might happen also at the cell level. In biology involution turning cell inside-out occurs during the gastrulation phase (see `http://tinyurl.com/y4pvpxyr`) of the embryonic development and leads to a development of 2 (ectoderm,endoterm) or 3 cell layers (ectoderm, mesoderm, endeterm) giving later rise to different types of tissues. This process looks rather mysterious - at least to me. Could involution be induced by the inversion of the magnetic body of the developing embryo?

(e) MB controls (also our) biological body (BB) and uses scaled variants of EEG consisting of dark photons for this purpose [K35]. It is natural to assume that our MB corresponds to the part of MB above the Earth's surface. If Z_2 acts as inversion with respect to the surface of Earth then also the part of MB below the surface of Earth should correspond to an intentional agent.

Could these MBs be associated intra-terrestrials ITs or could they control same BBs as our usual MBs? Here one must consider the precise definition of inversion: is it with respect to the surface of Earth or the boundary of the dipole core of the Earth's B? Taking inversion in the first sense of the definition very literally, one could argue that plants having also roots are inversion invariant but animals are strictly speaking not inversion invariant in either sense. Therefore we would have separate personal mirror MBs and also BBs: analogs of Dr. Jekyll and Mr. Hyde. In fact, I have have-jokingly considered a model for crop circles, and this led to a crazy idea about IT life [K32, K33]. Could this idea be not so crazy as it looks first? Accepting dark matter as $h_{eff}/h_0 = n$ phases, the high temperature in Earth interior ceases to be an objection.

(f) $n_1 = 2m_1$ implies also that conscious entity can have n_1 disjoint pieces. They could be MBs controlling the same BB (multiple personality disorder) or maybe even separate BBs. Could these possibly distinct BBs locate at different sides of globe or even cosmos? What comes in mind Kieslowski's trilogy "Three colors". When the connection between

hemispheres is destroyed, brain hemispheres controlling different body halves would live effectively separate lives, and could even fight for the control of BB. This gives some ideas as one tries to image what it is to have several BBs. It is interesting that in dreams we often have different identities than in wake-up state.

Consciousness

The existence of twin pairs might have profound implications for consciousness [L54, L64].

(a) I proposed for about 2 decades ago what I called magnetospheric consciousness [K53, K51, K32, K33]. The MB of not only Earth but also our MB would have parts assignable to the interior and exterior of the Earth. Even the structures of brain should have a scaled up MB image at both levels. The approximate inversion symmetry brings in exciting additional aspects. Maybe this division could provide the physical correlates for the Heaven-Hell dualism of religions and "as above-so below" dualism of perennial world views and mysticism.

(b) Interior-exterior divisions are central for consciousness and the hierarchy of conscious entities in correspondence with the hierarchy of space-time sheets inspires the question whether also our biological bodies and environment could be related by an approximate symmetry at the level of MB at least so that one could speak of MBs assignable to the interior and exterior of BB. The sensory representations would reflect this approximate symmetry. Subsystem able to remain entangled at the passive boundary of CD defines the permanent part of self. But also its complement remains unentangled and should define permanent part of self: does this mean that the world outside me is a conscious entity?

(c) One of the most dramatic predictions of TGD inspired theory of consciousness based on zero energy ontology (ZEO) is re-incarnation of self in death as a time-reversed self. There is indirect support for this: for instance, mental images identified as sub-selves die and re-incarnate and the period during which they are absent would correspond to the life with opposite arrow of time.

Where could these ghostly time-reversed re-incarnations live? Or putting it more formally: what regions of space-time surface do these entities control and receive sensory input from? Could inversion with respect to Earth's surface relate the space-time regions associated with self and its time reversal. If personal MB is part of MB above the Earth's surface, its inversion would be the part of MB below it. When we die we get buried. Could this ritual reflect the sub-conscious idea that our life continues as IT lifeform?

Chapter 3

Quantum Model for Bio-Superconductivity: I

3.1 Introduction

The model for EEG and its varints and nerve pulse relies on a general model of high T_c superconductivity [K17, K18]. In this chapter the general vision behind model of cell membrane as super-conductor inspired by the identification of dark matter in terms of hierarchy of Planck constants and the notion of magnetic body is discussed.

3.1.1 General Mechanism Of Bio-Superconductivity

The ideas about high temperature super-conductivity have evolved gradually as a reaction to experimental input and evelution in the understanding of TGD.

(a) The many-sheeted space-time concept suggests 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 criticism against this model is that particles topologically condensed to all space-time sheets having non-empty Minkowski space projection to the region where the particle is.

(b) The possibility of large $\hbar$ quantum coherent phases makes 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.

(c) It became clear quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity is essential. 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.

(d) Magnetic flux tubes would be carriers of dark particles and according to the findings about high temperature super-conductivity magnetic fields are indeed crucial for super-conductivity. Two parallel flux tubes carrying magnetic fluxes in opposite directions is the simplest candidate for super-conducting system. This conforms with the observation that antiferromagnetism is somehow crucial for high temperature super-conductivity. The spin interaction energy is proportional to Planck constant and can be above thermal energy: if the hypothesis that dark cyclotron energy spectrum is universal is accepted, then the energies would be in bio-photon range and high temperature super-conductivity is obtained. If fluxes are parallel spin $S = 1$ Cooper pairs are stable. $L = 2$ states are in question since the members of the pair are at different flux tubes. These two kinds of Cooper pairs could correspond to BCS type and 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.

(e) This mechanism of high temperature super-conductivity 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. If h_{eff} is proportional to the particle mass, the binding energy of Cooper pairs identifiable as spin-spin interaction energy and does not depend on the mass of the Cooper pair. The bindng energy is proportional to h_{eff} and in visible and UV range if bio-photons result when dark photon transforms to ordinary photon. The hypothesis that gravitational Planck constant and h_{eff} are identical ($h_{eff} = h_{gr}$) in microscopic domain, implies the universality.

3.1.2 Hierarchies Of Preferred P-Adic Length Scales And Values Of Planck Constant

All p-adic length scales above electron length scale $L_e(127)$ were identified erratically in all writings about TGD before 2014. This deserves some clarifying comments.

(a) The wrong identification was $L(151) \simeq 10$ nm implying wrong identification of other scales above $L(127)$ since I have calculated them by scaling $L(151)$ by an appropriate power of two. What I have denoted by $L(151)$ is actually obtained by scaling the Compton length $L_e(127) = \hbar/m_e$ by $2^{(151-127)/2}$ and therefore electrons Compton scale if it would correspond to $k = 151$. Since the mass of electron from p-adic mass calculations is given by $m_e = \sqrt{5 + X}\hbar/L(127)$, the correct identification of $L(151)$ would be

$$L(151) = 2^{(151-127)/2}L(127) = 2^{(151-127)/2}L_e(151)/\sqrt{5 + X} = 10/\sqrt{5 + X} \ \ nm \ \ , \ \ 0 \leq X \leq 1 \ \ .$$

Here X denotes the unknown second order contribution of form $X = n/M_{127}$, n integer, to the electron mass, and in the first approximation one can take $X = 0$ - the approximation is excellent unless n is very large. In the sequel I will try to use the shorthand

$L_e(k) = \sqrt{5}L(k)$ but cannot guarantee that the subscript "e" is always present when needed: it is rather difficult to identify all places where the earlier erratic definition appears. I can only apologise for possible confusions.

(b) This mistake has no fatal consequences for TGD inspired quantum biology. Its detection however provides a further support for the speculated central role of electron in living matter. Since the scales obtained by scaling the electron Compton scale seem to be important biologically (scaled up Comton scale $\sqrt{5}L(151)$ corresponds to cell membrane thickness), the conclusion is that electrons - or perhaps their Cooper pairs - play a fundamental role in living matter. The correct value of $L(151)$ is $L(151) = 4.5$ nm, which is slightly below the p-adic length scale $L_e(149) = 5$ nm assigned with the lipid layer of cell membrane.

(c) I have also assigned to electron the time scale $T = .1$ seconds defining a fundamental biorhythm as a secondary p-adic time scale $T_2(127) = \sqrt{M_{127}}T(127)$. The correct assignment of $T = .1$ seconds is as the secondary Compton time $T_{2,e}(127) = \sqrt{M_{127}}T_e(127)$ of electron: secondary p-adic time scale is $T_2(127) = \sqrt{M_{127}}T(127)$ and corresponds to $T_{2,e}(127)/\sqrt{5} = .045$ seconds and to $f(127) = 22.4$ Hz.

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 scale up Compton lengths of electron with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) 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 [K35]. 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.

3.1.3 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.

(a) 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.

(b) From the point of view of EEG especially interesting are the flux sheets which have thickness $L = 10$ nm (the thickness of cell membrane) carrying magnetic field having strength of endogenous magnetic field. $L = 10$ nm corresponds to p-adically scaled electron Compton length $L_e(151)$. In absence of supra currents these flux sheets have very large total transversal length proportional to r^2. The condition that the values of cycloctron 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.

(c) 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.

3.1.4 Bose-Einstein Condensates At Magnetic Flux Quanta In Astrophysical Length Scales

The model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B_{end} = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the values of Planck constant. The hypothesis for the preferred values of Planck constans allows to build quantitative model for the Bose-Einstein condensation at magnetic flux quanta assuming that the value of B_{end} scales like $1/\hbar$. A justification for this hypothesis comes form flux quantization conditions and from the similar scaling of Josephson frequencies [K35].

(a) There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. For instance, the formation of Cooper pairs involves dynamics at $k_d = 24 = 151 - 127$ level of dark matter hierarchy if one assumes that electrons and Cooper pairs have size given by the cell membrane thickess equal to $L_e(151)$. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_d > 24$ dynamics.

(b) Cyclotron energies scale as as $\hbar$ so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved for a fixed value of B. Same applies to spin flip transitions in the recent scenario. The model for EEG based on dark matter hierarchy [K35] involves the hypothesis that EEG quanta correspond to Josephson radiation with energies in the visible and UV range and that they produce in the decay to ordinary photons either bunches of EEG photons or visible/UV photons. This identification allows to deduce the value of k_d when the frequency of the dark photon is fixed. The Mersenne hypothesis for the preferred p-adic length scales and values of Planck constants leads to very precise predictions.

(c) Cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $r = 2^{k_d}$ from their ordinary values and for 10 Hz cyclotron frequency are in the range of energies of visible light for $k_d = 46$.

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` [L11].

3.2 General TGD Based View About Super-Conductivity

Today super-conductivity includes besides the traditional low temperature super-conductors many other non-orthodox ones [D61]. These unorthodox super-conductors carry various attributes such as cuprate, organic, dichalcogenide, heavy fermion, bismute oxide, ruthenate, antiferromagnetic and ferromagnetic. Mario Rabinowitz has proposed a simple phenomenological theory of superfluidity and super-conductivity which helps non-specialist to get a rough quantitative overall view about super-conductivity [D61].

3.2.1 Basic Phenomenology Of Super-Conductivity

The following provides the first attempt by a non-professional to form an overall view about super-conductivity.

Basic phenomenology of super-conductivity

The transition to super-conductivity occurs at critical temperature T_c and involves a complete loss of electrical resistance. Super-conductors expel magnetic fields (Meissner effect) and when the external magnetic field exceeds a critical value H_c super-conductivity is lost either completely or partially. In the transition to super-conductivity specific heat has singularity. For long time magnetism and super-conductivity were regarded as mutually exclusive phenomena but the discovery of ferromagnetic super-conductors [D45, D17] has demonstrated that reality is much more subtle.

The BCS theory developed by Bardeen, Cooper, and Schrieffer in 1957 provides a satisfactory model for low T_c super-conductivity in terms of Cooper pairs. The interactions of electrons with the crystal lattice induce electron-electron interaction binding electrons to Cooper pairs at sufficiently low temperatures. The electrons of Cooper pair are at the top of Fermi sphere (otherwise they cannot interact to form bound states) and have opposite center of mass momenta and spins. The binding creates energy gap E_g determining the critical temperature T_c. The singularity of the specific heat in the transition to super-conductivity can be understood as being due to the loss of thermally excitable degrees of freedom at critical temperature so that heat capacity is reduced exponentially. BCS theory has been successful in explaining the properties of low temperature super conductors but the high temperature super-conductors discovered in 1986 and other non-orthodox superconductors discovered later remain a challenge for theorists.

The reasons why magnetic fields tend to destroy super-conductivity is easy to understand. Lorentz force induces opposite forces to the electrons of Cooper pair since the momenta are opposite. Magnetic field tends also to turn the spins in the same direction. The super-conductivity is destroyed in fields for which the interaction energy of magnetic moment of electron with field is of the same order of magnitude as gap energy $E_g \sim T_c$: $e\hbar H_c/2m \sim T_c$.

If spins are parallel, the situation changes since only Lorentz force tends to destroy the Cooper pair. In high T_c super-conductors this is indeed the case: electrons are in spin triplet state ($S = 1$) and the net orbital angular momentum of Cooper pair is $L = 2$. The fact that orbital state is not $L = 0$ state makes high T_c super-conductors much more fragile to the destructive effect of impurities than conventional super-conductors (due to the magnetic

exchange force between electrons responsible for magnetism). Also the Cooper pairs of ^3He superfluid are in spin triplet state but have $S = 0$.

The observation that spin triplet Cooper pairs might be possible in ferro-magnets stimulates the question whether ferromagnetism and super-conductivity might tolerate each other after all, and the answer is affirmative [D17]. The article [D45] provides an enjoyable summary of experimental discoveries.

Basic parameters of super-conductors from universality?

Super conductors are characterized by certain basic parameters such as critical temperature T_c and critical magnetic field H_c, densities n_c and n of Cooper pairs and conduction electrons, gap energy E_g, correlation length ξ and magnetic penetration length λ. The super-conductors are highly complex systems and calculation of these parameters from BCS theory is either difficult or impossible.

It has been suggested [D61] that these parameters might be more or less universal so that they would not depend on the specific properties of the interaction responsible for the formation of Cooper pairs. The motivation comes from the fact that the properties of ordinary Bose-Einstein condensates do not depend on the details of interactions. This raises the hope that these parameters might be expressible in terms of some basic parameters such as T_c and the density of conduction electrons allowing to deduce Fermi energy E_F and Fermi momentum k_F if Fermi surface is sphere. In [D61] formulas for the basic parameters are indeed suggested based on this of argumentation assuming that Cooper pairs form a Bose-Einstein condensate.

(a) The most important parameters are critical temperature T_c and critical magnetic field H_c in principle expressible in terms of gap energy. In [D61] the expression for T_c is deduced from the condition that the de Broglie wavelength λ must satisfy in supra phase the condition

$$\lambda \geq 2d = 2(\frac{n_c}{g})^{-1/D} \tag{3.2.1}$$

guaranteeing the quantum overlap of Cooper pairs. Here n_c is the density of Bose-Einstein condensate of Cooper pairs and g is the number of spin states and D the dimension of the condensate. This condition follows also from the requirement that the number of particles per energy level is larger than one (Bose-Einstein condensation). Identifying this expression with the de Broglie wavelength $\lambda = \hbar/\sqrt{2mE}$ at thermal energy $E = (D/2)T_c$, where D is the number of degrees of freedom, one obtains

$$T_c \quad \leq \quad \frac{h^2}{4Dm}(\frac{n_c}{g})^{2/D} \quad . \tag{3.2.2}$$

m denotes the effective mass of super current carrier and for electron it can be even 100 times the bare mass of electron. The reason is that the electron moves is somewhat like a person trying to move in a dense crowd of people, and is accompanied by a cloud of charge carriers increasing its effective inertia. In this equation one can consider the possibility that Planck constant is not the ordinary one. This obviously increases the critical temperature unless n_c is scaled down in same proportion in the phase transition to large $\hbar$ phase.

(b) The density of n_c Cooper pairs can be estimated as the number of fermions in Fermi shell at E_F having width Δk deducible from kT_c. For $D = 3$-dimensional spherical Fermi surface one has

$$n_c \quad = \quad \frac{1}{2}\frac{4\pi k_F^2 \Delta k}{\frac{4}{3}\pi k_F^3}n \quad ,$$

$$kT_c \quad = \quad E_F - E(k_F - \Delta k) \simeq \frac{h^2 k_F \Delta k}{m} \quad . \tag{3.2.3}$$

Analogous expressions can be deduced in $D = 2$- and $D = 1$-dimensional cases and one has

$$n_c(D) \quad = \quad \frac{D}{2} \frac{T_c}{E_F} n(D) \ . \tag{3.2.4}$$

The dimensionless coefficient is expressible solely in terms of n and effective mass m. In [D61] it is demonstrated that the inequality 3.2.2 replaced with equality when combined with 3.2.4 gives a satisfactory fit for 16 super-conductors used as a sample.

Note that the Planck constant appearing in E_F and T_c in Eq. 3.2.4 must correspond to ordinary Planck constant $\hbar_0$. This implies that equations 3.2.2 and 3.2.4 are consistent within orders of magnitudes. For $D = 2$, which corresponds to high T_c superconductivity, the substitution of n_c from Eq. 3.2.4 to Eq. 3.2.2 gives a consistency condition from which n_c disappears completely. The condition reads as

$$n\lambda_F^2 = \pi = 4g \ .$$

Obviously the equation is not completely consistent.

(c) The magnetic penetration length λ is expressible in terms of density n_c of Cooper pairs as

$$\lambda^{-2} = \frac{4\pi e^2 n_c}{m_e} \ . \tag{3.2.5}$$

The ratio $\kappa \equiv \frac{\lambda}{\xi}$ determines the type of the super conductor. For $\kappa < \frac{1}{\sqrt{2}}$ one has type I super conductor with defects having negative surface energy. For $\kappa \geq \frac{1}{\sqrt{2}}$ one has type II super conductor and defects have positive surface energy. Super-conductors of type I this results in complex stripe like flux patterns maximizing their area near criticality. The super-conductors of type II have $\kappa > 1/\sqrt{2}$ and the surface energy is positive so that the flux penetrates as flux quanta minimizing their area at lower critical value H_{c_1} of magnetic field and completely at higher critical value H_{c_2} of magnetic field. The flux quanta contain a core of size ξ carrying quantized magnetic flux.

(d) Quantum coherence length ξ can be roughly interpreted as the size of the Cooper pair or as the size of the region where it is sensible to speak about the phase of wave function of Cooper pair. For larger separations the phases of wave functions are un-correlated. The values of ξ vary in the range $10^3 - 10^4$ Angstrom for low T_c super-conductors and in the range $5 - 20$ Angstrom for high T_c super-conductors (assuming that they correspond to ordinary $\hbar$!) the ratio of these coherence lengths varies in the range $[50 - 2000]$, with upper bound corresponding to $n_F = 2^{11}$ for $\hbar$. This would give range $1 - 2$ microns for the coherence lengths of high T_c super-conductors with lowest values of coherence lengths corresponding to the highest values of coherence lengths for low temperatures super conductors.

Uncertainty Principle $\delta E \delta t = \hbar/2$ using $\delta E = E_g \equiv 2\Delta$, $\delta t = \xi/v_F$, gives an order of magnitude estimate for ξ differing only by a numerical factor from the result of a rigorous calculation given by

$$\xi \quad = \quad \frac{4\hbar v_F}{E_g} \ . \tag{3.2.6}$$

E_g is apart from a numerical constant equal to T_c: $E_g = nT_c$. Using the expression for v_F and T_c in terms of the density of electrons, one can express also ξ in terms of density of electrons.

For instance, BCS theory predicts $n = 3.52$ for metallic super-conductors and $n = 8$ holds true for cuprates [D61]. For cuprates one obtains $\xi = 2n^{-1/3}$ [D61]. This expression can be criticized since cuprates are Mott insulators and it is not at all clear whether a description as Fermi gas makes sense. The fact that high T_c super-conductivity involves breakdown of anti-ferromagnetic order might justify the use of Fermi gas description for conducting holes resulting in the doping.

For large $\hbar$ the value of ξ would scale up dramatically if deduced theoretically from experimental data using this kind of expression. If the estimates for ξ are deduced from v_F and T_c purely calculationally as seems to be the case, the actual coherence lengths would be scaled up by a factor $\hbar/\hbar_0 = n_F$ if high T_c super-conductors correspond to large $\hbar$ phase. As also found that this would also allow to understand the high critical temperature.

3.2.2 Universality Of The Parameters In TGD Framework

Universality idea conforms with quantum criticality of TGD Universe. The possibility to express everything in terms of density of critical temperature coding for the dynamics of Cooper pair formation and the density charge carriers would make it also easy to understand how p-adic scalings and transitions to large $\hbar$ phase affect the basic parameters. The possible problem is that the replacement of inequality of Eq. 3.2.2 with equality need not be sensible for large $\hbar$ phases. It will be found that in many-sheeted space-time T_c does not directly correspond to the gap energy and the universality of the critical temperature follows from the p-adic length scale hypothesis.

The effect of p-adic scaling on the parameters of super-conductors

p-Adic fractality expresses as $n \propto 1/L^3(k)$ would allow to deduce the behavior of the various parameters as function of the p-adic length scale and naïve scaling laws would result. For instance, E_g and T_c would scale as $1/L^2(k)$ if one assumes that the density n of particles at larger space-time sheets scales p-adically as $1/L^3(k)$. The basic implication would be that the density of Cooper pairs and thus also T_c would be reduced very rapidly as a function of the p-adic length scale. Without thermal isolation between these space-time sheets and hight temperature space-time sheets there would not be much hopes about high T_c super-conductivity.

In the scaling of Planck constant basic length scales scale up and the overlap criterion for super-conductivity becomes easy to satisfy unless the density of electrons is reduced too dramatically. As found, also the critical temperature scales up so that there are excellent hopes of obtain high T_c super-conductor in this manner. The claimed short correlation lengths are not a problem since they are calculational quantities.

It is of interest to study the behavior of the various parameters in the transition to the possibly existing large $\hbar$ variant of super-conducting electrons. Also small scalings of $\hbar$ are possible and the considerations to follow generalize trivially to this case. Under what conditions the behavior of the various parameters in the transition to large $\hbar$ phase is dictated by simple scaling laws?

1. Scaling of T_c and E_g

T_c and E_g remain invariant if E_g corresponds to a purely classical interaction energy remaining invariant under the scaling of $\hbar$. This is not the case for BCS super-conductors for which the gap energy E_g has the following expression.

$$
\begin{aligned}
E_g &= \hbar\omega_c exp(-1/X) \ , \\
X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\
n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ . \\
\omega_c &= \omega_D = (6\pi^2)^{1/3}c_s n_n^{1/3} \ .
\end{aligned}
\tag{3.2.7}
$$

Here ω_c is the width of energy region near E_F for which "phonon" exchange interaction is effective. n_n denotes the density of nuclei and c_s denotes sound velocity.

$N(E_F)$ is the total number of electrons at the super-conducting space-time sheet. U_0 would be the parameter characterizing the interaction strength of of electrons of Cooper pair and should not depend on $\hbar$. For a structure of size $L \sim 1 \ \mu$ m one would have $X \sim n_a 10^{12} \frac{U_0}{E_F}$, n_a being the number of exotic electrons per atom, so that rather weak interaction energy U_0 can give rise to $E_g \sim \omega_c$.

The expression of ω_c reduces to Debye frequency ω_D in BCS theory of ordinary super conductivity. If c_s is proportional to thermal velocity $\sqrt{T_c/m}$ at criticality and if n_n remains invariant in the scaling of $\hbar$, Debye energy scales up as $\hbar$. This can imply that $E_g > E_F$ condition making scaling non-sensible unless one has $E_g \ll E_F$ holding true for low T_c super-conductors. This kind of situation would *not* require large $\hbar$ phase for electrons. What would be needed that nuclei and phonon space-time sheets correspond to large $\hbar$ phase.

What one can hope is that E_g scales as $\hbar$ so that high T_c superconductor would result and the scaled up T_c would be above room temperature for $T_c > .15$ K. If electron is in ordinary phase X is automatically invariant in the scaling of $\hbar$. If not, the invariance reduces to the invariance of U_0 and E_F under the scaling of $\hbar$. If n scales like $1/\hbar^D$, E_F and thus X remain invariant. U_0 as a simplified parameterization for the interaction potential expressible as a tree level Feynman diagram is expected to be in a good approximation independent of $\hbar$.

It will be found that in high T_c super-conductors, which seem to be quantum critical, a high T_c variant of phonon mediated superconductivity and exotic superconductivity could be competing. This would suggest that the phonon mediated superconductivity corresponds to a large $\hbar$ phase for nuclei scaling ω_D and T_c by a factor $r = \hbar/\hbar_0$.

Since the total number $N(E_F)$ of electrons at larger space-time sheet behaves as $N(E_F) \propto E_F^{D/2}$, where D is the effective dimension of the system, the quantity $1/X \propto E_F/n(E_F)$ appearing in the expressions of the gap energy behaves as $1/X \propto E_F^{-D/2+1}$. This means that at the limit of vanishing electron density $D = 3$ gap energy goes exponentially to zero, for $D = 2$ it is constant, and for $D = 1$ it goes zero at the limit of small electron number so that the formula for gap energy reduces to $E_g \simeq \omega_c$. These observations suggests that the super-conductivity in question should be 2- or 1-dimensional phenomenon as in case of magnetic walls and flux tubes.

2. Scaling of ξ and λ

If n_c for high T_c super-conductor scales as $1/\hbar^D$ one would have $\lambda \propto \hbar^{D/2}$. High T_c property however suggests that the scaling is weaker. ξ would scale as $\hbar$ for given v_F and T_c. For $D = 2$ case the this would suggest that high T_c super-conductors are of type I rather than type II as they would be for ordinary $\hbar$. This conforms with the quantum criticality which would be counterpart of critical behavior of super-conductors of type I in nearly critical magnetic field.

3. Scaling of H_c and B

The critical magnetization is given by

$$H_c(T) \quad = \quad \frac{\Phi_0}{\sqrt{8\pi}\xi(T)\lambda(T)} \quad , \tag{3.2.8}$$

where Φ_0 is the flux quantum of magnetic field proportional to $\hbar$. For $D = 2$ and $n_c \propto \hbar^{-2}$ $H_c(T)$ would not depend on the value of $\hbar$. For the more physical dependence $n_c \propto \hbar^{-2+\epsilon}$ one would have $H_c(T) \propto \hbar^{-\epsilon}$. Hence the strength of the critical magnetization would be reduced by a factor $2^{-11\epsilon}$ in the transition to the large $\hbar$ phase with $n_F = 2^{-11}$.

Magnetic flux quantization condition is replaced by

$$\int 2eBdS = n\hbar 2\pi \quad . \tag{3.2.9}$$

B denotes the magnetic field inside super-conductor different from its value outside the super-conductor. By the quantization of flux for the non-super-conducting core of radius ξ in the case of super-conductors of type II $eB = \hbar/\xi^2$ holds true so that B would become very strong since the thickness of flux tube would remain unchanged in the scaling.

3.2.3 Quantum Criticality And Super-Conductivity

The notion of quantum criticality has been already discussed in introduction. An interesting prediction of the quantum criticality of entire Universe also gives naturally rise to a hierarchy of macroscopic quantum phases since the quantum fluctuations at criticality at a given level can give rise to higher level macroscopic quantum phases at the next level. A metaphor for this is a fractal cusp catastrophe for which the lines corresponding to the boundaries of cusp region reveal new cusp catastrophes corresponding to quantum critical systems characterized by an increasing length scale of quantum fluctuations.

Dark matter hierarchy could correspond to this kind of hierarchy of phases and long ranged quantum slow fluctuations would correspond to space-time sheets with increasing values of $\hbar$ and size. Evolution as the emergence of modules from which higher structures serving as modules at the next level would correspond to this hierarchy. Mandelbrot fractal with inversion analogous to a transformation permuting the interior and exterior of sphere with zooming revealing new worlds in Mandelbrot fractal replaced with its inverse would be a good metaphor for what quantum criticality would mean in TGD framework.

How the quantum criticality of superconductors relates to TGD quantum criticality

There is empirical support that super-conductivity in high T_c super-conductors and ferromagnetic systems [D45, D31] is made possible by quantum criticality [D71]. In the experimental situation quantum criticality means that at sufficiently low temperatures quantum rather than thermal fluctuations are able to induce phase transitions. Quantum criticality manifests itself as fractality and simple scaling laws for various physical observables like resistance in a finite temperature range and also above the critical temperature. This distinguishes sharply between quantum critical super conductivity from BCS type super-conductivity. Quantum critical super-conductivity also exists in a finite temperature range and involves the competition between two phases.

The absolute quantum criticality of the TGD Universe maps to the quantum criticality of subsystems, which is broken by finite temperature effects bringing dissipation and freezing of quantum fluctuations above length and time scales determined by the temperature so that scaling laws hold true only in a finite temperature range.

Reader has probably already asked what quantum criticality precisely means. What are the phases which compete? An interesting hypothesis is that quantum criticality actually corresponds to criticality with respect to the phase transition changing the value of Planck constant so that the competing phases would correspond to different values of $\hbar$. In the case of high T_c super-conductors (anti-ferromagnets) the fluctuations can be assigned to the magnetic flux tubes of the dipole field patterns generated by rows of holes with same spin direction assignable to the stripes. Below T_c fluctuations induce reconnections of the flux tubes and a formation of very long flux tubes and make possible for the supra currents to flow in long length scales below T_c. Percolation type phenomenon is in question. The fluctuations of the flux tubes below $T_{c1} > T_c$ induce transversal phonons generating the energy gap for $S = 1$ Cooper pairs. $S = 0$ Cooper pairs are predicted to stabilize below T_c.

Scaling up of de Broglie wave lengths and criterion for quantum overlap

Compton lengths and de Broglie wavelengths are scaled up by an integer n, whose preferred values correspond to $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes. In particular, $n_F = 2^k 11$ seem to be favored in living matter. The scaling up means that the overlap condition $\lambda \geq 2d$ for the formation of Bose-Einstein condensate can be satisfied and the formation of Cooper pairs becomes possible. Thus a hierarchy of large $\hbar$ super-conductivities would be associated with to the dark variants of ordinary particles having essentially same masses as the ordinary particles.

Unless one assumes fractionization, the invariance of $E_F \propto \hbar_{eff}^2 n^{2/3}$ in $\hbar$ increasing transition would require that the density of Cooper pairs in large $\hbar$ phase is scaled down by an appropriate factor. This means that supra current intensities, which are certainly measurable quantities, are also scaled down. Of course, it could happen that E_F is scaled up and this would conform with the scaling of the gap energy.

Quantum critical super-conductors in TGD framework

For quantum critical super-conductivity in heavy fermions systems, a small variation of pressure near quantum criticality can destroy ferromagnetic (anti-ferromagnetic) order so that Curie (Neel) temperature goes to zero. The prevailing spin fluctuation theory [D13] assumes that these transitions are induced by long ranged and slow spin fluctuations at critical pressure P_c. These fluctuations make and break Cooper pairs so that the idea of super-conductivity restricted around critical point is indeed conceivable.

Heavy fermion systems, such as cerium-indium alloy $CeIn_3$ are very sensitive to pressures and a tiny variation of density can drastically modify the low temperature properties of the systems. Also other systems of this kind, such as $CeCu_2Ge_2$, $CeIn_3$, $CePd_2Si_2$ are known [D45, D17]. In these cases super-conductivity appears around anti-ferromagnetic quantum critical point.

The last experimental breakthrough in quantum critical super-conductivity was made in Grenoble [D31]. URhGe alloy becomes super-conducting at $T_c = .280$ K, loses its super-conductivity at $H_c = 2$ Tesla, and becomes again super-conducting at $H_c = 12$ Tesla and loses its super-conductivity again at $H = 13$ Tesla. The interpretation is in terms of a phase transition changing the magnetic order inducing the long range spin fluctuations.

TGD based models of atomic nucleus [K97] and condensed matter [K36] assume that weak gauge bosons with Compton length of order atomic radius play an essential role in the nuclear and condensed matter physics. The assumption that condensed matter nuclei possess anomalous weak charges explains the repulsive core of potential in van der Waals equation and the very low compressibility of condensed matter phase as well as various anomalous properties of water phase, provide a mechanism of cold fusion and sono-fusion, etc. [K36, K34]. The pressure sensitivity of these systems would directly reflect the physics of exotic quarks and electro-weak gauge bosons. A possible mechanism behind the phase transition to super-conductivity could be the scaling up of the sizes of the space-time sheets of nuclei.

Also the electrons of Cooper pair (and only these) could make a transition to large $\hbar$ phase. This transition would induce quantum overlap having geometric overlap as a space-time correlate. The formation of flux tubes between neighboring atoms would be part of the mechanism. For instance, the criticality condition $4n^2\alpha = 1$ for BE condensate of n Cooper pairs would give $n = 6$ for the size of a higher level quantum unit possibly formed formed from Cooper pairs. If one does not assume invariance of energies obtained by fractionization of principal quantum number, this transition has dramatic effects on the spectrum of atomic binding energies scaling as $1/\hbar^2$ and practically universal spectrum of atomic energies would result [K34] not depending much on nuclear charge. It seems that this prediction is non-physical.

Quantum critical super-conductors resemble superconductors of type I with $\lambda \ll \xi$ for which defects near thermodynamical criticality are complex structures looking locally like stripes of thickness λ. These structures are however dynamical in super-conducting phase. Quite generally, long range quantum fluctuations due to the presence of two competing phases would manifest as complex dynamical structures consisting of stripes and their boundaries. These patterns are dynamical rather than static as in the case of ordinary spin glass phase so that quantum spin glass or 4-D spin glass is a more appropriate term. The breaking of classical non-determinism for vacuum extremals indeed makes possible space-time correlates for quantum non-determinism and this makes TGD Universe a 4-dimensional quantum spin glass.

Could quantum criticality make possible new kinds of high T_c super-conductors?

The transition to large $\hbar = r\hbar_0$ phase increases various length scales by r and makes possible long range correlations even at high temperatures. Hence the question is whether large $\hbar$ phase could correspond to ordinary high T_c super-conductivity. If this were the case in the case of ordinary high T_c super-conductors, the actual value of coherence length ξ would vary in the range $5 - 20$ Angstrom scaled up by a factor r. For effectively D-dimensional super-conductor The density of Cooper pairs would be scaled down by an immensely small factor $1/r^D$ from its value deduced from Fermi energy.

Large $\hbar$ phase for some nuclei might be involved and make possible large space-time sheets of size at least of order of ξ at which conduction electrons forming Cooper pairs would topologically condense like quarks around hadronic space-time sheets (in [K36] a model of water as a partially dark matter with one fourth of hydrogen ions in large $\hbar$ phase is developed).

Consider for a moment the science fictive possibility that super conducting electrons for some quantum critical super-conductors to be discovered or already discovered correspond to large $\hbar$ phase with $\hbar = r\hbar_0$ keeping in mind that this affects only quantum corrections in perturbative approach but not the lowest order classical predictions of quantum theory. For $r \simeq n2^{k11}$ with $(n, k) = (1, 1)$ the size of magnetic body would be $L(149) = 5$ nm, the thickness of the lipid layer of cell membrane. For $(n, k) = (1, 2)$ the size would be $L(171) = 10$ μm, cell size. If the density of Cooper pairs is of same order of magnitude as in case of ordinary super conductors, the critical temperature is scaled up by 2^{k11}. Already for $k = 1$ the critical temperature of 1 K would be scaled up to $4n^2 \times 10^6$ K if n_c is not changed. This assumption is not consistent with the assumption that Fermi energy remains non-relativistic. For $n = 1$ $T_c = 400$ K would be achieved for $n_c \to 10^{-6}n_c$, which looks rather reasonable since Fermi energy transforms as $E_F \to 8 \times 10^3 E_F$ and remains non-relativistic. H_c would scale down as $1/\hbar$ and for $H_c = .1$ Tesla the scaled down critical field would be $H_c = .5 \times 10^{-4}$ Tesla, which corresponds to the nominal value of the Earth's magnetic field.

Quantum critical super-conductors become especially interesting if one accepts the identification of living matter as ordinary matter quantum controlled by macroscopically quantum coherent dark matter. One of the basic hypothesis of TGD inspired theory of living matter is that the magnetic flux tubes of the Earth's magnetic field carry a super-conducting phase and the spin triplet Cooper pairs of electrons in large $\hbar$ phase might realize this dream. That the value of Earth's magnetic field is near to its critical value could have also biological implications.

3.2.4   Space-Time Description Of The Mechanisms Of Super-Conductivity

The application of ideas about dark matter to nuclear physics and condensed matter suggests that dark color and weak forces should be an essential element of the chemistry and condensed matter physics. The continual discovery of new super-conductors, in particular of quantum critical superconductors, suggests that super-conductivity is not well understood. Hence super-conductivity provides an obvious test for these ideas. In particular, the idea that wormhole contacts regarded as parton pairs living at two space-time sheets simultaneously, provides an attractive universal mechanism for the formation of Cooper pairs and is not so far-fetched as it might sound first.

Leading questions

It is good to begin with a series of leading questions. The first group of questions is inspired by experimental facts about super-conductors combined with TGD context.

(a) The work of Rabinowitch [D61] suggests that that the basic parameters of super-conductors might be rather universal and depend on T_c and conduction electron density only and be to a high degree independent of the mechanism of super-conductivity. This is in a sharp contrast to the complexity of even BCS model with its somewhat misty description of the phonon exchange mechanism.
Questions: Could there exist a simple universal description of various kinds of super-conductivities?

(b) The new super-conductors possess relatively complex chemistry and lattice structure.
Questions: Could it be that complex chemistry and lattice structure makes possible something very simple describable in terms of quantum criticality. Could it be that the transversal oscillations magnetic flux tubes allow to understand the formation of Cooper pairs at T_{c1} and their reconnections generating very long flux tubes the emergence of supra currents at T_c?

(c) The effective masses of electrons in ferromagnetic super-conductors are in the range of 10-100 electron masses [D45] and this forces to question the idea that ordinary Cooper pairs are current carriers.
Questions: Can one consider the possibility that the p-adic length scale of say electron can vary so that the actual mass of electron could be large in condensed matter systems? For quarks and neutrinos this seems to be the case [K55, K65]. Could it be that the Gaussian Mersennes $(1+i)^k - 1$, $k = 151, 157, 163, 167$ spanning the p-adic lengthscale range 10 nm-2.5 μm very relevant from the point of view of biology correspond to p-adic length especially relevant for super-conductivity?

Second group of questions is inspired by quantum classical correspondence.

(a) Quantum classical correspondence in its strongest form requires that bound state formation involves the generation of flux tubes between bound particles. The weaker form of the principle requires that the particles are topologically condensed at same space-time sheet. In the case of Cooper pairs in ordinary superconductors the length of join along boundaries bonds between electrons should be of order $10^3 - 10^4$ Angstroms. This looks rather strange and it seems that the latter option is more sensible.
Questions: Could quantum classical correspondence help to identify the mechanism giving rise to Cooper pairs?

(b) Quantum classical correspondence forces to ask for the space-time correlates for the existing quantum description of phonons.
Questions: Can one assign space-time sheets with phonons or should one identify them as oscillations of say space-time sheets at which atoms are condensed? Or should the microscopic description of phonons in atomic length scales rely on the oscillations of wormhole contacts connecting atomic space-time sheets to these larger space-time sheets? The identification of phonons as wormhole contacts would be completely analogous to the

similar identification of gauge bosons except that phonons would appear at higher levels of the hierarchy of space-time sheets and would be emergent in this sense. As a matter fact, even gauge bosons as pairs of fermion and anti-fermion are emergent structures in TGD framework and this plays fundamental role in the construction of QFT limit of TGD in which bosonic part of action is generated radiatively so that all coupling constants follow as predictions [**?**]. Could Bose-Einstein condensates of wormhole contacts be relevant for the description of super-conductors or more general macroscopic quantum phases?

The third group of questions is inspired by the new physics predicted or by TGD.

(a) TGD predicts a hierarchy of macroscopic quantum phases with large Planck constant.
Questions: Could large values of Planck constant make possible exotic electronic super-conductivities? Could even nuclei possess large $\hbar$ (super-fluidity)?

(b) TGD predicts that classical color force and its quantal counterpart are present in all length scales.
Questions: Could color force, say color magnetic force which play some role in the formation of Cooper pair. The simplest model of pair is as a space-time sheet with size of order ξ so that the electrons could be "outside" the background space-time. Could the Coulomb interaction energy of electrons with positively charged wormhole throats carrying parton numbers and feeding em gauge flux to the large space-time sheet be responsible for the gap energy? Could wormhole throats carry also quark quantum numbers. In the case of single electron condensed to single space-time sheet the em flux could be indeed fed by a pair of $u\bar{u}$ and $\bar{d}d$ type wormhole contacts to a larger space-time sheet. Could the wormhole contacts have a net color? Could the electron space-time sheets of the Cooper pair be connected by long color flux tubes to give color singlets so that dark color force would be ultimately responsible for the stability of Cooper pair?

(c) Suppose that one takes seriously the ideas about the possibility of dark weak interactions with the Compton scale of weak bosons scaled up to say atomic length scale so that weak bosons are effectively massless below this length scale [K36].
Questions: Could the dark weak length scale which is of order atomic size replace lattice constant in the expression of sound velocity? What is the space-time correlate for sound velocity?

Photon massivation, coherent states of Cooper pairs, and wormhole contacts

The existence of wormhole contacts is one of the most stunning predictions of TGD. First I realized that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts. Then came the idea that Higgs particle could be identified as a wormhole contact. It was soon followed by the identification all bosonic states as wormhole contacts [K55]. Finally I understood that this applies also to their super-symmetric partners, which can be also fermion [**?**]. Fermions and their super-partners would in turn correspond to wormhole throats resulting in the topological condensation of small deformations of CP_2 type vacuum extremals with Euclidian signature of metric to the background space-time sheet. This framework opens the doors for more concrete models of also super-conductivity involving the effective massivation of photons as one important aspect in the case of ordinary super-conductors.

There are two types of wormhole contacts. Those of first type correspond to elementary bosons. Wormhole contacts of second kind are generated in the topological condensation of space-time sheets carrying matter and form a hierarchy. Classical radiation fields realized in TGD framework as oscillations of space-time sheets would generate wormhole contacts as the oscillating space-time sheet develops contacts with parallel space-time sheets (recall that the distance between space-time sheets is of order CP_2 size). This realizes the correspondence between fields and quanta geometrically. Phonons could also correspond to wormhole contacts of this kind since they mediate acoustic oscillations between space-time sheets and the description of the phonon mediated interaction between electrons in terms of wormhole

contacts might be useful also in the case of super-conductivity. Bose-Einstein condensates of wormhole contacts might be highly relevant for the formation of macroscopic quantum phases. The formation of a coherent state of wormhole contacts would be the counterpart for the vacuum expectation value of Higgs.

The notions of coherent states of Cooper pairs and of charged Higgs challenge the conservation of electromagnetic charge. The following argument however suggests that coherent states of wormhole contacts form only a part of the description of ordinary super-conductivity. The basic observation is that wormhole contacts with vanishing fermion number define space-time correlates for Higgs type particle with fermion and anti-fermion numbers at light-like throats of the contact.

The ideas that a genuine Higgs type photon massivation is involved with super-conductivity and that coherent states of Cooper pairs really make sense are somewhat questionable since the conservation of charge and fermion number is lost for coherent states. A further questionable feature is that a quantum superposition of many-particle states with widely different masses would be in question. These interpretational problems can be resolved elegantly in zero energy ontology [K25] in which the total conserved quantum numbers of quantum state are vanishing. In this picture the energy, fermion number, and total charge of any positive energy state are compensated by opposite quantum numbers of the negative energy state in geometric future. This makes possible to speak about superpositions of Cooper pairs and charged Higgs bosons separately in positive energy sector.

If this picture is taken seriously, super-conductivity can be seen as providing a direct support for both the hierarchy of scaled variants of standard model physics and for the zero energy ontology.

Space-time correlate for quantum critical superconductivity

The explicit model for high T_c super-conductivity relies on quantum criticality involving long ranged quantum fluctuations inducing reconnection of flux tubes of local (color) magnetic fields associated with parallel spins associated with stripes to form long flux tubes serving as wires along which Cooper pairs flow. Essentially [D5] [D5] type phenomenon would be in question. The role of the doping by holes is to make room for Cooper pairs to propagate by the reconnection mechanism: otherwise Fermi statistics would prevent the propagation. Too much doping reduces the number of current carriers, too little doping leaves too little room so that there exists some optimal doping. In the case of high T_c super-conductors quantum criticality corresponds to a quite wide temperature range, which provides support for the quantum criticality of TGD Universe. The probability $p(T)$ for the formation of reconnections is what matters and exceeds the critical value at T_c.

3.2.5 Super-Conductivity At Magnetic Flux Tubes

Super-conductivity at the magnetic flux tubes of magnetic flux quanta is one the basic hypothesis of the TGD based model of living matter. There is also evidence for magnetically mediated super-conductivity in extremely pure samples [D33]. The magnetic coupling was only observed at lattice densities close to the critical density at which long-range magnetic order is suppressed. Quantum criticality that long flux tubes serve as pathways along which Cooper pairs can propagate. In anti-ferromagnetic phase these pathways are short-circuited to closed flux tubes of local magnetic fields.

Almost the same model as in the case of high T_c and quantum critical super-conductivity applies to the magnetic flux tubes. Now the flux quantum contains BE condensate of exotic Cooper pairs interacting with wormhole contacts feeding the gauge flux of Cooper pairs from the magnetic flux quantum to a larger space-time sheet. The interaction of spin 1 Cooper pairs with the magnetic field of flux quantum orients their spins in the same direction. Large value of $\hbar$ guarantees thermal stability even in the case that different space-time sheets are not thermally isolated.

The understanding of gap energy is not obvious. The transversal oscillations of magnetic flux tubes generated by spin flips of electrons define the most plausible candidate for the counterpart of phonons. In this framework phonon like states identified as wormhole contacts would be created by the oscillations of flux tubes and would be a secondary phenomenon.

Large values of $\hbar$ allow to consider not only the Cooper pairs of electrons but also of protons and fermionic ions. Since the critical temperature for the formation of Cooper pairs is inversely proportional to the mass of the charge carrier, the replacement of electron with proton or ion would require a scaling of $\hbar$. If T_{c1} is proportional to $\hbar^2$, this requires scaling by $(m_p/m_e)^{1/2}$. For $T_{c1} \propto \hbar$ scaling by $m_p/m_e \simeq 2^{11}$ is required. This inspired idea that powers of 2^{11} could define favored values of $\hbar/\hbar_0$. This hypothesis is however rather ad hoc and turned out to be too restrictive.

Besides Cooper pairs also Bose-Einstein condensates of bosonic ions are possible in large $\hbar$ phase and would give rise to super-conductivity. TGD inspired nuclear physics predicts the existence of exotic bosonic counterparts of fermionic nuclei with given (A, Z) [L4], [L4].

Superconductors at the flux quanta of the Earth's magnetic field

Magnetic flux tubes and magnetic walls are the most natural candidates for super-conducting structures with spin triplet Cooper pairs. Indeed, experimental evidence relating to the interaction of ELF em radiation with living matter suggests that bio-super-conductors are effectively 1- or 2-dimensional. $D \leq 2$-dimensionality is guaranteed by the presence of the flux tubes or flux walls of, say, the magnetic field of Earth in which charge carries form bound states and the system is equivalent with a harmonic oscillator in transversal degrees of freedom.

The effect of Earth's magnetic field is completely negligible at the atomic space-time sheets and cannot make super conductor 1-dimensional. At cellular sized space-time sheets magnetic field makes possible transversal the confinement of the electron Cooper pairs in harmonic oscillator states but does not explain energy gap which should be at the top of 1-D Fermi surface. The critical temperature extremely low for ordinary value of $\hbar$ and either thermal isolation between space-time sheets or large value of $\hbar$ can save the situation.

An essential element of the picture is that topological quantization of the magnetic flux tubes occurs. In fact, the flux tubes of Earth's magnetic field have thickness of order cell size from the quantization of magnetic flux. The observations about the effects of ELF em fields on bio-matter [**?**] suggest that similar mechanism is at work also for ions and in fact give very strong support for bio-super conductivity based on the proposed mechanism.

Energy gaps for superconducting magnetic flux tubes and walls

Besides the formation of Cooper pairs also the Bose-Einstein condensation of charge carriers to the ground state is needed in order to have a supra current. The stability of Bose-Einstein condensate requires an energy gap $E_{g,BE}$ which must be larger than the temperature at the magnetic flux tube.

Several energies must be considered in order to understand $E_{g,BE}$.

(a) The Coulombic binding energy of Cooper pairs with the wormhole contacts feeding the em flux from magnetic flux tube to a larger space-time sheet defines an energy gap which is expected to be of order $E_{g,BE} = \alpha/L(k)$ giving $E_g \sim 10^{-3}$ eV for $L(167) = 2.5$ μm giving a rough estimate for the thickness of the magnetic flux tube of the Earth's magnetic field $B = .5 \times 10^{-4}$ Tesla.

(b) In longitudinal degrees of freedom of the flux tube Cooper pairs can be described as particles in a one-dimensional box and the gap is characterized by the length L of the magnetic flux tube and the value of $\hbar$. In longitudinal degrees of freedom the difference between $n = 2$ and $n = 1$ states is given by $E_0(k_2) = 3h^2/4m_eL^2(k_2)$. Translational energy gap $E_g = 3E_0(k_2) = 3h^2/4m_eL^2(k_2)$ is smaller than the effective energy gap

$E_0(k_1) - E_0(k_2) = h^2/4m_e L^2(k_1) - h^2/4m_e L^2(k_2)$ for $k_1 > k_2 + 2$ and identical with it for $k_1 = k_2 + 2$. For $L(k_2 = 151)$ the zero point kinetic energy is given by $E_0(151) = 20.8$ meV so that $E_{g,BE}$ corresponds roughly to a temperature of 180 K. For magnetic walls the corresponding temperature would be scaled by a factor of two to 360 K and is above room temperature.

(c) Second troublesome energy gap relates to the interaction energy with the magnetic field. The magnetic interaction energy E_m of Cooper pair with the magnetic field consists of cyclotron term $E_c = n\hbar eB/m_e$ and spin-interaction term which is present only for spin triplet case and is given by $E_s = \pm\hbar eB/m_e$ depending on the orientation of the net spin with magnetic field. In the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) explaining the effects of ELF em fields on vertebrate brain, this energy scale is $\sim 10^{-9}$ eV for $\hbar_0$ and $\sim 1.6 \times 10^{-5}$ eV for $\hbar = 2^{14} \times \hbar_0$.

The smallness of translational and magnetic energy gaps in the case of Cooper pairs at Earth's magnetic field could be seen as a serious obstacle.

(a) Thermal isolation between different space-time sheets provides one possible resolution of the problem. The stability of the Bose-Einstein condensation is guaranteed by the thermal isolation of space-time if the temperature at the magnetic flux tube is below E_m. This can be achieved in all length scales if the temperature scales as the zero point kinetic energy in transversal degrees of freedom since it scales in the same manner as magnetic interaction energy.

(b) The transition to large $\hbar$ phase could provide a more elegant way out of the difficulty. The criterion for a sequence of transitions to a large $\hbar$ phase could be easily satisfied if there is a large number of charge Cooper pairs at the magnetic flux tube. Kinetic energy gap remains invariant if the length of the flux tube scales as $\hbar$. If the magnetic flux is quantized as a multiple of $\hbar$ and flux tube thickness scales as $\hbar^2$, B must scale as $1/\hbar$ so that also magnetic energy remains invariant under the scaling. This would allow to have stability without assuming low temperature at magnetic flux tubes.

3.3   TGD Based Model For High T_c Super Conductors

High T_c superconductors are quantum critical and involve in an essential magnetic structures, they provide an attractive application of the general vision for the model of super-conductivity based on magnetic flux tubes.

3.3.1   Some Properties Of High T_c Super Conductors

Quite generally, high T_c super-conductors are cuprates with CuO layers carrying the supra current. The highest known critical temperature for high T_c superconductors is 164 K and is achieved under huge pressure of 3.1×10^5 atm for LaBaCuO. High T_c super-conductors are known to be super conductors of type II.

This is however a theoretical deduction following from the assumption that the value of Planck constant is ordinary. For $\hbar = 2^{14}\hbar_0$ (say) ξ would be scaled up accordingly and type I super-conductor would be in question. These super-conductors are characterized by very complex patterns of penetrating magnetic field near criticality since the surface area of the magnetic defects is maximized. For high T_c super-conductors the ferromagnetic phase could be regarded as an analogous to defect and would indeed have very complex structure. Since quantum criticality would be in question the stripe structure would fluctuate with time too in accordance with 4-D spin glass character.

The mechanism of high T_c super conductivity is still poorly understood [D53, D55].

(a) It is agreed that electronic Cooper pairs are charge carriers. It is widely accepted that electrons are in relative d-wave state rather than in s-wave (see [D44] and the references mentioned in [D53]). Cooper pairs are believed to be in spin triplet state and electrons combine to form $L = 2$ angular momentum state. The usual phonon exchange mechanism does not generate the attractive interaction between the members of the Cooper pair having spin. There is also a considerable evidence for BCS type Cooper pairs and two kinds of Cooper pairs could be present.

(b) High T_c super conductors have spin glass like character [D50]. High T_c superconductors have anomalous properties also above T_c suggesting quantum criticality implying fractal scaling of various observable quantities such as resistivity. At high temperatures cuprates are anti-ferromagnets and Mott insulators meaning freezing of the electrons. Superconductivity and conductivity are believed to occur along dynamical stripes which are antiferromagnetic defects.

(c) These findings encourage to consider the interpretation in terms of quantum criticality in which some new form of super conductivity which is not based on quasiparticles is involved. This super-conductivity would be assignable with the quantum fluctuations destroying antiferromagnetic order and replacing it with magnetically disordered phase possibly allowing phonon induced super-conductivity.

(d) The doping of the super-conductor with electron holes is essential for high T_c superconductivity, and there is a critical doping fraction $p = .14$ at which T_c is highest. The interpretation is that holes make possible for the Cooper pairs to propagate. There is considerable evidence that holes gather on one-dimensional stripes with thickness of order few atom sizes and lengths in the range 1-10 nm [D55], which are fluctuating in time scale of 10^{-12} seconds. These stripes are also present in non-superconducting state but in this case they do not fluctuate appreciably. The most plausible TGD based interpretation is in terms of fluctuations of magnetic flux tubes allowing for the formation of long connected flux tubes making super-conductivity possible. The fact that the fluctuations would be oscillations analogous to acoustic wave and might explain the BCS type aspects of high T_c super-conductivity.

(e) T_c is inversely proportional to the distance L between the stripes. A possible interpretation would be that full super-conductivity requires de-localization of electrons also with respect to stripes so that T_c would be proportional to the hopping probability of electron between neighboring stripes expected to be proportional to $1/L$ [D55].

From free fermion gas to Fermi liquids to quantum critical systems

The article of Jan Zaanen [D54] gives an excellent non-technical discussion of various features of high T_c super-conductors distinguishing them from BCS super-conductors. After having constructed a color flux tube model of Cooper pairs I found it especially amusing to learn that the analogy of high T_c super-conductivity as a quantum critical phenomenon involving formation of dynamical stripes to QCD in the vicinity of the transition to the confined phase leading to the generation of string like hadronic objects was emphasized also by Zaanen.

BCS super-conductor behaves in a good approximation like quantum gas of non-interacting electrons. This approximation works well for long ranged interactions and the reason is Fermi statistics plus the fact that Fermi energy is much larger than Coulomb interaction energy at atomic length scales.

For strongly interacting fermions the description as Fermi liquid (a notion introduced by Landau) has been dominating phenomenological approach. ^{3}He provides a basic example of Fermi liquid and already here a paradox is encountered since low temperature collective physics is that of Fermi gas without interactions with effective masses of atoms about 6 times heavier than those of real atoms whereas short distance physics is that of a classical fluid at high temperatures meaning a highly correlated collective behavior.

It should be noticed that many-sheeted space-time provides a possible explanation of the paradox. Space-time sheets containing join along boundaries blocks of ^3He atoms behave

like gas whereas the ^3He atoms inside these blocks form a liquid. An interesting question is whether the ^3He atoms combine to form larger units with same spin as ^3He atom or whether the increase of effective mass by a factor of order six means that $\hbar$ as a unit of spin is increased by this factor forcing the basic units to consist of Bose-Einstein condensate of 3 Cooper pairs.

High T_c super conductors are neither Fermi gases nor Fermi liquids. Cuprate superconductors correspond at high temperatures to doped Mott insulators for which Coulomb interactions dominate meaning that electrons are localized and frozen. Electron spin can however move and the system can be regarded as an anti-ferromagnet. CuO planes are separated by highly oxidic layers and become super-conducting when doped. The charge transfer between the two kinds of layers is what controls the degree of doping. Doping induces somehow a de-localization of charge carriers accompanied by a local melting of anti-ferromagnet.

Collective behavior emerges for high enough doping. Highest T_c results with 15 per cent doping by holes. Current flows along electron stripes. Stripes themselves are dynamical and this is essential for both conductivity and superconductivity. For completely static stripes super-conductivity disappears and quasi-insulating electron crystal results.

Dynamical stripes appear in mesoscopic time and length scales corresponding to 1-10 nm length scale and picosecond time scale. The stripes are in a well-defined sense dual to the magnetized stripe like structures in type I super-conductor near criticality, which suggests analog of type I super-conductivity. The stripes are anti-ferromagnetic defects at which neighboring spins fail to be antiparallel. It has been found that stripes are a very general phenomenon appearing in insulators, metals, and super-conducting compounds [D15].

Quantum criticality is present also above T_c

Also the physics of Mott insulators above T_c reflects quantum criticality. Typically scaling laws hold true for observables. In particular, resistivity increases linearly rather than transforming from T^2 behavior to constant as would be implied by quasi-particles as current carriers. The appearance of so called pseudo-gap [D59] at $T_{c1} > T_c$ conforms with this interpretation. In particular, the pseudo-gap is non-vanishing already at T_{c_1} and stays constant rather than starting from zero as for quasi-particles.

Results from optical measurements and neutron scattering

Optical measurements and neutron scattering have provided especially valuable microscopic information about high T_c superconductors allowing to fix the details of TGD based quantitative model.

Optical measurements of copper oxides in non-super-conducting state have demonstrated that optical conductivity $\sigma(\omega)$ is surprisingly featureless as a function of photon frequency. Below the critical temperature there is however a sharp absorption onset at energy of about 50 meV [D37]. The origin of this special feature has been a longstanding puzzle. It has been proposed that this absorption onset corresponds to a direct generation of an electron-hole pair. Momentum conservation implies that the threshold for this process is $E_g + E$, where E is the energy of the "gluon" which binds electrons of Cooper pair together. In the case of ordinary super-conductivity E would be phonon energy.

Soon after measurements, it was proposed that in absence of lattice excitations photon must generate two electron-hole pairs such that electrons possess opposite momenta [D37]. Hence the energy of the photon would be $2E_g$. Calculations however predicted soft rather than sharp onset of absorption since pairs of electron-hole pairs have continuous energy spectrum. There is something wrong with this picture.

Second peculiar characteristic [D40, D35, D25] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor. This scattering occurs only below the critical temperature, in spin-flip channel and for a favored momentum exchange $(\pi/a, \pi/a)$, where a denotes the size of the lattice cube [D40, D35, D25]. The

transferred energy is concentrated in a remarkably narrow range around E_w rather than forming a continuum.

In [D11] is is suggested that e-e resonance with spin one gives rise to this excitation. This resonance is assumed to play the same role as phonon in the ordinary super conductivity and e-e resonance is treated like phonon. It is found that one can understand the dependence of the second derivative of the photon conductivity $\sigma(\omega)$ on frequency and that consistency with neutron scattering data is achieved. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV. This would suggest that the energy of the excitations generating the binding between the members of the Cooper pair is indeed 41 meV, that two electron-hole pairs and excitation of the super conductor are generated in photon absorption above threshold, and that the gap energy of the Cooper pair is 27 meV. Of course, the theory of Carbotte *et al* does not force the "gluon" to be triplet excitation of electron pair. Also other possibilities can be considered. What comes in mind are spin flip waves of the spin lattice associated with stripe behaving as spin 1 waves.

In TGD framework more exotic options become possible. The transversal fluctuations of stripes- or rather of the magnetic flux tubes associated with the stripes- could define spin 1 excitations analogous to the excitations of a string like objects. Gauge bosons are identified as wormhole contacts in quantum TGD and massive gauge boson like state containing electron-positron pair or quark-antiquark pair could be considered.

3.3.2   TGD Inspired Vision About High T_c Superconductivity

The following general view about high T_c super-conductivity as quantum critical phenomenon suggests itself. It must be emphasized that this option is one of the many that one can imagine and distinguished only by the fact that it is the minimal option.

The interpretation of critical temperatures

The two critical temperatures T_c and $T_{c_1} > T_c$ are interpreted as critical temperatures. The recent observation that there exists a spectroscopic signature of high T_c super-conductivity, which prevails up to T_{c_1} [D9], supports the interpretation that Cooper pairs exist already below T_{c1} but that for some reason they cannot form a coherent super-conducting state.

One can imagine several alternative TGD based models but for the minimal option is the following one.

(a) T_{c_1} would be the temperature for the formation of two-phase system consisting of ordinary electrons and of Cooper pairs with a large value of Planck constant explaining the high critical temperature.

(b) Magnetic flux tubes are assumed to be carriers of supra currents. These flux tubes are very short in in anti-ferromagnetic phase. The holes form stripes making them positively charged so that they attract electrons. If the spins of holes tend to form parallel sequences along stripes, they generate dipole magnetic fields in scales of order stripe length at least. The corresponding magnetic flux tubes are assumed to be carriers of electrons and Cooper pairs. The flux tube structures would be closed so that the supra currents associated with these flux tubes would be trapped in closed loops above T_c.

(c) Below T_{c1} transversal fluctuations of the flux tubes structures occur and can induce reconnections giving rise to longer flux tubes. Reconnection can occur in two ways. Recall that upwards going outer flux tubes of the dipole field turn downwards and eventually fuse with the dipole core. If the two dipoles have opposite directions the outer flux tube of the first (second) dipole can reconnect with the inward going part of the flux tube of second (first) dipole. If the dipoles have same direction, the outer flux tubes of the dipoles reconnect with each other. Same applies to the inwards going parts of the flux tubes and the dipoles fuse to a single deformed dipole if all flux tubes

reconnect. This alternative looks more plausible. The reconnection process is in general only partial since dipole field consists of several flux tubes.

(d) The reconnections for the flux tubes of neighboring almost dipole fields occur with some probability $p(T)$ and make possible finite conductivity. At T_c the system the fluctuations of the flux tubes become large and also $p(T, L)$, where L is the distance between stripes, becomes large and the reconnection leads to a formation of long flux tubes of length of order coherence length at least and macroscopic supra currents can flow. One also expects that the reconnection occurs for practically all flux tubes of the dipole field. Essentially a percolation type phenomenon [D5] would be in question. Scaling invariance suggests $p_c(T, L) = p_c(TL/\hbar)$, where L is the distance between stripes, and would predict the observed $T_c \propto \hbar/L$ behavior. Large value of $\hbar$ would explain the high value of T_c.

This model relates in an interesting manner to the vision of Zaanen [D57] expressed in terms of the highway metaphor visualizing stripes as quantum highways along which Cooper pairs can move. In antiferromagnetic phase the traffic is completely jammed. The doping inducing electron holes allows to circumvent traffic jam due to the Fermi statistics generates stripes along which the traffic flows in the sense of ordinary conductivity. In TGD framework highways are replaced with flux tubes and the topology of the network of highways fluctuates due to the possibility of reconnections. At quantum criticality the reconnections create long flux tubes making possible the flow of supra currents.

The interpretation of fluctuating stripes in terms of 1-D phonons

In TGD framework the phase transition to high T_c super-conductivity would have as a correlate fluctuating stripes to which supra currents are assigned. Note that the fluctuations occur also for $T > T_c$ but their amplitude is smaller. Stripes would be parallel to the dark magnetic flux tubes along which dark electron current flows above T_c. The fluctuations of magnetic flux tubes whose amplitude increases as T_c is approached induce transverse oscillations of the atoms of stripes representing 1-D transverse phonons.

The transverse fluctuations of stripes have naturally spin one character in accordance with the experimental facts. They allow identification as the excitations having 41 meV energy and would propagate in the preferred diagonal direction $(\pi/a, \pi/a)$. Dark Cooper pairs would have a gap energy of 27 meV. Neutron scattering resonance could be understood as a generation of these 1-D phonons and photon absorption a creation of this kind of phonon and breaking of dark Cooper pair. The transverse oscillations could give rise to the gap energy of the Cooper pair below T_{c1} and for the formation of long flux tubes below T_c but one can consider also other mechanisms based on the new physics predicted by TGD.

Various lattice effects such as superconductivity-induced phonon shifts and broadenings, possible isotope effects in T_c (questionable), the penetration depth, infrared and photoemission spectra have been observed in the cuprates [D3]. A possible interpretation is that ordinary phonons are replaced by 1-D phonons defined by the transversal excitations of stripes but do not give rise to the binding of the electrons of the Cooper pair but to reconnection of flux tubes. An alternative proposal which seems to gain experimental support is that spin waves appearing near antiferromagnetic phase transitions replace phonons.

More precise view about high T_c superconductivity taking into account recent experimental results

There are more recent results allowing to formulate more precisely the idea about transition to high T_c super-conductivity as a percolation type phenomenon. Let us first summarize the recent picture about high T_c superconductors.

(a) 2-dimensional phenomenon is in question. Supra current flows along preferred lattice planes and type II super-conductivity in question. Proper sizes of Cooper pairs (coherence lengths) are ξ =1-3 nm. Magnetic length λ is longer than $\xi/\sqrt{2}$.

(b) Mechanism for the formation of Cooper pairs is the same water bed effect as in the case of ordinary superconductivity. Phonons are only replaced with spin-density waves for electrons with periodicity in general not that of the underlying lattice. Spin density waves relate closely to the underlying antiferromagnetic order. Spin density waves appear near phase transition to antiferromagnetism.

(c) The relative orbital angular mentum of Cooper pair is L=2 ($x^2 - y^2$ wave), and vanishes at origin unlike for ordinary s wave SCs. The spin of the Cooper pair vanishes.

Consider now the translation of this picture to TGD language. Basic notions are following.

(a) Magnetic flux tubes and possibly also dark electrons forming Cooper pairs.

(b) The appearence of spin waves means sequences of electrons with opposite spins. The magnetic field associated with them can form closed flux tube containing both spins. Assume that spins-are orthogonal to the lattice plane in which supracurrent flows. Assume that the flux tube branches associated with electron with given spin branches so that it is shared with both neighboring electrons.

(c) Electrons of opposite spins at the two portions of the closed flux tube have magnetic interaction energy. The total energy is minimal when the spins are in opposite directions. Thus the closed flux tube tends to favor formation of Cooper pairs.

(d) Since magnetic interaction energy is proportional to $h_{eff} = n \times h$, it is expected stabilize the Cooper pairs at high temperatures. For ordinary super-conducti- vity magnetic fields tends to de-stabilize the pairs by trying to force the spins of spin singlet pair to the same direction.

(e) This does not yet give super-conductivity. The closed flux tubes associated with paired spins can however reconnect so that longer flux closed flux tubes are formed. If this occurs for entire sequences, one obtains two flux tubes containing electrons with opposite spins forming Cooper pairs: this would be the "highway" and percolation would corresponds to this process. The pairs would form supracurrents in longer scales.

(f) The phase phase transitions generating the reconnections could be percolation type phase transition.

This picture might apply also in TGD based model of bio-superconductivity.

(a) The stability of dark Cooper pairs assume to reside at magnetic flux tubes is a problem also now. Fermi statistics favors opposite spins but this means that magnetic field tends to spit the pairs if the members of the pair are at the same flux tube.

(b) If the members of the pair are at different flux tubes, the situation changes. One can have $L = 1$ and $S = 1$ with parallel spins (ferromagnetism like situation) or $L = 2$ and $S = 0$ state (anti-ferromagnetism like situation). $L > 0$ is necessary since electrons must reside at separate flux tubes.

Nematics and high T_c superconductors

Waterloo physicists discover new properties of superconductivity is the title of article (see http://tinyurl.com/jfz3l45) popularizing the work of David Hawthorn, Canada Research Chair Michel Gingras, doctoral student Andrew Achkar and post-doctoral student Zhihao Hao published in Science [D27] (see http://tinyurl.com/zycahrx). There is a dose of hype involved. As a matter of fact, it has been known for years that electrons flow along stripes, kind of highways in high T_c superconductors.

This effect is known as nematicity and means that electron orbitals break lattice symmetries and align themselves like a series of rods. Nematicity in long length scales occurs a temperatures below the critical point for super-conductivity. In the above mentioned work cuprate CuO_2 is studied. For non-optimal doping the critical temperature for transition to macroscopic superconductivity is below the maximal critical temperature. Long length scale nematicity is observed in these phases.

In the article by Rosenthal *et al* [D39] (see `http://tinyurl.com/h34347f`) it is however reported that nematicity is in fact preserved above critical temperature as a local order -at least up to the upper critical temperature, which is not easy to understand in the BCS theory of superconductivity. One can say that the stripes are short and short-lived so that genuine super-conductivity cannot take place.

These two observations lend further support for the TGD inspired model of high T_c super-conductivity and bio-superconductivity. It is known that antiferromagnetism is essential for the phase transition to superconductivity but Maxwellian view about electromagnetism and standard quantum theory do not make it easy to understand how. Magnetic flux tube is the first basic new notion provided by TGD. Flux tubes carry dark electrons with scaled up Planck constant $h_{eff} = n \times h$: this is second new notion. This implies scaling up of quantal length scales and in this manner makes also super-conductivity possible.

Magnetic flux tubes in antiferromagnetic materials form short loops. At the upper critical point they however reconnect with some probability to form loops with look locally like parallel flux tubes carrying magnetic fields in opposite directions. The probability of reverse phase transition is so large than there is a competion. The members of Cooper pairs are at parallel flux tubes and have opposite spins so that the net spin of pair vanishes: $S = 0$. At the first critical temperature the average length and lifetime of flux tube highways are too short for macroscopic super-conductivity. At lower critical temperature all flux tubes re-connect permanently average length of pathways becomes long enough.

This phase transition is mathematically analogous to percolation in which water seeping through sand layer wets it completely. The competion between the phases between these two temperatures corresponds to quantum criticality in which phase transitions $h_{eff}/h = n_1 \leftrightarrow n_2$ take place in both directions ($n_1 = 1$ is the most plausible first guess). Earlier I did not fully realize that Zero Energy Ontology provides an elegant description for the situation [L38] [**?**]. The reason was that I thought that quantum criticality occurs at single critical temperature rather than temperature interval. Nematicity is indeed detected locally below upper critical temperature and in long length scales below lower critical temperature.

Explanation for the spectral signatures of high T_c superconductor

The model should explain various spectral signatures of high T_c super-conductors. It seems that this is possible at qualitative level at least.

(a) Below the critical temperature there is a sharp absorption onset at energy of about $E_a = 50$ meV.

(b) Second characteristic [D40, D35, D25] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor also visible only below the critical temperature.

(c) The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV for the energy gap.

$E_g = 27$ meV has a natural interpretation as energy gap of spin 1 Cooper pair. $E_w = 41$ meV can be assigned to the transversal oscillations of magnetic flux tubes inducing 1-D transversal photons which possibly give rise to the energy gap. $E_a = 50$ meV can be understood if also $S = 0$ Cooper pair for which electrons of the pair reside dominantly at the "outer" dipole flux tube and inner dipole core. The presence of this pair might explain the BCS type aspects of high T_c super-conductivity. This identification would predict the gap energy of $S = 0$ Cooper pair to be $E_g(S = 0) = 9$ meV. Since the critical absorption onset is observed only below T_c these Cooper pairs would become thermally stable at T_c and the formation of long flux tubes should somehow stabilize them. For very long flux tubes the distance of a point of "outer" flux tube from the nearby point "inner" flux tube becomes very long along dipole flux tube. Hence the transformation of $S = 0$ pairs to $S = 1$ pairs is not possible anymore and $S = 0$ pairs are stabilized.

Model for Cooper pairs

The TGD inspired model for Cooper pairs of high T_c super-conductor involves several new physics aspects: large $\hbar$ phases, the notion of magnetic flux tubes. One can also consider the possibility that color force predicted by TGD to be present in all length scales is present.

(a) One can consider two options for the topological quantization of the dipole field. It could decompose to a flux tube pattern with a discrete rotational symmetry Z_n around dipole axis or to flux sheets identified as walls of finite thickness invariant under rotations around dipole axis. Besides this there is also inner the flux tube corresponding to the dipole core. For the flux sheet option one can speak about eigenstates of L_z. For flux tube option the representations of Z_n define the counterparts of the angular momentum eigenstates with a cutoff in L_z analogous to a momentum cutoff in lattice. The discretized counterparts of spherical harmonics make sense. The counterparts of the relative angular momentum eigenstates for Cooper pair must be defined in terms of tensor products of these rather than using spherical harmonics assignable with the relative coordinate $r_1 - r_2$. The reconnection mechanism makes sense only for the flux tube option so that it is the only possibility in the recent context.

(b) Exotic Cooper pair is modeled as a pair of large $\hbar$ electrons with zoomed up size at space-time representing the dipole field pattern associated with a sequence of holes with same spin. If the members of the pair are at diametrically opposite flux tubes or at the "inner" flux tube (dipole core) magnetic fluxes flow in same direction for electrons and spin 1 Cooper pair is favored. If they reside at the "inner" flux tube and outer flux tube, spin zero state is favored. This raises the question whether also $S = 0$ variant of the Cooper pair could be present.

(c) Large $\hbar$ is needed to explain high critical temperature. By the general argument the transition to large $\hbar$ phase occurs in order to reduce the value of the gauge coupling strength - now fine structure constant- and thus guarantee the convergence of the perturbation theory. The generation or positive net charge along stripes indeed means strong electromagnetic interactions at stripe.

Color force in condensed matter length scales is a new physics aspect which cannot be excluded in the case that transverse oscillations of flux tubes do not bind the electrons to form a Cooper pair. Classically color forces accompany any non-vacuum extremal of Kähler action since a non-vanishing induced Kähler field is accompanied by a classical color gauge field with Abelian holonomy. Induced Kähler field is always non-vanishing when the dimension of the CP_2 projection of the space-time surface is higher than 2. One can imagine too alternative scenarios.

(a) Electromagnetic flux tubes for which induced Kähler field is non-vanishing carry also classical color fields. Cooper pairs could be color singlet bound states of color octet excitations of electrons (more generally leptons) predicted by TGD and explaining quite impressive number of anomalies [K112]. These states are necessarily dark since the decay widths of gauge bosons do not allow new light fermions coupling to them. The size of these states is of order electron size scale $L(127)$ for the standard value of Planck constant. For the non-standard value of Planck constant it would be scaled up correspondingly. For $r = \hbar/\hbar_0 = 2^{14}$ the size would be around 3.3 Angströms and for $r = 2^{24}$ of order 10 nm. Color binding could be responsible for the formation of the energy gap in this case and would distinguish between ordinary two-electron states and Cooper pair. The state with minimum color magnetic energy corresponds to spin triplet state for two color octed fermions whereas for colored fermion and anti-fermion it corresponds to spin singlet (pion like state in hadron physics).

(b) A more complex variant of this picture served as the original model for Cooper pairs. Electrons at given space-time sheet feed their gauge flux to large space-time sheet via wormhole contacts. If the wormhole throats carry quantum numbers of quark and antiquark one can say that in the simplest situation the electron space-time sheet is color singlet state formed by quark and antiquark associated with the upper throats

of the wormhole contacts carrying quantum numbers of u quark and $\overline{d}$ quark. It can also happen that the electronic space-time sheets are not color singlet but color octet in which case the situation is analogous to that above. Color force would bind the two electronic space-time sheets to form a Cooper pair. The neighboring electrons in stripe possess parallel spins and could form a pair transforming to a large $\hbar$ Cooper pair bound by color force. The Coulombic binding energy of the charged particles with the quarks and antiquarks assignable to the two wormhole throats feeding the em gauge flux to Y^4 and color interaction would be responsible for the energy gap.

Estimate for the gap energy

If transverse oscillations are responsible for the binding of the Cooper pairs, one expects similar expression for the gap energy as in the case of BCS type super conductors. The 3-D formula for the gap energy reads as

$$
\begin{aligned}
E_g &= \hbar\omega_D exp(-1/X) \ , \\
\omega_D &= (6\pi^2)^{1/3} c_s n^{1/3} \\
X &= n(E_F)U_0 = \frac{3}{2} N(E_F) \frac{U_0}{E_F} \ , \\
n(E_F) &= \frac{3}{2} \frac{N(E_F)}{E_F} \ .
\end{aligned}
$$

(3.3.1)

X depends on the details of the binding mechanism for Cooper pairs and U_0 parameterizes these details.

Since only stripes contribute to high T_c super-conductivity it is natural to replace 3-dimensional formula for Debye frequency in 1-dimensional case with

$$
\begin{aligned}
E_g &= \hbar\omega exp(-1/X) \ , \\
\omega &= kc_s n \ .
\end{aligned}
$$

(3.3.2)

where n is the 1-dimensional density of Cooper pairs and k a numerical constant. X would now correspond to the binding dynamics at the surface of 1-D counterpart of Fermi sphere associated with the stripe.

There is objection against this formula. The large number of holes for stripes suggests that the counterpart of Fermi sphere need not make sense, and one can wonder whether it could be more advantageous to talk about the counterpart of Fermi sphere for holes and treat Cooper pair as a pair of vacancies for this "Fermi sphere". High T_c super conductivity would be 1-D conventional super-conductivity for bound states of vacancies. This would require the replacement of n with the linear density of holes along stripes, which is essentially that of nuclei.

From the known data one can make a rough estimate for the parameter X. If $E_w = hf = 41$ meV is assigned with transverse oscillations the standard value of Planck constant would give $f = f_0 = 9.8 \times 10^{12}$ Hz. In the general case one has $f = f_0/r$. If one takes the 10^{-12} second length scale of the transversal fluctuations at a face value one obtains $r = 10$ as a first guess. $E_g = 27$ meV gives the estimate

$$
exp(-1/X) = \frac{E_g}{E_w}
$$

(3.3.3)

giving $X = 2.39$.

The interpretation in terms of transversal oscillations suggests the dispersion relation

$$f = \frac{c_s}{L} \quad .$$

L is the length of the approximately straight portion of the flux tube. The length of the "outer" flux tube of the dipole field is expected be longer than that of stripe. For $L = x$ nm and $f_D \sim 10^{12}$ Hz one would obtain $c_s = 10^3 x$ m/s.

Estimate for the critical temperatures and for $\hbar$

One can obtain a rough estimate for the critical temperature T_{c1} by following simple argument.

(a) The formula for the critical temperature proposed in the previous section generalize in 1-dimensional case to the following formula

$$T_{c1} \quad \leq \quad \frac{h^2}{8m_e}(\frac{n_c}{g})^2 \quad . \tag{3.3.4}$$

g is the number of spin degrees of freedom for Cooper pair and n_c the 1-D density of Cooper pairs. The effective one-dimensionality allows only single $L = 2$ state localized along the stripe. The $g = 3$ holds true for $S = 1$.

(b) By parameterizing n_c as $n_c = (1 - p_h)/a$, $a = x$ Angstrom, and substituting the values of various parameters, one obtains

$$T_{c1} \quad \simeq \quad \frac{r^2(1 - p_h)^2}{9x^2} \times 6.3 \; meV \quad . \tag{3.3.5}$$

(c) An estimate for p_h follows from the doping fraction p_d and the fraction p_s of parallel atomic rows giving rise to stripes one can deduce the fraction of holes for a given stripe as

$$p_h \quad = \quad \frac{p_d}{p_s} \quad . \tag{3.3.6}$$

One must of course have $p_d \leq p_s$. For instance, for $p_s = 1/5$ and $p_d = 15$ per cent one obtains $p_h = 75$ per cent so that a length of four atomic units along row contains one Cooper pair on the average. For $T_{c1} = 23$ meV (230 K) this would give the rough estimate $r = 23.3$: $r = 24$ satisfies the Fermat polygon constraint. Contrary to the first guess inspired by the model of bio-superconductivity the value of $\hbar$ would not be very much higher than its standard value. Notice however that the proportionality $T_c \propto r^2$ makes it difficult to explain T_{c1} using the standard value of $\hbar$.

(d) One $p_h \propto 1/L$ whereas scale invariance for reconnection probability $(p = p(x = TL/\hbar))$ predicts $T_c = x_c\hbar/L = x_c p_s\hbar/a$. This implies

$$\frac{T_c}{T_{c1}} \quad = \quad 32\pi^2 \frac{m_e a}{\hbar_0} x^2 g^2 \frac{p_s}{(1 - (p_d/p_s)^2)^2} \frac{x_c}{r} \quad . \tag{3.3.7}$$

This prediction allows to test the proposed admittedly somewhat ad hoc formula. For $p_d \ll p_s$ T_c/T_{c1} does behaves as $1/L$. One can deduce the value of x_c from the empirical data.

(e) Note that if the reconnection probability p is a universal function of x as quantum criticality suggests and thus also x_c is universal, a rather modest increase of $\hbar$ could allow to raise T_c to room temperature range.

The value of $\hbar$ is predicted to be inversely proportional to the density of the Cooper pairs at the flux tube. The large value of $\hbar$ needed in the modelling of living system as magnetic flux tube super-conductor could be interpreted in terms of phase transitions which scale up both the length of flux tubes and the distance between the Cooper pairs so that the ratio rn_c remains unchanged.

Coherence lengths

The coherence length for high T_c super conductors is reported to be 5-20 Angstroms. The naïve interpretation would be as the size of Cooper pair. There is however a loophole involved. The estimate for coherence length in terms of gap energy is given by $\xi = \frac{4\hbar v_F}{E_g}$. If the coherence length is estimated from the gap energy, as it seems to be the case, then the scaling up of the Planck constant would increase coherence length by a factor $r = \hbar/\hbar_0$. $r = 24$ would give coherence lengths in the range $12 - 48$ nm.

The interpretation of the coherence length would be in terms of the length of the connected flux tube structure associated with the row of holes with the same spin direction which can be considerably longer than the row itself. As a matter fact r would characterize the ratio of size scales of the "magnetic body" of the row and of row itself. The coherence lengths could relate to the p-adic length scales $L(k)$ in the range $k = 151, 152, .., 155$ varying in the range $(10, 40]$) nm. $k = 151$ correspond to thickness cell membrane.

Why copper and what about other elements?

The properties of copper are somehow crucial for high T_c superconductivity since cuprates are the only known high T_c superconductors. Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages the question whether the doping by holes needed to achieve superconductivity induces the phase transition transforming the electrons to dark Cooper pairs.

More generally, elements having one electron in s state plus full electronic shells are good candidates for doped high T_c superconductors. If the atom in question is also a boson the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Superfluid would be in question. Thus elements with odd value of A and Z possessing full shells plus single s wave valence electron are of special interest. The six stable elements satisfying these conditions are ^{5}Li, ^{39}K, ^{63}Cu, ^{85}Rb, ^{133}Cs, and ^{197}Au.

A new phase of matter in the temperature range between pseudo gap temperature and T_c?

Kram sent a link to a Science Daily popular article titled "High-Temperature Superconductor Spills Secret: A New Phase of Matter?" (see `http://tinyurl.com/49vnvsu`: see also `http://tinyurl.com/yb7rs3fs`). For more details see the article in Science [D29].

Zhi-Xun Shen of the Stanford Institute for Materials and Energy Science (SIMES), a joint institute of the Department of Energy's SLAC National Accelerator Laboratory and Stanford University, led the team of researchers, which discovered that in the temperature region between the pseudo gap temperature and genuine temperature for the transition to super-conducting phase there exists a new phase of matter. The new phase would not be super-conducting but would be characterized by an order of its own which remains to be understood. This phase would be present also in the super-conducting phase.

The announcement does not come as a complete surprise for me. A new phase of matter is what TGD inspired model of high T_c superconductivity indeed predicts. This phase would consist of Cooper pairs of electrons with a large value of Planck constant but associated with magnetic flux tubes with short length so that no macroscopic supra currents would be possible.

The transition to super-conducting phase involves long range fluctuations at quantum criticality and the analog of a phenomenon known as percolation (see `http://tinyurl.com/oytvosv`) [D5]. For instance, the phenomenon occurs for the filtering of fluids through porous materials. At critical threshold the entire filter suddenly wets as fluid gets through the filter. Now this phenomenon would occur for magnetic flux tubes carrying the Cooper pairs. At criticality the short magnetic flux tubes fuse by reconnection to form long ones so that supra currents in macroscopic scales become possible.

It is not clear whether this prediction is consistent with the finding of Shen and others. The simultaneous presence of short and long flux tubes in macroscopically super-conducting phase is certainly consistent with TGD prediction. The situation depends on what one means with super-conductivity. Is super-conductivity super-conductivity in macroscopic scales only or should one call also short scale super-conductivity not giving rise to macroscopic super currents as super-conductivity. In other words: do the findings of Shen's team prove that the electrons above gap temperature do not form Cooper pairs or only that there are no macroscopic supra currents?

Whether the model works as such or not is not a life and death question for the TGD based model. One can quite well imagine that the first phase transition increasing $\hbar$ does not yet produce electron Compton lengths long enough to guarantee that the overlap criterion for the formation of Cooper pairs is satisfied. The second phase transition increasing $\hbar$ would do this and also scale up the lengths of magnetic flux tubes making possible the flow of supra currents as such even without reconnections. Also reconnections making possible the formation of very long flux tubes could be involved and would be made possible by the increase in the length of flux tubes.

3.3.3 Speculations

21-Micrometer mystery

21 micrometer radiation from certain red giant stars have perplexed astronomers for more than a decade [D10]. Emission forms a wide band (with width about 4 micrometers) in the infrared spectrum, which suggests that it comes form a large complex molecule or a solid or simple molecules found around starts. Small molecules are ruled out since they produce narrow emission lines. The feature can be only observed in very precise evolutionary state, in the transition between red giant phase and planetary nebular state, in which star blows off dust that is rich in carbon compounds. There is no generally accepted explanation for 21-micrometer radiation.

One can consider several explanations based on p-adic length scale hypothesis and some explanations might relate to the wormhole based super-conductivity.

(a) 21 micrometers corresponds to the photon energy of 59 meV which is quite near to the zero point point kinetic energy 61.5 meV of proton Cooper pair at $k = 139$ space-time sheet estimated from the formula

$$\Delta E(2m_p, 139) = \frac{1}{2} \frac{\pi^2}{(2m_p)L_e(139)^2} = \frac{1}{8} \Delta E(m_p, 137) \simeq 61.5 \; meV \;\; .$$

Here the binding energy of the Cooper pair tending to reduce this estimate is neglected, and this estimate makes sense only apart from a numerical factor of order unity. This energy is liberated when a Cooper pair of protons at $k = 139$ space-time sheet drops to the magnetic flux tube of Earth's magnetic field (or some other sufficiently large space-time sheet). This energy is rather near to the threshold value about 55 meV of the membrane potential.

(b) 21 micrometer radiation could also result when electrons at $k = 151$ space-time sheet drop to a large enough space-time sheet and liberate their zero point kinetic energy. Scaling argument gives for the zero point kinetic energy of electron at $k = 151$ space-time sheet the value $\Delta(e, 151) \simeq 57.5$ meV which is also quite near to the observed

value. If electron is bound to wormhole with quantum numbers of $\overline{d}$ Coulombic binding energy changes the situation.

(c) A possible explanation is as a radiation associated with the transition to high T_c super conducting phase. There are two sources of photons. Radiation could perhaps result from the de-excitations of wormhole BE condensate by photon emission. $\lambda = 20.5$ micrometers is precisely what one expects if the space-time sheet corresponds to $p \simeq 2^k$, $k = 173$ and assumes that excitation energies are given as multiples of $E_w(k) = 2\pi/L_e(k)$. This predicts excitation energy $E_w(173) \simeq 61.5$ meV. Unfortunately, this radiation should correspond to a sharp emission line and cannot explain the wide spectrum.

Are living systems high T_c superconductors?

The idea about cells and axons as superconductors has been one of the main driving forces in development of the vision about many-sheeted space-time. Despite this the realization that the supra currents in high T_c superconductors flow along structure similar to axon and having same crucial length scales came as a surprise. Axonal radius which is typically of order $r = .5$ μm. $r = 151 - 127 = 24$ favored by Mersenne hypothesis would predict $r = .4$ μm. The fact that water is liquid could explain why the radius differs from that predicted in case of high T_c superconductors.

Interestingly, Cu is one of the biologically most important trace elements [D2]. For instance, copper is found in a variety of enzymes, including the copper centers of cytochrome c-oxidase, the Cu-Zn containing enzyme superoxide dismutase, and copper is the central metal in the oxygen carrying pigment hemocyanin. The blood of the horseshoe crab, Limulus polyphemus uses copper rather than iron for oxygen transport. Hence there are excellent reasons to ask whether living matter might be able to build high T_c superconductors based on copper oxide.

Neuronal axon as a geometric model for current carrying "rivers"

Neuronal axons, which are bounded by cell membranes of thickness $L_e(151)$ consisting of two lipid layers of thickness $L_e(149)$ are good candidates for high T_c superconductors in living matter.

These flux tubes with radius $.4$ μm would define "rivers" along which conduction electrons and various kinds of Cooper pairs flow. Scaled up electrons have size $L_e(k_{eff} = 151)$ corresponding to 10 nm, the thickness of the lipid layer of cell membrane. Also the quantum fluctuating stripes of length 1-10 nm observed in high T_c super conductors might relate to the scaled up electrons with Compton length 10 nm, perhaps actually representing zoomed up electrons!

The original assumption that exotic *resp.* BCS type Cooper pairs reside at boundaries *resp.* interior of the super-conducting rivulet. It would however seem that the most natural option is that the hollow cylindrical shells carry all supra currents and there are no Cooper pairs in the interior. If exotic Cooper pairs reside only at the boundary of the rivulet or the Cooper pairs at boundary remain critical against exotic-BCS transition also below T_c, the time dependent fluctuations of the shapes of stripes accompanying high T_c super-conductivity can be understood as being induced by the fluctuations of membrane like structures. Quantum criticality at some part of the boundary is necessary in order to transform ordinary electron currents to super currents at the ends of rivulets. In biology this quantum criticality would correspond to that of cell membrane.

3.4 Models For Ionic Superconductivity

In this section the model for ionic superconductivity is constructed as a straightforward generalization of the model of high T_c electronic superconductivity. There is however a loophole involved. TGD based model of atomic nucleus predicts that fermionic ions can have

bosonic chemical equivalents for which one of the color bonds connecting nucleons to nuclear string is charged. Dark fermionic ions like Na^+, K^+, and Cl^- could be actually exotic ions of this kind having different mass number and be able to form Bose-Einstein condensates. This is required by the recent model for nerve pulse [K80]. The prediction can be tested.

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field differs radically from the earlier model and allows to understand that effects of ELF em fields on brain. Bose-Einstein condensates of bosonic ions are predicted to be of special importance for the functioning of living systems. Also a quantitative understanding of the effects of Schumann resonances and EEG emerges.

3.4.1   Model For Ionic Superconductivity

Exactly the same mechanisms are expected to work also in the case of ions and the only differences come from the different mass and charge of ion.

(a) Magnetic flux tubes are carriers of supra currents and magnetic fields favor the formation of spin 1 Cooper pairs which are parallel and have also spins parallel to the flux tubes. In living matter the flux tubes could be dark magnetic flux tubes connecting different biomolecules. For instance, DNA as topological quantum computer model [K2] assumes that flux tubes connect nucleotides of DNA with the lipid layers of nuclear or cell membrane.

(b) Mersenne hypothesis discussed in the introduction is assumed and makes possible precise quantitative predictions using scaling arguments. With the motivation coming from the model of cell membrane as Josephson junction it is also assumed that magnetic field scales as $1/\hbar$ and that the supra currents at the boundaries of flux tubes guarantee that the quantization condition $\oint (p - eA) \cdot dl = 0$ is satisfied. This allows the flux tubes to have a fixed transversal size (cell membrane thickness) irrespective of the value of Planck constant. An attractive hypothesis is that the $B_{end} = 0.2$ Gauss and its $1/\hbar$ scaled variants define preferred values of magnetic field.

(c) In the case of ionic super-conductivity there is no antiferromagnetic lattice present. Therefore there is no obvious reason for having higher critical temperature $T_{c,1}$. Percolation type mechanism is possible if a recombination of shorter magnetic flux tubes to form longer ones takes place at critical temperature. According to the model of DNA as topological quantum computer recombination of the flux tubes is a basic mechanism of information processing mechanism in living matter so that percolation type criticality might be present.

(d) For large values of $\hbar$ the gap for magnetic cyclotron energies implies that proton Cooper pairs condense to the ground state in the degrees of freedom transversal to the flux tube in which harmonic oscillator states provide a good approximate model. In the longitudinal degrees of freedom one has effectively particle in box. The corresponding energy gap $E = \pi^2 \hbar^2 / 2m_p L^2$ is below thermal energy at room temperature for flux tube lengths L of order $L(139)$ for ordinary value of $\hbar$. For electron this length scale is by a factor $m_p/m_e \simeq 2^{11}$ longer and corresponds to about 100 nm. The value of flux tube length however scales as $\hbar$ if one assumes that energy does not change in the scaling of $\hbar$. Hence arbitrarily long flux tube lengths are possible. For ion with mass number A the minimnum value of $\hbar$ allowing given flux tube length L scales as $\hbar \propto AL$.

(e) In the case of bosonic ions there is no need for Cooper pairs and super-conductivity would be due to the Bose-Einstein condensation of ions. TGD based nuclear physics also predicts exotic ions, which are chemically like their fermionic counterparts but are actually bosons. This is made possible by the possibility of the color flux tubes connecting nucleons to nuclear string to carry charges $1, 0, -1$.

(f) Whether the Cooper pairs of fermionic ions can be thermally stable is far from obvious. The model for electronic super-conductivity would suggest transversal fluctuations of the flux tube as the mediator of the attractive interaction winning Coulomb repulsion and making possible the formation of the Cooper pairs.

$$
\begin{array}{llll}
Ion & f_c/Hz & Pseudo-ion & f_c/Hz \\
{}^{23}Na^+ & 13.1 & {}^{19}Ne_+ & 15.7 \\
{}^{23}Na^+ & 13.1 & {}^{24}Mg_-^{++} & 12.5 \\
{}^{39}K^+ & 7.7 & {}^{40}A_+ & 7.5 \\
{}^{39}K^+ & 7.7 & {}^{40}Ca_-^{++} & 7.5 \\
{}^{35}Cl^- & 8.6 & {}^{40}A_- & 7.5
\end{array}
\tag{3.4.1}
$$

Table 3.1: The modification of cyclotron frequencies of most important ions are modified by simplest replacements with exotic ions

One might hope that the ions are trapped to the neighboring nodes of the transversal standing wave type oscillations and in this manner form correlated pairs. The size of the Cooper pairs would correspond to a multiple of wavelength for the transversal oscillations in this case. The approximation of the magnetic flux tube as string would suggest that waves are of form $sin(\omega t)sin(kz)$, $k = \omega$. The frequencies $\omega = n\pi/L$ would be allowed for a flux tube of length L.

Perhaps it would be more appropriate to say that one has Bose-Einstein condensate of transverse phonons making possible the Bose-Einstein condensate of Cooper pairs. It is quite possible that metabolic energy must be pumped to the Bose-Einstein condensate of transverse oscillations in order to not lose the ionic super-conductivity.

3.4.2 Super conductors of exotic bosonic counterparts of fermionic ions

If ion is boson, no Cooper pairs is needed in order to have a super conductor, and Ca^{++} and Mg^{++} ions at dark magnetic flux tubes with large value of Planck constant could give rise to high T_c super-conductors in this manner. Fermionic ions (Na$^+$, K$^+$, Cl$^-$, ..) would not define supra currents. The explanation of the effects of ELF em fields on vertebrate brain however suggests cyclotron Bose-Einstein condensates of also ions behaving chemically like fermionic ions. Also the model of nerve pulse requires Josephson currents of ions which are chemical equivalents of fermionic ions.

TGD based nuclear physics [L4] allows this kind of ions. The model indeed predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation. The **Table 12.1** describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation Mg_-^{++} tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

$f_c(K+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{++})/2 = 7.5$ Hz, $f_c(Mg^{++}) = 12.5$ Hz, and $f(Ca^{++}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

3.4.3 More Quantitative Picture About Bose-Einstein Condensates

Cyclotron frequencies of biologically important ions in the endogenous magnetic field $B_{end} = 0.2$ Gauss are involved with the effects of ELF em fields on vertebrate brain and are also central in the model of EEG [K35]. This motivates a more detailed study of these frequencies. Also the cyclotron frequencies of biologically important molecules are interesting.

Ion	f_1/Hz	E_1/eV
$^6Li^+$	50.1	3.3
$^{24}Mg^{2+}$	25.0	1.65
$^{16}O^{2-}$	37.6	2.48
$^{32}S^{2-}$	18.8	1.24
$^{40}Ca^{2+}$	15.0	.99
$^{55}Mn^{2+}$	11.4	.75
$^{56}Fe^{2+}$	10.8	.71
$^{59}Co^{2+}$	10.0	.66
$^{64}Zn^{2+}$	9.4	.62
$^{80}Se^{2-}$	7.6	.5

Table 3.2: The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in $B_{end} = .2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

Bose-Einstein condensates of bosonic ionized atoms

The number of elements for which ions are bosons is not very large. **Table 3.2** lists the cyclotron frequencies of bosonic ions which are biologically important for $B_{end} = .2 \times 10^{-4}$ Tesla.

Table 3.2 inspires some comments.

(a) For Li$^+$ the dominating isotope ^{7}Li$^+$ is fermion. ^{6}Li$^+$ is boson and its abundance is 5 per cent. Li$^+$ ions are used as medications in mania and represents mood stabilizer [J7]. A possible explanation is that the cyclotron oscillations of Bose-Einstein condensate of ^{6}Li$^+$ ions serve as a biological clock helping to stabilize the mood. The cyclotron frequency is however 50 Hz and higher than thalamocortical resonance frequency having nominal value 40 Hz.

An alternative explanation for the effect of Li^+ is based on the observation that $^7Li_+$ has cyclotron frequency equal to 42.9 Hz for $B_{end} = .2 \times 10^{-4}$ Tesla, which is at the upper limit of the 40 Hz resonance band. The presence of lithium ions or their Cooper pairs could enhance thalamocortical resonance.

These hypothesis could be tested by looking whether the use of pure $A = 6$ ($A = 7$) isotope of Li$^+$ amplifies the beneficial effect and the use of $A = 7$ ($A = 6$) isotope nullifies it.

(b) For Mg^{2+} cyclotron energy corresponds to the energy of photon of green light. Chlorophyll is not able to convert nutrients to sugar without magnesium, which suggests that cyclotron transitions of Mg BE condensate are at least partially responsible for the green color of plants. Mg BE condensate could control the coherent occurrence of photosynthesis in the size scale of plant.

(c) For oxygen ion the cyclotron frequency is 37.6 Hz and rather near to ~ 40 Hz thalamocortical resonance frequency, which suggests that the cyclotron transitions of oxygen ions might play key role in inducing coherent firing of neurons at this frequency. This would mean that oxygen would be much more than a mere provider of metabolic energy. Note also that $\Delta n = 3$ cyclotron transition of Na$^+$ ion corresponds to frequency 39 Hz and might be involved with the synchronous firing.

(d) Ca^{2+} ions play a unique role in the functioning of living matter. In particular, calcium waves appearing in a wide range of time scales are known to serve a crucial role in nervous system [**?**]. Ca^{2+} corresponds to .99 eV cyclotron energy scale, which is twice the energy of metabolic energy quantum. Hence one can ask whether the cyclotron transitions of Ca^{2+} BE condensate could induce a collective emission of metabolic energy quanta and in this manner induce coherent metabolic activity in the scale of entire body.

Ion	f/Hz	E_c/eV
$^7Li_+$	42.9	
F^-	15.8	1.04
Na^+	13	.86
Al^+	11.1	.73
Cl^-	8.5	.56
K^+	7.5	.50
Cu^+	4.8	333.9
Ag^+	2.8	.18
I^+	2.4	.16
Au^+	1.5	.10

Table 3.3: The first columns give cyclotron frequencies and corresponding cyclotron energies for some ions in $B_{end} = .2 \times 10^{-4}$ Tesla for some fermionic ions.

(e) The cyclotron frequencies Mn, Fe, Co, Cu, and Zn are in alpha band and corresponding cyclotron energies are somewhat above metabolic energy quantum. These energy quanta could drive protons from larger space-time sheet to $k = 137$ atomic space-time sheet. 10 Hz frequency is known to define an important biological clock and Co ions could be essential for the functioning of this clock. $n = 3$ multiple of Co^{2+} cyclotron frequency corresponds to the 30 Hz threshold of gamma band known to be important for cognition. Also $3f_c(Fe^{2+}) = 32.2$ Hz and $3f_c(Mn^{2+}) = 34.2$ belong to gamma band. The presence of Bose-Einstein condensates of these ions in length scale of $5L(212) = 141$ km could mean that these bio-rhythms are shared by different organisms inside regions of this size.

(f) The fact that the cyclotron frequency of Se^{2-} ion, which is known to be a biologically important trace element, corresponds to the nominal value of the metabolic energy quantum, raises the question whether Selenium BE condensate might act as a metabolic synchronizer.

Cyclotron frequencies and Schumann frequencies

Even in the case that Cooper pairs of fermionic ions are not thermally stable, the cyclotron transitions of fermionic ions like K^+, Cl^-, and Na^+ are expected to be important. In **Table 3.3** cyclotron frequencies and energies of some fermionic ions are given. Notice that the cyclotron energy of K^+ ion corresponds to metabolic energy quantum. Quite generally fermionic ions cannot be involved with the generation of Josephson part of EEG.

The first thing to notice is the close relationship of cyclotron frequencies with the lowest resonance frequencies in the spectrum of geo-electromagnetic field starting from 5 Hz, so called Schumann frequencies [F8], are $7.8, 14, 20, 26, 33, 39$ and 45 Hz. 5 Hz corresponds roughly to the threshold 4 Hz of theta frequency range below which EEG spectrum lies during sleep which suggests that wake-up state involves the coupling of brain with geo-electro-magnetic activity. 7.8 Hz corresponds to the threshold for alpha waves associated with wake-up state without cognition; 14 Hz corresponds to threshold of 13 Hz for beta waves accompanying cognitive activities, and 33 Hz is quite near to the threshold 30 Hz for gamma waves known to be important in the temporal coding of sensory data.

Consider now examples of cyclotron frequencies keeping in mind that Schumann frequencies vary typically within 1 Hz interval around their mean values [F8].

(a) As already noticed, the frequencies, which are multiples of 15 Hz can be assigned to Ca^{2+} ion. The excitations $n = 3, 5, 7, ..$ correspond to the frequencies $45, 75, 105, ...$ Hz. All these frequencies have been observed. The two lowest frequencies correspond to Schumann frequencies 14 and 45 Hz with accuracy of 1 Hz.

(b) Na_+ has $A = 23$ and gives $f = 13$ Hz. This is the lower bound for the frequency of beta EEG waves which are associated with conscious cognition. This would suggest that the presence of em field of 13 Hz frequency correlates with large fluxes of Na_+ ions through the axonal cell membrane during nerve pulse generation. This could result from increased amplitude of Na_+ Josephson current facilitating the emission of nerve pulses at the second half of the EEG cycle. Silencing of mind by meditation or closing eyes reduces amplitudes associated with EEG frequencies below 13 Hz and conscious cognition disappears.

$n = 3$ excitation of Na_+ corresponds to 39 Hz, which is one of the Schumann frequencies and quite near to the 40 Hz resonant frequency associated with the thalamocortical circuit. This could correspond to jumping of Na_+ ions from ground state to $n = 3$ state or vice versa. $n = 5$ quantum jumps correspond to 65 Hz which is average EEG frequency during REM sleep! Thus 13, 39 and 65 Hz frequencies correspond to the basic signatures of conscious cognition. The two lowest transition frequencies correspond to Schumann frequencies 14 and 45 Hz within accuracy of 1 Hz.

(c) K_+ has $A = 39$ and gives $f = 7.5$ Hz, which is theta frequency rather near to the lowest Schumann resonance frequency 7.8 Hz. K_+ ion flux could correlate with em fields in the range of the alpha frequencies creating cyclotron resonance. Theta activity dominates during sleep and Adey's observations [**?**] demonstrate that 7 Hz ELF field increases reaction times. Second and third transition frequencies are within 1.5 Hz Schumann frequencies 20 and 37.5 Hz.

(d) Cl_- ion has $A = 35$ and gives $f = 8.5$ Hz. Chloride ion has inhibitory effect. $n = 3, 7, ..$ excitations correspond to 25.5, 42.5 Hz, ... Rather interestingly, frequencies rather near to 40 Hz associated with thalamo-cortical loops appear as excitations for all ions relevant to nerve pulse activity. Note that 39 Hz is also Schumann frequency. Two lowest transition frequencies of Cl_- are quite near to Schumann frequencies 7.8 and 25 Hz.

(e) Fe^{2+} has $A = 56$ and corresponds to 10.7 Hz. $3f_c(Fe^{2+}) = 32.2$ Hz is rather near to Schumann frequency 33 Hz whereas Co^{2+} corresponds to 10 Hz in excellent accuracy. Co has especially large nuclear magnetic moment and serves as a natural magnet. Fe^{2+} and/or Co^{2+} could be present in magnetic sensory organ possessed also by humans making it possible to navigate using magnetic fields. Yarrow suggests that Co makes B_{12} magnetic vitamin [**?**] so that it can serve as fundamental biological clock at frequency very precisely equal to 10 Hz. Co is carried by B_{12} vitamin and is known to be important for normal consciousness: among other things the lack of B_{12} causes fatigue, blurred vision and cognitive problems.

(f) Mg^{2+} has A=24 and $f = 25$ Hz which is near to Schumann frequency: $n = 3$ corresponds 75 Hz. Charged polypeptides could also form BE condensates and be involved with cyclotron mechanism: they are rather heavy and their cyclotron frequencies are in Hz range. Negatively charged organic molecules are indeed known to be present in neurons.

To sum up, surprisingly many magnetic transition frequencies are near to Schumann frequencies which suggests strong resonant interaction between brain and geo-electromagnetic fields.

What about proton's cyclotron frequency?

There are good reasons to expect that the cyclotron frequency of proton and its odd harmonics play an important role in brain functioning. The cyclotron frequency of proton in $B_{end} = .2$ Gauss is $f(p) = 300$ Hz. The frequency associated with $n = 3$ transition would be $3f(p) = 900$ Hz. Third harmonics of cyclotron frequencies of many ions with f_c in alpha band belong to gamma band known to relate to cognition. Perhaps this is true also in the case of proton.

The duration of single bit of the memetic codeword consisting of 127 bits and having total duration defined by the p-adic timescale $T_{M_{127}}^{(2)} = .1$ seconds corresponds to the frequency $f_m = 1027$ Hz. This frequency is by 10 per cent higher than the cyclotron frequency of

proton for $B_{end} = .2$ Gauss. If magnetic homeostasis is realized, as will be discussed later, and if it allows 10 per cent variation of the strength of magnetic field as the width 1 Hz of alpha band suggests, it is possible to realize this frequency as proton's cyclotron transition frequency.

The frequency of neuronal synchronization, which is obviously associated with cognitive processing, is $\simeq$ 1 kHz and might well be identifiable with f_m. The maximum rate of neuronal firing is slightly below kHz: this rate however corresponds to the rate of quantum jumps rather than oscillation frequency at space-time level.

Bose-Einstein condensates of bosonic molecular ions

Also biologically relevant bosonic molecular ions such SO_4^{2-}, CO_3^{2-}, NO_3^-, NO_2^- could form Bose-Einstein condensates. The cyclotron frequencies for bosonic molecular ions satisfying the thermal stability condition $A \leq 233 \times Z$ at room temperature are typically in theta and delta band and above $f_{min} = 1.29$ Hz.

DNA is negatively charged and an interesting question is whether DNA satisfies the stability condition. The molecular weights of DNA nucleotides A, T, C, G are 132, 126, 96, 149. The molecular weight of deoxyribose sugar attached to the nucleotide is 100 and that of phosphate group PO_4^{2-} is 95. Altogether this makes molecular weights 327, 321, 291, 344. Since phosphate group is doubly charged this structure has cyclotron energy which is higher than thermal energy. Also DNA sequences satisfy the thermal stability condition. The presence of DNA Bose-Einstein condensates at magnetic flux quanta could mean that DNA can be transferred between different organisms along these space-time sheets and that DNAs of different organisms of same species could form quantum coherent systems inside regions where magnetic field can be regarded as a constant.

3.5 About high T_c superconductivity and other exotic conductivities

During years I have been developing a model for high T_c superconductivity (see `http://tinyurl.com/b25sucr`). The recent view is already rather detailed but the fact that I am not a condensed matter physicist implies that professional might regard the model as rather lopsided. Quite recently I read several popular articles related to superconductivity and various types of other exotic conductivities: one can say that condensed matter physics has experienced an inflation of poorly understood conductivities. This of course is an fascinating challenge for TGD. In fact, super string theorist Subir Sachdev has taken the same challenge (see `http://tinyurl.com/hu4a27f`).

In particular, the article about superconductivity (see `http://tinyurl.com/h59yqn4`) provides a rather general sketch about the phase diagram for a typical high T_c super conductor and discusses experimental support for the idea quantum criticality in standard sense and thus defined only at zero temperature could be crucial for the understanding of high T_c super conductivity.

The cuprates doped with holes by adding atoms binding some fraction of conduction electrons are very rich structured. The transition from antiferromagnetic insulator to ordinary metal involves several steps described by a 2-D phase diagram in the plane defined by temperature and doping fraction. Besides high T_c super conducting region the phases include pseudogap region, a region allowing charge oscillations, strange metal region, and metal region.

In the following I consider the general vision based on magnetic flux tubes carrying the dark $h_{eff}/n = n$ variants of electrons as Cooper pairs or as free electrons allowing to understand not only high T_c super-conductivity and various accompanying phases but also exotic variants of conductivity associated with strange and bad metals, charge density waves and spin density waves. One could also understand the anomalous conductivity of SmB_6 [L22], and the fact

that electron currents in graphene behave more like viscous liquid current than ohmic current (see http://tinyurl.com/jlgd2we).

The TGD inspired model for the anomalous conductivity of SmB_6 as flux tube conductivity developed during last year [L22] forms an essential element of the mode. This model implies that Fermi energy controlled by the doping fraction would serve as a control variable whose value determines whether electrons can be transferred to magnetic flux tubes to form cyclotron orbits at the surface of the tube. Also the metals (such as graphene) for which current behaves more like a viscous flow rather than Ohmic current can be understood in this framework: the liquid flow character comes from magnetic field which is mathematically like incompressible liquid flow.

3.5.1 The phase diagram and observation

The popular article "The Quantum Secret to Superconductivity" (see http://tinyurl.com/h59yqn4) tells about an article published in Nature [D18] (see http://tinyurl.com/go9k8cs) about the work of a group o researchers at the National Laboratory for Intense Magnetic Fields (LNCMI) in Toulouse, France led by Cyril Proust and Louis Taillefer.

The popular article contains a phase diagram, which gives a bird's eye of view about high T_c superconductors and provided the stimulus for this article. The diagram describes the phases of a doped cuprate (now yttrium barium copper oxide superconductor $YBa_2Cu_3O_7$, see http://tinyurl.com/ycpscdfe). Doping means an addition of impurities, which bind electrons and lead to the formation of holes. Also electron doping is possible. The diagrams contains several regions representing phases of the system.

The diagram (see **Fig. 3.1**), which probably should not be taken too literally, can be seen as a qualitative representation of the phase transition sequence leading from an antiferromagnetic insulator to a conducting metal. It is considerably more complex than the corresponding diagram for the ordinary insulator metal transition. One starts from un-doped antiferromagnetic insulator and increases the doping fraction and ends up with metal. The holistic strategy is to try to understand all transitions and phases appearing in the entire diagram using same basic model rather than the mere transition to super-conductivity.
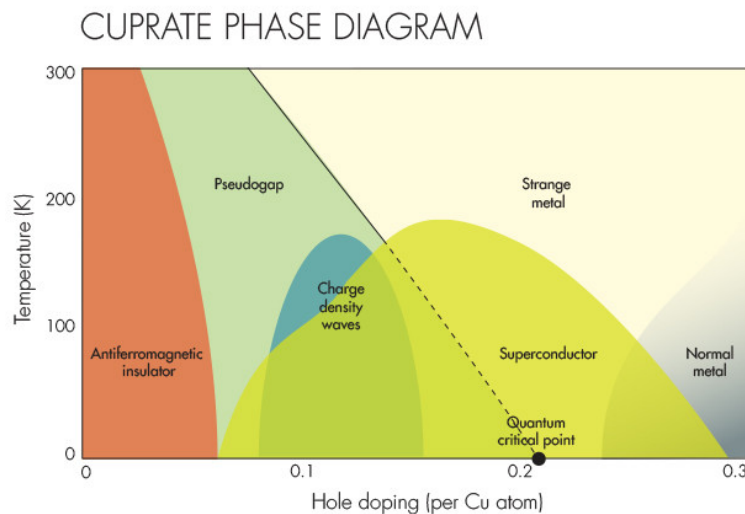
Figure 3.1: The phase diagram of typical high T_c superconductor

(a) Above temperature dependent critical doping around $d = .05$ (meaning addition of impurities) a transition to so called pseudogap phase occurs. At a higher temperature

dependent critical doping ratio varying in the range $(.05, .14)$ emerges a hill representing high T_c superconductivity.

(b) There is also a parabola shaped region bounded at the top of super-conducting hill in which charge density wave define the ground state. In his phase kind of jerkwise conductivity but not yet superconductivity occurs. The piece of parabola is contained in doping fraction interval between $(.08, .13)$ (reader might disagree, I apologize for my bad eye sight).

(c) At temperature above 170 K and for temperature depending doping ratio decreasing with temperature linearly pseudogap is transformed to a strange metal bounded by superconductor hill below. Farthest to the right is the ordinary metal phase bounded by superconducting hill and strange metal region. Critical doping fraction for the transition from superconductivity to ordinary conductivity decreases with temperature and is in the range $(.26, .29)$.

The challenge is to understand what these regions correspond physically and what happens in the transitions between them. The crucial observation is following. The researchers realized that the line representing the boundary between pseudogap and strange metal seems to continue below the super-conducting regions. Could one destroy the superdonducting region to see whether it meets the $T = 0$ axis at the bottom and could at this point quantum phase transition occur at critical value of doping?

This was done by putting the system to a strong magnetic field of 90 Tesla destroying the superconducting phase by making Cooper pair unstable. It was indeed observed that the number of holes per Cu atom - called charge carrier density (perhaps misleadingly) - increased by a factor 6 at this critical point - actually in its vicinity since $T = 0$ is not reachable exactly. The researchers think that this might be crucial guideline in attempts to understand high T_c superconductivity and I share their belief. The understanding of what really happens in the transition to super-conductivity or rather in the transition from the pseudogap state to super-conductivity is the problem.

3.5.2 Alternative proposals for the mechanism of superconductivity

What has been observed is quantum critical point at $T = 0$ at which the density of holes per atom increases by a factor of 6. This does not mean that the superconducting charge carriers are Cooper pairs of holes. The phenomenon might have nothing to do with superconductivity in superconducting phase. The phenomenon is observed by using strong magnetic fields preventing superconductivity so that one in principles does not study the same system anymore.

Several hypothesis for the mechanism of super conductivity have been proposed and some of them are mentioned in the popular article (see `http://tinyurl.com/h59yqn4`) .

(a) Spin density waves (mentioned in Wikipedia article but not discussed in the popular article) would take the role of phonons and induce the formation of Cooper pairs by a kind of water bed effect. These waves do not appear in the phase diagram. Now the Coulomb repulsion forces the members of Cooper pair to reside at different lattice sites and the outcome would be d-wave Cooper pair having a note at origin. In TGD the members of Cooper pair at parallel flux tubes so that also now d-wave is obtained for spin singlet state and p-wave for spin triplet.

(b) Charge density wave fluctuations would somehow be involved with the formation of Cooper pairs. Phase diagram for charge density fluctuations does not support this picture since the superconducting regions is much larger. Transitions to superconductivity can happen from 4 regions: pseudo gap region, the regions with fluctuating charge density, strange conductor, and ordinary conductor. Also spin density wave fluctuations could have similar role.

(c) A phase transition occurring to the anti-ferromagnetic phase is suggested to somehow induce the formation of Cooper pairs. The called Merlin-Wagner theorem stating the

absence of breakdown of continuous symmetry in two-dimensional models of statistical physics at non-zero temperatures does not support this hypothesis. One could circumvent this problem by assuming that only patches forming kind of checkerboard consisting of super-conducting and non-superconducting regions can develop in 2-D. No checkerboards have been observed. Note that there is however an objection against Merlin-Wagner theorem. Antiferromagnetic order has been detected in undoped cuprates with the same 2-D structure.

Subir Sachdev is a super string theoretician, who has been developing superstring inspired methods - in particular AdS/CFT correspondence - to study quantum critical phenomena. Sachev and collaborators have developed methods for studying "strange metals". These systems are exceptional in that they do not have any quasiparticle excitations. Sachev has correctly predicted charge density fluctuations in high T_c superconductors and also proposed that the precursor for high T_c superconductivity would be what he calls fractionized Fermi liquid meaning fractional spin and charge. One would have something like ordinary conductivity but with fractional charges. This phase could correspond to strange metal.

3.5.3 TGD proposal for the mechanism of high T_c superconductivity

The challenge for TGD inspired qualitative model is to understand these phases in terms of magnetic flux tubes and dark electrons possibly forming Cooper pairs at them.

Formulation of the model

The starting point is the model developed hitherto.

(a) Consider first Merlin-Wagner theorem as an objection against breaking of 2-D continuous symmetries. TGD suggests however a mechanism allowing a breakdown of 2-D continuous symmetries (by strong form of holography TGD space-time is almost 2-D as far as scattering amplitudes are considered: string world sheets and partonic 2-surfaces). The continuous symmetries in question include supersymplectic transformations having conformal structure meaning that the generators are labelled by conformal weights which come as integer multiples of generating weights. This symmetry breaking would lead from the original symmetry algebra to its sub-algebra isomorphic with the original. Just a zoom up of the original symmetry would be the outcome! Maybe Merlin and Wagner could tolerate this!

Now one would have something different from a checkerboard of patches. There would be quantum critical phase in which a phase containing Cooper pairs at short flux tubes with Planck constant $h_{eff}/h = n_1$ and phase containing long flux tubes with $n_2 > n_1$ but no Cooper pairs at them. There would be fluctuationS between these phases. Fluctuation would have in ZEO as correlate space-time surface connecting three surfaces at opposite boundaries of CD such that the values of n would be different at them [L38] (see http://tinyurl.com/y7znls3j).

(b) The earlier model [L25] (see http://tinyurl.com/yaoghft8) identifies the pseudogap as quantum fluctuating phase in which there isA competition between short and long flux tubes pairs related by re-connections for short flux tubes containing Cooper pairs such that their members are at parallel flux tubes of pair carrying magnetic fields in opposite direction. Long flux tubes canot carry Cooper pairs and this together with fluctuations spoils macroscopic super-conductivity in pseudogap phase and makes it a poor conductor.

Pseudogap is present in the density of states since part of electrons goes to the short flux tubes. The transition to superconducting phase identified in terms long flux tubes carrying Cooper pairs would occur when Cooper pairs go also to the long flux tubes and would be analogous to the percolation phase transition in which water begins to dribble through a sand layer. Pseudogap phase is quantum critical: zero energy ontology

(ZEO), which allows to see quantum theory as a square root of thermodynamics at single particle level indeed allows quantum criticality also at non-vanishing temperatures.

(c) Strange metal phase can be identified as a phase in which only short super-conducting flux tubes are present and carry supra currents but in short scales only. Since Cooper pairs have spin zero, the charged currents do not carry spin: this conforms with the observation that the resistance for spin currents has different temperature dependence than for charged currents. Therefore the generalization to 2-D case of the charge-spin separation possible in 1-D case (but also in this case non gauge-invariant notion, (see `http://tinyurl.com/znsver8`) is not needed. Quite generally, the possibility of short scale $S = 0$ super conductivity could explain the charge-spin separation.

The fact that scattering leads from dark phase at flux tubes to ordinary phase could explain the linear temperature dependence of the resistance of strange metals. In ordinary metals the dependence is quadratic: the reason is that the number of initial and final state electrons is proportional to T. If the number of dark Cooper pairs at flux tubes does not depend on temperature one obtains linear dependence.

The absence of quasiparticle excitations in strange metal would be due to the fact that Cooper pairs are dark and at magnetic flux tubes. Both n_1 and $n_2 > n_1$ phase would be present below critical doping fraction in the experiment discussed and would correspond to a situation in which there is a fluctuation between the short length scale superconductivity and long length scale flux tubes not containing Cooper pairs. The strong magnetic field used in the experiment would not destroy the long flus tubes and the quantum critical phase would survive.

(d) The quantum critical phase transition discussed in the article at zero temperature and critical doping fraction increases the number of holes per copper atom by a factor 6. Also this can be understood qualitatively. The transfer of electrons to dark Cooper pairs generates holes. In pseudogap region the long flux tubes do not carry Cooper pairs. As the phase transition occurs, only short flux tubes remain and accept pairs maximal number so that the number of holes per copper atom increases. Also the properties of pseudogap can be understood. Pseudo gap means a low density of states at certain points of Fermi surface (the point defines a preferred direction of current) and is known to be only in direction parallel to CuO bonds: this can be understood if flux tubes are parallel to them.

Charge density waves and spin density waves and their fluctuations

Can TGD say something interesting about charge density waves (see `http://tinyurl.com/y9g7t34j`) and spin density waves (see `http://tinyurl.com/y97vmya7`)?

(a) Charge density wave defines a ground state of the system having lower energy than the state with constant density of electrons. These waves are periodic standing waves with wavelength $\lambda = \hbar/k_F$. Wavelength does not in general correspond to a multiple of lattice constant. In presence of these waves conduction occurs in random jerkwise fashion like the water dribbling from faucet. The standard explanation for the jerkwise current is that the charge density wave is in a potential well caused by defect and when the electric field exceeds the critical value it is released and slides generating an ohmic current. Below the threshold the system would behave as an insulator.

(b) Spin density waves are very similar to charge density waves: instead of charge, the direction of spin varies in oscillatory manner with wavelength defined by Fermi wave vector in ground state. Also now a current is formed in direction of the magnetic field above critical value of magnetic field. Sliding mechanism is proposed also now as the underlying mechanism of conductivity.

(c) The key question is where a spatially varying fraction of charge/spin goes as charge/spin density wave is formed. In TGD Universe the answer would be rather obvious: "To flux tubes!". Both charge density wave and spin density could involve a sequence of magnetic flux loops with a period defined by k_F so that supra currents could flow below

this length scale. Charge density wave could result from a transfer of electrons to flux tubes producing oscillator charge density at the flux tube inducing corresponding charge density oscillation in lattice. In the case of spin density wave the spin directions would be correlated at flux tubes and induce corresponding correlation in the lattice.

(d) The conductivity associated with charge density wave above critical electric field could correspond to a kind of premature and temporary phase transition to super-conducting phase in which long flux tubes contain Cooper pairs but are still unstable. In the transition to super-conductivity a reconnecting to long flux loop looking like long and thin rectangle would be formed by reconnections. One would have a system fluctuating between short and long scale superconductivities. One could of course consider also sliding of the flux tubes but this does not seem so plausible option in TGD framework.

The conductivity induced by critical magnetic field could be understood if the magnetic field induced a phase transition reconnections transforming the periodic short flux tube structure to a pair of long flux tubes. Why the magnetic field would induce this, is not clear. Same question of course applies in the case of the critical electric field inducing the generation of current in charge density wave.

The role of doping fraction

Can one understand the role of doping fraction?

(a) The number of holes per copper atom depends on the doping fraction. The holes would be created when dark Cooper pairs are generated. If the density of dark Cooper pairs increases dramatically at critical doping fraction, the density of holes must increase. Somehow the over-critical doping fraction would favor the formation and stability of short dark flux tubes. Maybe it becomes energetically more favorable for electrons to go to flux tubes. This might relate to cyclotron energy proportional to h_{eff} at flux tubes and Fermi energy E_F: a kind of resonant transfer suggests itself.

For some time ago I constructed a model for the anomalous conductivity of SmB_6 in external field in terms of Haas-van-Alphen effect for non-standard value of h_{eff} [L22] (see `http://tinyurl.com/y8oblpl9`). A resonant transfer of electrons to flux tubes occurs if the energy energy at the surface of the Fermi sphere corresponds to energy for a cyclotron orbit at the surface of the flux tube. The largest orbit at Fermi sphere would be at the surface of the flux tube. This implies the occurrence of Haas van Alphen as a periodic dependence of magnetization on the value of external magnetic field $1/B$ and also explains also the anomalous conductivity of SmB_6 as flux tube conductivity occurring when the resonance condition is satisfied.

A rather natural expectation is that same happens now. The doping fraction would control the value of Fermi energy, and this in turn would control the rate for the leakage of electrons to Cooper pairs at flux tubes by resonance condition. If the dependence of the Fermi energy on doping fraction is slow this could allow to understand why an entire range of doping fractions is possible. That the electrons must have Fermi energy must correlate with the wave length of of charge and spin density waves. The length of the short flux tube loop corresponds to Fermi wave vector.

There is also a feedback effect involved. When electrons become Cooper pairs at short flux tubes, their density in lattice is reduced and this reduces Fermi energy so that resonance condition might fail to be satisfied. If flux tubes carry monopole flux, flux is quantized and the value of the magnetic field depends on the thickness of the flux tube, which could also be dynamical.

(b) Below critical doping fraction long flux tubes would be possible but would be unstable and unable to carry stable Cooper pairs. The reason could be that the resonance condition for the transfer fails to be satisfied (the thickness of long flux tubes would not satisfy the resonance condition). Superconductivity and strange metal property would disappear above certain temperature dependent value of the doping fraction. Also this could be understood in terms the failure of the resonance condition for both short and

long flux tubes. In the charge density wave region the resonance condition would be satisfied for the long flux tubes.

Connection with Sachdev's ideas

Sachdev's ideas mentioned above have correspondences in TGD. AdS/CFT is central in Sachev's approach and it has been also proposed as a solution of so called sign problem (see `http://tinyurl.com/h9ogjjd`) plaguing QFT models and statistical physics models in dimension $D \geq 3$. Sign problem gives one additional good reason for the localization of the induced spinor fields at 2-D string world sheets in TGD framewwork [K121].

(a) AdS/CFT relies on conformal symmetry: in TGD framework the conformal symmetry is generalized to super-symplectic symmetry and other symmetries having conformal structure and assignable to the boundary of light-cone and to the light-like orbits of partonic 2-surfaces at which the induced metric changes its signature from Minkowskian to Euclidian.

(b) TGD Universe is quantum critical so that also this aspect is shared. AdS/CFT correspondence relies on holography: in TGD framework one has strong form of holography and one can say that the 10-D bulk is replaced with 4-D space-time surface in $M^4 \times CP_2$.

(c) Charge and spin fractionization are plausible also in TGD: the unit would be scaled down by $1/n$ ($h_{eff}/h = n$) and in twistorial approach [K38] this is understood quite satisfactorily.

(d) Also in TGD the precursor would be strange metal. I have already explained how charge spin separation reflecting itself as different temperature dependences of resistances for charged and spin currents and the linear dependence of resistivity on temperature can be understood.

There are also differences. In TGD framework strange conductor would be flux tube superconductor in short length scales with $h_{eff}/h = n_1 < n_2$ rather than fractional ordinary conductor.

Bad and strange metals and metals behaving like water

Besides high T_c superconductors there are also other exotic conductors such as strange and so called bad metals `http://tinyurl.com/zzzyenp`) difficult to understand using the ideas of existing condensed matter physics.

In the case of bad metals (see `http://tinyurl.com/k54k9oa`) the conductivity is low but is preserved to too high temperatures. The problem is that if the electrons scatter as usual the time τ between collisions becomes too small and at higher temperatures Uncertainty Principle requiring $T \times \tau \geq h$ fails to be satisfied. Quite recent proposal [D30] is that current carrying electrons somehow disappear and this fluctuation is not only responsible for low but on-vanishing conductivity. These fluctuations could be due to the quantum critical fluctuations transforming electrons to Cooper pairs at short flux tubes. Bad metal would be unable to decide whether to be an insulator or strange metal.

Also graphene behaves in a strange manner (see `http://tinyurl.com/hffdl8s`) in the sense that currents behave more like viscous liquid flow rather than ohmic currents. The presence of vortices is a basic signal about this. A model assuming a negative resistance allowing electrons to move in "wrong direction" in electric field is considered as an explanation. To me this option looks tricky.

Liquid like behavior might be understood if the currents flow at magnetic flux tubes. Magnetic field is mathematically analogous to an incompressible liquid flow. Flux tubes would be like water pipes forming a network and the topology of the ohmic currents would reflect the topology of this loopy magnetic network. The direction of the electric field inside flux tube space-time sheet would be parallel to the flux tube so that negative resistance would not be required: electric field would change direction locally rather than resistance its sign. In long

scales at the space-time sheets assignable to the ordinary matter the direction of electric field would be constant. The phenomenon would reflect many-sheetedness of space-time lost in the gauge theory limit of TGD. Note that if currents are supra currents along flux tube pairs in short scales, there would be no resistivity in these scales.

To sum up, the notions of magnetic flux tube and dark matter hierarchy suggest common mechanisms for all the exotic conductivities. From this it is of course a long way to quantitative models.

3.5.4   New findings about high-temperature super-conductors

Bozovic *et al* have reported rather interesting new findings about high T_c super-conductivity: for over-critical doping the critical temperature is proportional to the density of what is identified as Cooper pairs of electronic super-fluid. Combined with the earlier findings that super-conductivity is lost - not by splitting of Cooper pairs - but by reduction of the scale of quantum coherence, and that below minimal doping fraction critical temperature goes abruptly to zero, allows to add details to the earlier TGD inspired model of high T_c super-conductivity. The super-conductivity would be indeed lost by the reconnection of flattened square shaped long flux loops to shorter loops of pseudogap phase. Quantum coherence would be reduced to smaller scale as h_{eff} is reduced. Transversal flux tube "sound waves" would induce the reconnections. Electrons at flux loops would stabilize them by contributing to the energy density and thus to the inertia increasing the string tension so that the average amplitude squared of oscillations is reduced and critical temperature increases with electron density.

Results

A popular article in Phys.org (see `http://tinyurl.com/htr2qjj`) tells about new interesting results about high T_c superconductivity. Bozovic *et al* have published in Nature an article titled "*Dependence of the critical temperature in overdoped copper oxides on superfluid density*" (see `http://tinyurl.com/gqo9j67`) [D21]. The abstract of the article gives first glimpse about the work.

> *The physics of underdoped copper oxide superconductors, including the pseudogap, spin and charge ordering and their relation to superconductivity is intensely debated. The overdoped copper oxides are perceived as simpler, with strongly correlated fermion physics evolving smoothly into the conventional Bardeen–Cooper–Schrieffer behaviour. Pioneering studies on a few overdoped samples indicated that the superfluid density was much lower than expected, but this was attributed to pair-breaking, disorder and phase separation. Here we report the way in which the magnetic penetration depth and the phase stiffness depend on temperature and doping by investigating the entire overdoped side of the La2xSrxCuO4 phase diagram. We measured the absolute values of the magnetic penetration depth and the phase stiffness to an accuracy of one per cent in thousands of samples; the large statistics reveal clear trends and intrinsic properties. The films are homogeneous; variations in the critical superconducting temperature within a film are very small (less than one kelvin). At every level of doping the phase stiffness decreases linearly with temperature. The dependence of the zero-temperature phase stiffness on the critical superconducting temperature is generally linear, but with an offset; however, close to the origin this dependence becomes parabolic. This scaling law is incompatible with the standard Bardeen–Cooper–Schrieffer description.*

I do my best in order to understand what this says. The Wikipedia article (see `http://tinyurl.com/b25sucr`) helps to get overall view about high T_c superconductivity. The Phys.org article (see `http://tinyurl.com/htr2qjj`) gives first clues in attempts to understand what the abstract says. The earlier article of Bozovic *et al* (see `http://tinyurl.com/hk88h5w`) [D20] stating that the loss of super-conductivity does not mean splitting of

Cooper pairs but loss of quantum coherence or rather its reduction to shorter length scale gives additional insights.

In the following I proceed by self-Socratean method by making questions and bringing in the TGD view based on quantum criticality and magnetic flux tube pairs as carriers of members of Cooper pairs responsible for the supra current.

Basic notions

I try first to understand the notions of doping and phase stiffness.

(a) In the work under discussion [D21] overdoped cuprate superconductors were studied. Doping by holes and electrons is possible. Underdoped superconductors are studied and are not well-understood. Superconductivity appears in some range for the values of the doping fraction: the minimal doping is typically something like .05 for holes and .2 for electrons from the diagram of Wikipedia article.

"Overdoping" is achieved by the addition of strontium atoms as impurities. It had been already known that overdoping induces a reduction of the density of electron pairs and that critical temperature is reduced as a consequence. In the experiments discussed the critical temperature was found to depend linearly on the density of what was identified as super-fluid electron pairs linearly and going to zero as the doping fraction increases. In TGD pairs would correspond to small scale super-conductivity.

There is also the notion of self-doping, see the popular article titled "*Self-doping may be the key to superconductivity in room temperature*" at `http://tinyurl.com/jxrdagm` telling about the article of Magnuson *et al* [D32] (see `http://tinyurl.com/zvfhqu2`). There are mysterious chains between the lattice planes of cuprate carrying negative charge. Self doping means that the system itself generates them and controls the charge density at them. Could these chains be associated with the flux tube pairs carrying the Cooper pairs in TGD framework?

(b) Phase stiffness refers to the phase of a complex order parameter (see the article "*Weak phase stiffness and nature of the quantum critical point in underdoped cuprates*" of Yildrim and Ku at `http://tinyurl.com/yauzaz6r`), which might correspond to that assignable to the short range super-conductivity (or superfluidity as authors identify it). One poses twisted boundary conditions forcing the phase to vary spatially. How this is done, I do not understand.

The phase stiffness corresponds to energy density forced by these boundary conditions. In lowest order approximation energy density is proportional to the square of the gradient of the phase and coefficient is analogous to string tension. This parameter is proportional the density of Cooper pairs theoretically. The strange thing is that phase stiffness goes to zero below the minimal doping rather than going to zero smoothly. In overdoped region the phase stiffness at zero temperature limit was found to depend linearly on the critical temperature.

TGD based model for the findings

TGD inspired model for high T_c superconductivity and bio-superconductvity have been developed gradually during two decades [K17, K18, K77, K78] [L25, L28]. The new results allow to add new details to this model, in particular to the understanding of what happens when the superconductivity is lost.

(a) The popular article says that the critical temperature is controlled by the 2-dimensional density of electron pairs identified as super-fluid Cooper pairs. They would correspond to the so called pseudogap phase. An important point is that super conductivity is not lost due to the breaking of Cooper pairs as in the ordinary super-conductivity but due to too small value of the density of electron pairs: this is also the TGD view. In an earlier work to which Bojovic also contributed it is claimed that super-conductivity is

lost due to the loss of quantum coherence rather than splitting of Cooper pairs [D20] (see `http://tinyurl.com/zmbeynz`).

Both these findings conform with the TGD view that transition to super-conductivity means a phase transition increasing the value of h_{eff} increasing the range of quantum coherence scaling like h_{eff}. Cooper pairs exist also in pseudogap phase and can have non-standard value of h_{eff} but the closed flattened square shaped flux loops along which the members of pairs flow are too short to give rise to super-conductivity in macroscopic scales. in TGD framework the electron super-fluid about which the article talks would correspond to short scale superconductivity.

The density of Cooper pairs for small value of h_{eff} identified by authors as super-fluid carriers would be the critical quantity: for some range of this parameter the h_{eff} increasing phase transition would take place. This range would in turn correspond to a range for the energy assignable to the pair if the energy is proportional to 2-D Fermi energy.

(b) This allows to consider TGD based model of high T_c super-conductivity in which Cooper pairs have their members at parallel magnetic flux tubes closing to a loop and carrying magnetic fluxes in opposite direction in the case of antiferromagnet. In pseudogap phase the pairs would have their members at the flux tubes with opposite spin directions. In the phase transition to superconductivity the value of h_{eff} would increase and the flux tubes would reconnect to much longer flux tubes and macroscopic super current would flow.

(c) What happens in the phase transition increasing h_{eff} giving rise to superconductivity in macroscale? The lengths of closed flux loops are scaled up in reconnection. Longitudinal energy is not affected. It seems that the transversal distances between flux tubes cannot change.

What happens to the strength of magnetic field? Is should be reduced to keep cyclotron energy proportional to $h_{eff}B$ constant? For monopole flux, flux conservation requires that magnetic flux BS does not change so that the area S of the flux tube would scale like h_{eff}. That cyclotron energy is not changed at all would conform with the intuition about quantum criticality.

(d) Why the phase trasition to larger h_{eff} phase occurs only above the critical temperature? Why these flux loops are unstable against reconnection above critical temperature? Cooper pairs do not split but reconnection splitting long closed flux loop to a sequence of shorter ones takes place.

Some energy assignable to large h_{eff} flux tubes is reduced below the thermal energy above critical temperature and a transition to small h_{eff} phase. In reconnection process the parallel flux tubes with opposite fluxes touch each other. This touching occurs if there are oscillations of flux tubes in transversal direction analogous to transversal sound waves.

Does the average amplitude of transversal "sound waves" become so large above critical temperature that reconnections occur? This brings in mind ordinary BSC superconductivity in which phonon-electron interaction makes possible formation of Cooper pairs as bound states. Phonons for the ordinary super-conductvity however corresponds to lattice oscillations and make superconductivity possible. Now just the opposite happens.

(e) What the proportionality of T_c to the density of small Cooper pairs could mean? The energy of transversal phonon is proportional to its amplitude squared. If the amplitude and thus energy is above critical value the reconnection occurs.

Why the critical thermal energy increases with the density of small Cooper pairs? Does the presence of Cooper pairs stabilize the flux tubes: for too small density flux tubes are not stable since their string tension is too low and they are too soft and have large amplitude of thermal fluctuations.

Does the presence of Cooper pairs increase the inertia of flux tubes and therefore their string tension? The hermal energy of stringy sound waves proportional to critical temperature becomes proportional to electron density if the electron density dominates in string tension. This would explain also the lower critical value for the doping fraction.

Below it flux tubes become so soft that reconnection occurs too fast to allow super-conductivity at all. Above pseudogap temperature even the short loops would become unstable.

What we have obtained? In TGD framework the super-conductivity is not spoiled by the splitting of Cooper pairs but by the reconnection of flattened square shaped long flux loops. Super-conductivity is lost by the reconnection of flattened square shaped long flux loops to shorter loops of pseudogap phase, which is super-conducting but in smaller scale. Transversal flux tube "sound waves" induce the reconnections. Electrons at flux tubes stabilize them by contributing to the energy density and thus to the inertia increasing the string tension so that the average amplitude squared of oscillations is reduced and critical temperature increases with electron density.

3.6 Self Hierarchy And Hierarchy Of Weakly Coupled Super Conductors

The realization that bio-systems are full of macroscopic quantum phases led to the general idea about the dynamical realization of the self-hierarchy as a master-slave hierarchy formed by weakly coupled super conductors. It is now clear that mere Josephson currents are not enough: the breaking of super-conductivity due to leakage of supra currents from the super-conducting space-time sheets might also be an essential part of bio-control. A possible general conclusion is that Josephson currents are responsible for coordination whereas dissipative currents are related with the control aspect. The idea about charge entanglement made possible by W MEs and generating the dissipative currents makes this vision more precise.

One of the great ideas was that soliton sequences associated with the Josephson currents underly nerve pulse sequences. This idea turned out be be wrong as such: as a matter, soliton sequences correspond to various bio-rhythms such as kHz resonance frequency and various EEG rhythms in the recent model and nerve pulses could be understood as a perturbation of this sequence when rotational motion of some pendulum in the sequence of penduli becomes oscillatory. Since homeostasis as a many-sheeted ionic flow equilibrium involves also Josephson currents in an essential manner, it would be however light hearted to assume that Josephson currents and the dynamics at the level of cell membrane were totally uncorrelated. The model for sol-gel phase transition indeed demonstrates that Josephson currents generate Josephson photons crucial for stabilizing gel phase.

The hierarchy of favored Planck constants predicted by the Mersenne hierarchy implies a hierarchy of Josephson junctions defined by cell membranes and the value of Planck constants defines the evolutionary level of cell. As already noticed, EEG radiation and its fractal generalization and bio-photons can be identified as decay products of dark Josephson radiation in the case that the cell membrane space-time sheet is almost vacuum extremal. The frequency of the possible Josephson currents associated with the atomic space-time sheets of the cell membrane (or some larger space-time sheets with the same potential difference by the average many-sheeted ir-rotationality of the cell membrane electric field) corresponds in the resting potential of about -70 mV. For almost vacuum extremal option the Josephson currents could define bio-rhythms in extremely wide range from 10^{-15} s time scale to time scales comparable to the duration of life cycle.

Also hierarchies with levels characterized by the size scale of the membrane like structure involved can be considered but experimentally the situation remains open. Potential differences are in any case limited by the condition that Josephson energies are above thermal threshold. One possibility is that pairs or parallel super-conducting magnetic flux tubes form Josephson junctions. Indeed, at the higher levels of dark matter hierarchy one obtains both time-like and space-like soliton sequences and their Lorentz boosts.

What remained open in the earlier picture was the relationship between Josephson current circuitry and EEG, and nerve pulse generation and the possible analogs of EEG, ZEG (and

WEG) and nerve pulse generation in various other frequency scales. The possibility of generalized EEG hierarchy associated with dark matter hierarchy lead to a general quantitative picture in this respect and allows to interpret the components of generalized EEG in terms of cyclotron radiation and Josephson radiation as a response to cyclotron radiation. The general manner to code information about sensory input and motor actions is in terms of frequency modulation of the EEG frequencies defining EEG rhyths. A fascinating possibility is that scaled up variants of nerve pulses with typical time scale of about 2 seconds instead of millisecond associated with say neuronal bi-layers are realized in higher vertebrates. At the next level the "nerve pulses" would have duration of order 1.1 hours.

Supra currents running parallel to the axon suggest an important additional piece to the picture about of quantum control. Constructive interference of supra currents leads to a large net Josephson current and various biological clocks could rely on this mechanism. When reference supra current representing the expected sensory input and a current representing real sensory input and flowing in parallel manner in weakly coupled super conductors, are sufficiently near to each other, constructive interference of the Josephson currents occurs and can give rise to a synchronous firing. This makes possible conscious comparison circuits. Conscious novelty detectors can be build easily from comparison circuits using inhibitory and excitatory synaptic connections.

It must be emphasized that detailed models cannot be taken too seriously. There are simply quite too many new physic mechanisms to be considered. The following considerations actually represent the first general vision about the role of super conductivity in living matter, and also this is a good reason for not taking them too literally. As in the case of other similar sections, I have made the decision to keep it as such since the general vision might apply also in the recent framework although it failed in the original model of nerve pulse and EEG. The replacement of the representation of Josephson junction by magnetic flux tubes carrying dark variants of electrons and ions might provide a general realization of the vision. For instance, standing wave solitons associated with the Josephson currents between cytoskeletal microtubules and regions of the cell membrane could be involved with DNA - cell membrane TQC. These currents - at least in the case of axons- might be also responsible for ordinary EEG (note that a hierarchy of fractal variants of EEG are predicted [K35].

3.6.1 Simple Model For Weakly Coupled Super Conductors

Several kinds of Josephson currents between cell interior and exterior are possible. Solitons represent quantized Josephson currents which are large and able to facilitate the generation of nerve pulse in the case of Na_+ and Ca_{++}. Soliton sequences are the simplest solutions of Sine-Gordon equation for the Josephson junctions associated with a linear structure such as axon idealized as an infinitely long and thin cylindrical surface and are mathematically equivalent with a rotating gravitational pendulum.

The most general formulation starts from the Klein-Gordon equation for the order parameters Ψ_i, $i = 1, 2$ for the super-conductors coupled linearly to each other in the junction

$$
\begin{aligned}
D\Psi_1 &= m^2\Psi_1 + m_{12}^2\Psi_2 \ , \\
D\Psi_2 &= m^2\Psi_2 + m_{12}^2\Psi_1 \ , \\
D &= (\partial_\mu + iZeA_\mu)(\partial_\mu - iZeA_\mu)
\end{aligned}
\tag{3.6.1}
$$

Here m denotes the charge of the super-conducting particle (say Cooper pair) and m_{12}^2 is real parameter characterizing the coupling between the super conductors. A_μ denotes electromagnetic vector potential associated with the super conductors. D denotes d'Alembert operator $\partial_t^2 - \nabla^2$.

Weakly coupled super conductors are assumed to possess cylindrical symmetry and can regarded as inner and out cylinder with Josephson junctions idealized with smooth distribution of them. If ME acts as Josephson junctions this assumption is exact. Weak coupling means

that that the densities of charge carriers are same at the two sides of the junction in a good approximation:

$$\Psi_i \quad = \quad \sqrt{n} exp(i\Phi_i) \ , \ \ i = 1, 2 \ .$$
(3.6.2)

Under these assumptions one obtains for the phase difference $\Phi \equiv \Phi_1 - \Phi_2$ the Sine-Gordon equation with a coupling to the vector potential

$$\partial^\mu \left[\partial_\mu \Phi - q\Delta A_\mu \right] \quad = \quad m_{12}^2 sin(\Phi)$$
(3.6.3)

ΔA_μ denotes the difference of the vector potential over the junction. q denotes the charge of the super-conducting charge carrier.

Note that Lorentz gauge condition

$$\partial_\mu A^\mu \quad = \quad 0$$
(3.6.4)

does not trivialize the coupling to the vector potential since the equation holds true only in 3-dimensional surface defining the junction and the contribution from the direction of the normal is not present.

Josephson current J_J can be identified as the divergence of the 4-current $j_\mu = Ze\rho = Ze\Psi^*(\overrightarrow{\partial_\mu} - \overleftarrow{\partial_\mu})\Psi$ at the either side of the junction.

$$J_J \quad = \quad \partial_\mu J^\mu = Ze \times \frac{n}{m} \times m_{12}^2 sin(\Phi) \ .$$
(3.6.5)

The Josephson current per unit length of axonal membrane of radius R and thickness d is given by

$$J \quad = \quad Ze \times \frac{n2\pi R d}{m} \times m_{12}^2 sin(\Phi) \ .$$
(3.6.6)

The parameter m_{12}^2 is analogous to the inverse of the magnetic penetration length squared ($\hbar = c = 1$) for the super-conductors involved.

$$m_{12}^2 \quad = \quad \frac{1}{\Lambda^2} \ .$$
(3.6.7)

If one can regard the Josephson junction region as a defect in a super-conductor, Λ is apart from a numerical constant of order unity equal to the thickness of the Josephson junction. In the case of the cell membrane this would mean that the small oscillations associated with the Josephson junction have frequencies of order 10^{16} Hz and correspond to quanta with energies of order 100 eV.

The covariant constancy conditions

$$\partial_t \Phi \quad = \quad ZeV(t, z) \ ,$$
$$\partial_z \Phi \quad = \quad ZeA_z(t, z) \ .$$
(3.6.8)

are mutually consistent only if the electric field in the axial direction vanishes. They are not however consistent with the right hand side of the equation and only one of the conditions can be satisfied. The condition effectively reduces the equation to an ordinary differential equation. Of course, one cannot assume the condition for general solutions.

For a constant potential difference V_0 the Josephson current is sinusoidal for $\partial_t \Phi = ZeV_0$ ansatz with the basic frequency given by $\omega = eV_0$. An exact treatment replaces the sinusoidal time dependence of Φ with the time dependence of the angle coordinate of gravitational pendulum so that higher harmonics are involved. In the case of cell membrane $V(t)$ is typically a sum of constant part and time dependent part giving rise to frequency modulation of the basic Josephson current:

$$\omega(t) = eV = eV_0 + eV_1(t) \ .$$

Entire hierarchy of frequency modulations is possible since also eV_1 can be frequency modulated by Josephson currents.

3.6.2 Simplest Solutions Of Sine-Gordon Equation

Free Sine-Gordon equation resulting, when the coupling to the em field can be neglected, gives a good view about the solutions of full equation. In cylindrical geometry Sine-Gordon equation becomes effectively 2-dimensional under rather natural conditions. This is rather nice since two-dimensional Sine-Gordon equation is completely integrable and thus allows an infinite number of conserved charges [B4].

Sine-Gordon equation allows two kinds of vacua. The vacua of first type correspond to $\Phi = 2n\pi$ ground state configuration and vacua second type to $\Phi = (2n + 1)\pi$. The small perturbations around these vacua correspond to massive 1+2 dimensional free field theory with field equations

$$
\begin{aligned}
D\Phi &= \epsilon \frac{1}{\Lambda^2}\Phi \ ; \\
D &= \partial_t^2 - \nabla^2 \ , \\
\epsilon &= -1 \ \text{for} \ \Phi = n2\pi \ , \\
\epsilon &= 1 \ \text{for} \ \Phi = (2n + 1)\pi \ .
\end{aligned}
\tag{3.6.9}
$$

In the language of quantum field theory, the small perturbations around $\Phi = n2\pi$ describe particle with mass squared $m^2 = \frac{1}{\Lambda^2}$ whereas the small perturbations of the $\Phi = (2n + 1)\pi$ vacuum describe tachyons with negative mass squared $m^2 = -\frac{1}{\Lambda^2}$. Therefore these vacua will be referred to as time like and space-like respectively.

One might argue that the space-like vacua are un-stable in the case that the continuous sheet of the Josephson junctions consists actually of discrete Josephson junctions, whose dynamics is given by the differential equation

$$\frac{d^2\Phi}{dt^2} = -\frac{sin(\Phi)}{\Lambda^2}$$

allowing only $\Phi = n2\pi$ as stable ground state. For MEs acting as Josephson junction the situation is different. On the other hand, the ground state at which soliton generation is possible should be quantum critical and hence very sensitive to external perturbations. Note that time like and space-like sectors in axonal portion of neuron are permuted by a duality transformation $z \leftrightarrow vt$ (v=c=1), $\Phi \rightarrow \Phi + \pi$, which is exact symmetry of the 1+1-dimensional Sine-Gordon equation.

The propagating waves are of form $sin(u)$, where one has

$$
\begin{aligned}
u &= \gamma_P(t - \frac{v_P z}{v^2}) \;, \quad \text{time like case} \\
u &= \gamma_P(z - v_P t) \;, \quad \text{space-like case} \\
\gamma_P &= \sqrt{\frac{1}{1 - (\frac{v_P}{v})^2}} \;.
\end{aligned}
\tag{3.6.10}
$$

Here v_P is the velocity parameter characterizing the boost. The frequency of these small propagating oscillations (plane waves) is in two cases given by

$$
\begin{aligned}
\Omega &= \frac{\gamma_P v}{\Lambda} \;, \quad \text{time like case} \;, \\
\Omega &= \frac{\gamma_P v_P}{\Lambda} \;, \quad \text{space-like case} \;.
\end{aligned}
\tag{3.6.11}
$$

The frequency is very high for time like waves, of order 10^{10} Hz and therefore a typical time scale for the conformational dynamics of proteins. In space-like case the phase velocity of the propagating waves is $v_P < v$ and frequencies are small and one could consider the possibility of identifying these oscillations as propagating EEG waves. For the time like excitations phase velocity is $v_p = v^2/v_P > v$ and larger than light velocity. For ordinary elementary particles the situation is same but since phase velocity is in question, there are no interpretational problems.

One-dimensional solutions of the Sine-Gordon equation give quite satisfactory picture about the situation as far as the physical interpretation is considered. The simplest solutions of this type correspond to solutions depending on time or spatial coordinates only. For time like vacua one-dimensional solutions depend on time only: note that these solutions are possible for arbitrary geometry of the Josephson junction. For space-like like vacua one-dimensional solutions are possible in the axonal portions of the neuron: the simplest one-dimensional solutions depend on the axonal coordinate z only.

Field equations reduce to the equations of motion for gravitational pendulum:

$$
\frac{d^2 \Phi}{du^2} = -\frac{1}{\Lambda^2} sin(\Phi) \;.
\tag{3.6.12}
$$

$u = vt$ holds true in time like case ($v = c \equiv 1$ is good approximation). $u = z$ holds true in space-like case (in this case equation makes sense for axonal portions only). Energy conservation for the gravitational pendulum gives

$$
\frac{1}{2}v^2(\frac{d\Phi}{du})^2 + \frac{v^2}{\Lambda^2}\left[1 - cos(\Phi)\right] = K\frac{2v^2}{\Lambda^2} \;,
\tag{3.6.13}
$$

where K is dimensionless constant analogous to energy. There are two kinds of solutions: oscillating solutions ($K < 1$) and rotating solutions ($K > 1$): single soliton solution corresponds to $K = 1$.

One can integrate the conservation law for energy to give the time/spatial period of oscillation or rotation (T/λ). For oscillating solutions one has

$$
T = \frac{\lambda}{v} = \frac{\Lambda}{v} \int_{-\Phi_0}^{+\Phi_0} d\Phi \frac{1}{\sqrt{2\left[-cos(\Phi_0) + cos(\Phi)\right]}} \;.
\tag{3.6.14}
$$

Here Φ_0 is maximum value of the phase angle for oscillating solution. For the rotation period one obtains

$$T \quad = \quad \frac{\lambda}{v} = \frac{\Lambda}{v} \int_0^{2\pi} d\Phi \frac{1}{\sqrt{(\frac{d\Phi}{dt})^2(\Phi = \pi) + 2\left[1 - cos(\Phi)\right]}} \quad . \tag{3.6.15}$$

By Lorentz-boosting space-like axonal solutions to move with velocity v_p one obtains propagating soliton sequences.

Sine-Gordon equation is completely integrable and thus allows an infinite number of conserved charges. In quantum theory the eigenvalues of mutually commuting charges characterize the quantum state and these charges are basic quantum observables. Does it make sense to quantize Sine-Gordon and could one characterize the state of the axonal membrane in terms of these charges? Here one must point out the similarity to the ideas of Nanopoulos [?], who speculates with the possibility that certain 2-dimensional conformal field theory characterizes the state of micro-tubule and the infinite number of conserve charges characterize the information content of the micro-tubule. It is perhaps also worth of mentioning that the quantum group $SU(2)$ appears in the quantization of the Sine-Gordon equation [B17]: could quantum groups have important applications in biology?

3.6.3   Are Both Time Like And Space-Like Soliton Sequences Possible Ground States?

The model for the Josephson junction predicts the existence of both time like and space-like soliton sequences. Mathematician would expect that both ground states of coupled super conductors are realized in brain. The presence of space-like and time like modes could provide general insights to brain functioning and could relate to the fundamental dichotomies of brain consciousness.

Time like soliton sequences do not in general propagate and if they propagate, the phase velocity exceeds light velocity (due to $t - vx/c^2$ dependence). The size of coherence region in the case of gap junction connected neurons can be rather large. Also micro-tubuli could form large coherent regions.

The time scales involved with the time like soliton sequence are however very fast, much faster that the time scales of EEG. This suggests that soliton sequences and oscillations are responsible for a synchronization in various scales defined by p-adic and dark matter hierarchies. One cannot exclude the possibility that the appearance of time like soliton sequences correlates with the emergence of standing EEG waves and synchronous firing whereas propagating space-like soliton sequences could accompany nerve pulse conduction. Since non-propagating collective firing does not occur, standing soliton sequences could be associated with glial cells and propagating soliton sequences with neuronal axons.

Soliton sequences could provide a general realization of biological clocks and facilitate the generation of macroscopic quantum systems. Also the gap junction connected neuron groups associated with primary sensory organs, various organs and brain could correspond to time like solitons.

For ordinary value of $\hbar$ the small oscillations for time like ground state have period of order 10^{-10} seconds: this follows solely from the spatial extension of nerve pulse of order $\Lambda \sim 10^{-2}$ meters and involves no assumptions about the detailed properties of the super conductor. These oscillations could coordinate protein dynamics. I do not know whether endoplasma membranes inside cells have resting potential: if not, they are good candidates for the carriers of time like ground states with oscillating voltage.

For cell membrane situation is different and the only possible interpretation is that the resting potential for ordinary value of Planck constant and for far-from-vacuum ground state corresponds to the 10^{-13} second time scale determined by the membrane voltage and the

mechanical analog is very rapidly rotating gravitational pendulum. Almost vacuum extremal property and large values of Planck constant change the situation and $k_d = 47$ level would correspond to 5 Hz oscillation frequency. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. These time-like soliton sequences could indeed be interpreted as standing EEG waves whereas space-like soliton sequences would correspond to propagating EEG waves. The presence of perturbations appearing at multiples of cyclotron frequencies of biologically important ions means that standing and moving waves at other frequencies are possible. Nerve pulse patterns induces frequency modulations of the corresponding Josephson currents and Josephson radiation.

Glial cells [I22] form a considerable fraction of cell population of brain are glial cells and are connected to each other by gap junctions, which can serve as Josephson junctions. In glial cells large amplitude oscillations with longer oscillation period could be present. The ciliar beating of monocellular animals [I22] could be coordinated to coherent motion (making possible swimming of the monocellular organism) by the "EEG" waves.

Gap junctions between the nerve cells are not common but are encountered in the large coherently firing groups of nerve cells in the brain, in the sensory organs and other organs such as heart. The value of the parameter K is only slightly larger than the critical value $K = 1$ for EEG since the period of EEG oscillations is typically by a factor of order 10^8 longer than the period of small oscillations. The problem disappears when higher levels of dark matter hierarchy are allowed. Of course, if the potential difference in question corresponds to the membrane potential, one must have $K \gg 1$. One can wonder whether the criticality might have some deeper significance: perhaps phase transitions between EEG: s corresponding to rotating and oscillating gravitational penduli are possible.

3.6.4   Quantum Tools For Bio-Control And -Coordination

Coordination and control are the two fundamental aspects in the functioning of the living matter. TGD suggests that at quantum level deterministic unitary time evolution of Dirac equation corresponds to coordination whereas time evolution by quantum jumps corresponds to quantum control. More precisely, the non-dissipative Josephson currents associated with weakly coupled super conductors would be the key element in coordination whereas resonant dissipative currents between weakly coupled super conductors would make possible quantum control.

This view allows to consider more detailed mechanisms. What is certainly needed in the coordination of the grown up organism are biological clocks, which are oscillators coupled to the biological activity of the organ. Good examples are the clocks coordinating the brain activity, respiration and heart beat [I50]. For example, in the heart beat the muscle contractions in various parts of heart occur in synchronized manner with a well defined phase differences. Various functional disorders, say heart fibrillation, result from the loss of this spatial coherence. For a control also biological alarm clocks are needed. An alarm clock is needed to tell when the time is ripe for the cell to replicate during morphogenesis. Some signal must tell that is time to begin differentiation to substructures during morphogenesis: for example, in the case of the vertebrates the generation of somites is a very regular process starting at certain phase of development and proceeding with a clockwise precision.

Homeostasis as many-sheeted ionic flow equilibrium

The experimental work of Ling, Sachs and Qin [I42, I59] and other pioneers [I30, I20] challenges the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic pumps. The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! this challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane:

ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why it is so difficult to get the water out of it?

These puzzling observations can be understood if the homeostasis of cell and its exterior is regarded as an ionic flow equilibrium in the many-sheeted space-time. Ionic super currents from super-conducting controlling space-time sheets flow to controlled atomic space-time sheets and back. Currents are of course ohmic at the atomic space-time sheets. One can understand how extremely small ionic densities and super currents at cellular space-time sheets can control ionic currents and much higher ionic densities at atomic space-time sheets. Immense savings in metabolic energy are achieved if the ohmic currents at the atomic space-time sheets flow through the cell membrane region containing the strong electric field along super-conducting cell membrane space-time sheet (rather than atomic space-time sheets) as a non-dissipative supra current. This clever energy saving trick makes also the notion of ionic channels obsolete for weak ionic currents at least.

Super-conducting space-time sheets contain a plan of the bio-system coded to ion densities and magnetic quantum numbers characterizing the super currents. Bio-control by em fields affects these super currents and one can understand the effects of ELF em fields on bio-system in this framework. The model relies crucially on the liquid crystal property of bio-matter (hamburger mystery!) making possible ohmic current circuitry at the atomic space-time sheets as a part of the many-sheeted control circuitry. There is a considerable evidence for this current circuitry, Becker is one of the pioneers in the field [**?**]: among other things the circuitry could explain how acupuncture works.

Quantum model for pattern recognition

Time translation invariant pattern recognition circuit can be realized by using two coupled super-conductors. The first super-conductor contains the reference supra current and second super-conductor contains the supra current determined by the sensory input. Supra currents are assumed to have same spatially and temporally constant intensity. If the supra currents have spatially constant phase difference, also Josephson currents are in the same phase and sum up to a large current facilitating synchronous firing. The temporal phase difference of supra currents does not matter since it affects only the overall phase of the Josephson current. Therefore patterns differing by time translations are treated as equivalent. Quite generally, the requirement of time translational invariance, favors the coding of the sensory qualia to transition frequencies.

The destructive interference of supra currents provides an tool of pattern cognition in situations when the precise timing is important. The pattern to be recognized can be represented as a reference current pattern in some neuronal circuit. Input pattern determined by sensory input in turn is represented by supra current interfering with the reference current. If interference is destructive, synchronous generation of nerve pulses in the circuit occurs and leads to a conscious pattern recognition. Obviously the loss of time translation invariance makes this mechanism undesirable in the situations in which the precise timing of the sensory input does not matter. One can however imagine situations when timing is important: for instance, the deduction of the direction of the object of the auditory field from the phase difference associated with signals entering into right and left ears could correspond to this kind of situation.

In both cases one can worry about the regeneration of reference currents. The paradigm of four-dimensional quantum brain suggests that sensory input leads by self-organization to a stationary spatial patterns of supra-currents and this process depends only very mildly on initial values. Thus self-organization would generate automatically pattern recognizers.

General mechanism making possible biological clocks and alarm clocks, comparison circuits and novelty detectors

Weakly coupled super conductors and quantum self-organization make possible very general models of biological clocks and alarm clocks as well as comparison circuits and novelty

detectors.

The Josephson junction between two super-conductors provides a way to realize a biological clock. Josephson current can be written in the form [D73]

$$
\begin{aligned}
J &= J_0 sin(\Delta\Phi) = J_0 sin(\Omega t) \ , \\
\Omega &= ZeV \ ,
\end{aligned}
\tag{3.6.16}
$$

where Ω is proportional to the potential difference over the Josephson junction. Josephson current flows without dissipation.

In BCS theory of super-conductivity the value of the current J_0 can be expressed in terms of the energy gap Δ of the super conductor and the ordinary conductivity of the junction. When the temperature is much smaller than critical temperature, the current density for a junction is given by the expression [D73]

$$
J_0 = \frac{\pi}{2e}\frac{\sigma_s\Delta}{d} \ .
\tag{3.6.17}
$$

Here σ_s is the conductivity of the junction in the normal state assuming that all conduction electrons can become carriers of the supra current. d is the distance between the super conductors. The current in turn implies a position independent(!) oscillation of the Cooper pair density inside the two super conductors. By the previous arguments the density of the Cooper pairs is an ideal tool of bio-control and a rhythmic change in biological activity expected to result in general. Josephson junctions are therefore good candidates for pacemakers not only in brain but also in heart and in respiratory system.

In the presence of several parallel Josephson junctions quantum interference effects become possible if supra currents flow in the super conductors. Supra current is proportional to the gradient of the phase angle associated with the order parameter, so that the phase angle Φ is not same for the Josephson junctions anymore and the total Josephson current reads as

$$
J = \sum_n J_0(n)sin(\Omega t + \Delta\Phi(n)) \ .
\tag{3.6.18}
$$

It is clear that destructive interference takes place. The degree of the destructive interference depends on the magnitude of the supra currents and on the number of Josephson junctions.

There are several options depending on whether both super conductors carry parallel supra currents or whether only second super conductor carries supra current.

(a) If both super conductors carry supra currents of same magnitude but different velocity, the phases associated with the currents have different spatial dependence and destructive interference occurs unless the currents propagate with similar velocity. This mechanism makes possible comparison circuit serving as a feature detector. What is needed is to represent the feature to be detected by a fixed supra current in the second super conductor and the input as supra current with same charge density but difference velocity. The problem is how the system is able to generate and preserve the reference current. If case that feature detector "wakes-up" into self state when feature detection occurs, the subsequent quantum self-organization should lead to the generation of the reference current representing the feature to be detected.

(b) If only second super conductor carries supra current and of this supra current for some reason decreases or becomes zero, constructive interference occurs for individual Josephson currents and net Josephson current increases: current causes large gradients of Cooper pair density and can lead to the un-stability of the structure. When the supra current in the circuit dissipates below a critical value, un-stability emerges. This provides a general mechanism of biological alarm clock.

Assume that the second super conductor carriers a supra current. As the time passes the reference current dissipates by phase slippages [D69, D73]. If the reference current is large enough, the dissipation takes place with a constant rate. This in turn means that the Josephson current increases in the course of time. When the amplitude of the Josephson current becomes large enough, the density gradients of the charge carriers implied by it lead to a un-stability of the controlled system: the clock rings. Since the dissipation of (a sufficiently large) Josephson current takes place at constant rate this alarm clock can be quite accurate. It will be found that a variant of this mechanism might be at work even in the replication of DNA. The un-stability itself can regenerate the reference current to the clock. If the alarm clock actually "wakes-up" the alarm clock to self state, self-organization by quantum jumps must lead to an asymptotic self-organization pattern in which the supra current in the circuit is the original one. Actually this should occur since asymptotic self-organization pattern depends only weakly on the initial values.

(c) Novelty detector can be build by feeding the outputs of the feature detectors to an alarm clock circuit. In alarm clock circuit only the second super conductor carries supra current, which represents the sum of the outputs of the feature detectors. Since the output of a feature detector is non-vanishing only provided the input corresponds to the feature to be detected, the Josephson current in additional circuit becomes large only when the input does not correspond to any familiar pattern.

How MEs could generate soliton sequences?

MEs could as bio-controllers using the same general mechanism which underlies remote mental interactions and this aspect of bio-control could be seen as endogenous remote mental interactions between cells and other parts of organism. Pairs of low and high frequency MEs are involved. Low frequency MEs, say EEG MEs, serve as correlates for quantum entanglement between body parts: already this is enough for remote viewing regarded as sharing of mental images by fusion of mental images. The psychokinesis aspect is possible by high frequency MEs propagating like massless particles inside low frequency MEs. These MEs induce bridges and thus leakage of ions between various space-time sheets at the receiving end. This means self-organization by dissipation.

MEs can also act as Josephson junctions connecting super-conducting space-time sheet characterized by p-adic primes which can be different. This kind of Josephson junction contains the em field associated with ME as an external field and the mathematical description of this coupling follows from the model for the coupling of electromagnetic field to super conducting order parameters. In Minkowski coordinates the modification of the Sine-Gordon equation is simple:

$$\partial^\mu \left[\partial_\mu \Phi - Ze\Delta A_\mu \right] \quad = \quad m_{12}^2 sin(\Phi) \ . \tag{3.6.19}$$

Here Φ denotes the phase difference over the Josephson junction, which is idealized with a continuous Josephson junction, and actually is a continuous Josephson junction in the case of ME. ΔA_μ denotes the difference of the vector potential over the junction.

The coupling to the vector potential can in the lowest order described by the condition

$$\partial_\mu \Phi_0 = Ze\Delta A_\mu$$

assumed to hold for a maximal number of components of vector potential. Here of course integrability conditions pose restrictions. One can develop perturbation series for Φ by substituting Φ_0 to the right hand side and calculating Φ_1 using the right hand side as a source term, and so on.

If the transversal em field associated with ME contains time independent radial electric field this gives rise to a constant potential term giving rise to a generation of soliton sequences. The period Ω of rotation for the soliton satisfies $\Omega = eV$, where eV corresponds to the potential difference defined by the constant part of the electric field of ME. It can also happen that ME contains only the oscillatory electromagnetic field: if the frequency is same as the frequency associated with small oscillations of the Sine-Gordon pendulum a resonant coupling is expected to result. In this case the frequency is in radio frequency range.

Also noise is present and it is quite possible that the noise provides the energy needed to amplify the weak periodic signal provided by ME to a soliton sequence by stochastic resonance. The mechanism is discussed in detail in the chapter "Quantum model for EEG and nerve pulse". This suggests that MEs could basically control small very fast oscillations of the membrane potential.

3.7 Model For The Hierarchy Of Josephson Junctions

As far as hierarchy of EEGs and its generalizations is considered the hierarchy of Josephson junctions assignable to cell membrane itself is relevant. Dark matter hierarchy and p-adic fractality allow to imagine a fractal hierarchy of structures analogous to cell membrane with arbitrarily large thickness. One can even imagine scaled up variants of cell membrane with different p-adic length scale and value of Planck constant but possessing same membrane potential as ordinary cell membrane. The generalization of the embedding space helps to understand what is involved and is discussed in Appendix.

3.7.1 The Most Recent Model For The Generation Of Nerve Pulse

For some time ago I learned [?, ?, ?, ?, ?] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (TQC) [K2] leads to a rather precise model for the generation of nerve pulse.

(a) The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of TQC. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating soliton solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

(b) During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary

conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

(c) The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that soliton velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as TQC sine also microtubule-cell membrane systems are good candidates for performers of TQC. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane TQC would represent higher level TQC distinguishing between multi-cellulars and mono-cellulars.

(d) New physics would enter in several ways. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [L4], [L4] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number obtained by replacing one or more neutral color flux tubes connecting nucleons of neutral atom with a charged one. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^\pm$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

3.7.2 Quantum model for sensory receptor

This original model of nerve pulse and EEG was still based on the implicit assumption that the space-time sheet carrying the Josephson currents is far from vacuum. The model for sensory receptor and sensory qualia however led to a the proposal that the space-time sheet in question is near vacuum extremal [K39, K79]. Near vacuum extremal property does not affect the general structure of the model in an essential manner.

(a) The only change [K79, K80] is the replacement of charges ± 1 of ions with effective charges given as

$$Q_{eff} \quad = \quad -\frac{Z-N}{2p} + 2Z + q_{em} \ . \tag{3.7.1}$$

Z and N denote nuclear charge and neutron number. $p = sin^{(}\theta_W)$ corresponds to Weinberg angle. For K^+, Cl^-, Na^+, Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 12.2** gives the values of Josephson energies for some values of resting potential for $p = sin^{(}\theta_W) = .0295$ reproducing the frequencies of peak sensitivity for photoreceptors. Rather remarkably, they are in IR or visible range.

(b) The energies are in UV and visible range. Hence one can consider also Josephson junctions with considerably lower membrane potentials of order mV are possibly without losing the thermal stability. For instance, one could consider $k = 151, 157, 163, 167$

Ion	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	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 3.4: 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.

Josephson junctions with a membrane potential scaling as $1/L(k)$. For $k = 167$ the energies would be scaled down by a factor $2^{-(167-151)/2} = 2^{-8}$ giving for $V_{eff} = .09$ V a photon energy somewhat below the thermal energy at room temperature. On the other hand, the fact that Josephson junctions with a vanishing Z^0 field are at the verge of thermal instability suggests that also they might be present in living matter.

(c) From **Table 12.2** one can evaluate the value of Planck constant for a given Josephson frequency for various ions. For $f_J = 5$ Hz giving a first estimate for neuronal Josephson frequency and V=-55 mV corresponding to the critical voltage for the generation of action potential one obtains the values $r = \hbar/\hbar_0 = (1.51, 1.89, 2.11, 1.59) \times 2^{46}$ for $(Na^+, Cl^-, K^+, Ca^{++})$. For V=-70 mV corresponding to the resting potential of neuron and same Josephson frequency one obtains $r = (0.961.201.341.01) \times 2^{47}$. For Ca^{++} ion r is very near to a power of 2. A good mnemonic is that the Josephson energies of biologically important ions vary in an interval, which is in a reasonable approximation half octave $(E_J(K^+)/E_J(Na^+) = 1.3958 \simeq \sqrt{2} \simeq 1.4142)$.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions. **Table 12.2** gives the values of Josephson frequencies of basic biological ions for typical values of the membrane potential.

(a) The maximum value of the action potential during nerve pulse is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

(b) For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

(c) The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum.

(d) For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.

(e) For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

(f) For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

3.7.3   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.

(a) 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.

(b) 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.

(c) 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 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

$$r(q) = \frac{Q_{eff}(q)}{Q_{em}(q)} = \frac{\epsilon(q)}{2pQ_{em}(q)} + 1 \quad , \quad \epsilon(u) = -1 \ , \epsilon(d) = 1 \qquad (3.7.2)$$

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 3.5: 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.

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 by **Table 3.5** 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 $d$quark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

(d) 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.

3.7.4   What Is The Role Of The Magnetic Body?

The basic vision is that magnetic body receives sensory data from the biological body- basically from cell membranes and possibly via genome - and controls biological body via genome. This leaves a huge amount of details open and the almost impossible challenge of theoretician is to guess the correct realization practically without any experimental input. The following considerations try to clarify what is involved.

Is magnetic body really needed?

Libet's findings and the model of memory based on time mirror (see **Fig. http://tgdtheory. fi/appfigures/timemirror.jpg** or **Fig. ??** in the appendix of this book) 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.

Is motor action time reversal of sensory perception in zero energy ontology?

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 [**?**]. 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.

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 however 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?

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(a) 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.

(b) 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.

(c) 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 superorganism 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.

(d) Flux quantization for large value of $\hbar$ poses an additional constraint on the model.

   i. 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.

   ii. The quantization of magnetic flux could be replaced by a more general condition

$$\oint (p - ZeA)dl = n\hbar \ , \tag{3.7.3}$$

   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.

   iii. 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

$$N = \frac{2m}{RZ^2e^2} \tag{3.7.4}$$

   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

$$N_i = \frac{2m_i v_i}{RZ_i \sum_k Z_k v_k e^2} \ . \tag{3.7.5}$$

   It seems that this condition is the most realistic one for the large $\hbar$ flux sheets at which Josephson radiation induces cyclotron transitions.

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.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

3.7.5 Dark Matter Hierarchies Of Josephson Junctions

The hierarchy of Josephson junctions assignable to cell membrane and characterized by values of Planck constant provides a rather nice model for cell membrane but one can consider also more general dark hierarchies of Josephson junctions. This model conforms with the general vision that living matter processes information by locating it to various pages of the "Big Book".

Maximization of Planck constant in quantum control and communication in living matter

The sectors of the embedding space for which CD and CP_2 are replaced with their n_a- *resp.* n_b-fold coverings define the most promising candidates concerning the understanding of living matter, at least the quantum control of living matter. The reason is that the value of the Planck constant is maximized and given by $r = \hbar/\hbar_0 = n_a n_b$. Also the number of pages with same Planck constant would be finite unlike for the more general option allowing rational values of Planck constant. In particular, infinite number of pages with the standard value of Planck constant would be possible and this might lead to mathematical difficulties.

Experimental constraints allow to consider also the possibility that only covering spaces are possible. One must be however very cautious in making hasty conclusions. If also factor spaces are allowed one can have G_a or G_b as discrete and exact symmetry groups at the level of dark matter and these symmetries would be manifested as approximate symmetries of the visible matter topologically condensed around the dark matter.

(a) In M^4 degrees of freedom since the restriction to the orbifold $\hat{M}^4/G_a$ is equivalent to the exact G_a-invariance of dark matter quantum states. Molecular rotational symmetries correspond typically to small groups G_a and might relate to this symmetry. Small values of n_a would not affect dramatically the value of Planck constant if n_b is large.

(b) $G_a = Z_n$, $n = 5, 6$ are favored for molecules containing aromatic cycles. Also genuinely 3-dimensional tetrahedral, octahedral, and icosahedral symmetries appear in living matter.

In the sequel only integer values of Planck constant will be considered. An especially interesting hierarchy corresponds to ruler and compass integers expressible as a product of power of two and distinct Fermat primes (see Appendix). The reason is that these integers correspond to number theoretically very simple quantum phases. This hierarchy includes as a special case powers of two and one can imagined a resonant interaction between p-adic length scale hierarchy and hierarchy of Planck constants.

Dark hierarchy of Josephson junctions with a constant thickness

The model for EEG relies on fractal hierarchy of cell membrane like structures with a fixed thickness and membrane potential. Therefore cell membrane thickness is not scaled by $\hbar$ as one might naïvely expect. Same applies to magnetic flux tubes: this is possible since the condition for the quantization of magnetic flux can be replaced with a more general one if one allows charged currents at the boundaries of flux quanta [K79]. In this model the value of $\hbar$ becomes a measure for the evolutionary level of cell and neurons in hippocampus, associative regions of cortex and their motor counterparts, and frontal lobes are expected to correspond to the largest values of $\hbar$ measuring also the time scale of long term memory and planned action. Note that cell membrane corresponds to twin primes $k = 149$ and $k = 151$ with $k = 151$ defining a Gaussian Mersenne so that it is indeed very special.

Page of a book is rather precise metaphor for the magnetic flux sheet going through a linear array of strings of nuclei and also for a collection flux tubes parallel to axons. This raises several questions. Do the lines of the text of this book correspond to axons in neural circuits? Do the pages correspond to larger structures formed by the axons?

The quantum model for qualia [K79] implies that Josephson radiation travels through flux tubes parallel to sensory pathways and there could be also a horizontal organization of the neurons- at least at the level of sensory receptors in the sense that magnetic flux tubes connecting DNA nucleotides to lipids of cell membrane fuse to form longer flux tubes between DNA nucleotides of different cells when sensory receptor is active. Axons could thus be seen as the analogs of text lines which however can interact with each other. Similar organization would appear at the level of flux sheets traversing through DNA strands.

Books are made for reading and one can thus ask whether the book metaphor extends. Could the observed moving brain waves scanning cortex relate to the "reading" of the information associated with these sheets of book by the magnetic body and does our internal speech correspond to this "reading" ? One is also forced to ask whether these brain waves are induced by waves propagating along magnetic flux quanta of the magnetic body of Earth or personal magnetic body in the case that it has components other than magnetic flux sheets serving as Josephson junctions.

An objection against a fractal hierarchy of Josephson junctions with thickness scaling as $\hbar$

One can consider also a hierarchy of Josephson junctions with a scaled up thickness proportional to $\hbar$ instead of constant thickness. If these junctions have same voltage at all levels of the hierarchy a resonant interaction between various levels of the hierarchy would become possible.

One can represent common sense objections against this idea. The electric field involved with the higher levels of Josephson junction hierarchy is very weak: something like 10^{-7} V/m for lito-ionospheric Josephson junctions (of thickness about 176 km from the scaling of the cell membrane thickness by $\lambda^4 = 2^{44}$) which might be responsible for EEG. The electric field of the Earth at space-time sheets corresponding to ordinary matter is much stronger: about $10^2 - 10^4$ V/m at the surface of Earth but decreasing rapidly as ionosphere is approached being about.3 V/m at 30 km height. The estimate for the voltage between ionosphere and Earth surface is about 200 kV [F11].

The many-sheeted variant of Faraday law implies that on order to have a voltage of order.08 V over lito-ionospheric Josephson junction at dark matter space-time sheet, the voltage over ionospheric cavity must be almost completely compensated by an opposite voltage over litosphere so that lito-ionospheric double layer could be seen as a pair of capacitor plates in a radial electric field of order 10^{-7} V/m generated by the charge density in sub-litospheric part of Earth. This condition requires fine-tuning and therefore looks unrealistic.

A natural distance scale in which the electric field is reduced would correspond to 10-20 km thick layer in which whether phenomena are present. The mirror image of this layer would be Earth's crust. The cell membrane counterpart would be a dipole layer like charge density between the lipid layers of the cell membrane. Note that the electric field at dark matter space-time can be constant. However, as far as Josephson junction is considered, it is only the net voltage what matters.

3.7.6   P-Adic Fractal Hierarchy Of Josephson Junctions

p-Adic length scale hypothesis allows to imagine a hierarchy of Josephson junctions at least in length scales regarded usually as biologically relevant. The voltage through the junction need not however be same as for the ordinary cell membrane anymore. Twin primes are especially interesting since they would naturally correspond to pairs of structures analogous to a pair of lipid layers defining cell membrane.

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

Also Gaussian Mersennes define highly interesting p-adic length scales and the length scale range between cell membrane thickness and the size of cell contains as many as four Gaussian

$(k, k+2)$	$(137, 139)$	$(149, 151)$	$(167, 169 = 13^2)$	$(179, 181)$
$L_e(k)$	.78 A	5 nm	2.5μm	.32 mm
$(k, k+2)$	$(191, 193)$,	$(197, 199)$		
$L_e(k)$	1 cm	8 cm		

Table 3.6: Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair $(137, 13^2 = 169)$ although $k = 169$ is not prime. The two largest scales could relate to structures appearing in brain.

Mersennes corresponding to $k = 151, 157, 163, 167$. Only the smallest one is associated with a twin prime but p-adic length scale hypothesis allows also non-prime values of k.

The possibility of a p-adic hierarchy of membrane like structures accompanied by Josephson junctions

One can imagine the existence of fractally scaled up variants of cell membrane defining hierarchy of Josephson junctions possibly realized as magnetic flux tubes. The possible existence of this hierarchy is however not relevant for the model of EEG in its recent form.

The first hierarchy correspond to the p-adic length scales varying in the range of biologically relevant p-adic length scales $L(k)$ involving membrane like structures. Twin primes $(k, k+2)$ are good candidates here (Table 3). Second hierarchy corresponds to dark matter hierarchy for which length scales come as $\sqrt{r}L(k))$, $r = \hbar/\hbar_0$. Later the question which values of r are favored will be discussed.

The size of cell nucleus varies in the range $(L(169) = 5 \ \mu m, 2L(169) = 10 \ \mu m)$. This is consistent with the assumption that cell nucleus provides the fundamental representation for this block. This would mean that at least the multiply coiled magnetic flux quantum structures associated with DNA appear as fractally scaled up copies.

Each dark matter level corresponds to a block of p-adic length scales $L(k)$, $k = 151, ..., 169$. Also new length scales emerge at given level and correspond to $L(k)$, $k > 169$. The dark copies of all these length scales are also present. Hence something genuinely new would emerge at each level.

Fractal hierarchy of magnetic bodies assignable to cell

Second hierarchy corresponds to a dark matter hierarchy involving values of Planck constant. The original hypothesis was that the values of Planck constant comes as $r \equiv \hbar/\hbar_0 = 2^{11k}$ of given p-adic length scale assignable to biological membrane like structure. A possible justification for the hypothesis is that the ratio of electron and proton masses is rather near to 2^{11} and that this number appears in quantum TGD in the role of fundamental constant. This hypothesis is however un-necessarily restrictive and it is better to consider at least the values of r given as products of two ruler and compass integers n_F expressible as a product of distinct Fermat primes and some power of two. The justification comes from the number theoretic vision about evolution and number theoretical simplicity of the phases $q = exp(i2\pi/n_F)$ (Appendix).

The emergence of a genuinely new structure or function in evolution would correspond to the emergence of new level in this fractal hierarchy. Quantum criticality would be essential: phases corresponding different values of Planck constant would compete at quantum criticality.

The flux sheet or tubes through cell membranes should integrate to larger structures at the higher levels of dark matter hierarchy implying the integration of sensory inputs from a large number of cells to single coherent input at higher levels of dark matter hierarchy. One can think two options: the sensory inputs from cell membranes are communicated directly to

the magnetic body or via the DNA. The second option would require that the flux sheets or tubes starting from cell membrane traverse also the DNA.

Chapter 4

Quantum Model for Bio-Superconductivity: II

4.1 Introduction

The models for EEG and its variants and for nerve pulse rely on a general model of high T_c superconductivity [K17, K18]. In this chapter the general vision behind model of cell membrane as super-conductor inspired by the identification of dark matter in terms of hierarchy of Planck constants and the notion of magnetic body considered in the previous chapter is tested by applying it to various anomalous findings about the behavior of the cell membrane.

4.1.1 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 [I54]. 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 [I42, I32, I20, I59, I30]. One of the pioneers in the field has been Gilbert Ling [I42]. 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 [I39]) gives an excellent layman summary about the paradoxical experimental results.

One can imagine several charge transfer mechanisms.

(a) Ionic supra currents and Josephson currents define the first candidate for exotic charge transfer. 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 supracurrents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets.

(b) The most feasible model for cell membrane and charge transfer found hitherto relies on Pollack's observations about fourth gel like phase of water. The model for the findings leads to a generalization of the cell membrane as Josephson junction obtained by adding to Josephson energy the difference of the cyclotron energies of dark ion at two sides of the cell membrane. Cyclotron energy difference replaces chemical potential difference in the generalization of the thermodynamical model inspired by Zero Energy Ontology, and replacing thermodynamical distributions with their quantal "square roots". Charge transfer would be induced by a phase transition changing the value of Planck constant at either or both sides of the membrane. This would induce the change of the equilibrium concentrations of ions and also charge transfer.

(c) I have also considered the exchange of exotic W bosons as a non-local charge transfer mechanism involving quantum entanglement in an essential way. 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 way 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 [K2]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

4.1.2 Further Experimental Findings

There are further experimental findings giving support for the TGD based vision about living cell. The following findings are discussed.

(a) Mainstream scientists refuse often to take seriously water memory and homeopathy using arguments which do not tolerate daylight. There is rich amount of evidence that water is able to store information about diluted molecules even at the limit of vanishing dilution [K42]. The explanation is of course that water somehow stores the information about molecules instead of molecules (this kind of explanation should be easy to discover at the computer era but the simplistic argument of skeptics is that those taking seriously water memory are crackpots not able to realize that the density of molecules after the preparation of homeopathic remedy is vanishingly small!). The notion of magnetic body and Pollack's findings about fourth phase of water inspired TGD based model of water memory. The emergence of vertebrate genetic code in the model of dark proton and nuclei allows even the possibility that exclusion domains of Pollack define primitive life forms.

(b) Chiral selection of bio-molecules is one of the basic mysteries of biology. Dark matter realized in terms of a hierarchy of Planck constants suggests that electroweak physics could appear as scaled up dark and also ordinary copies in various preferred p-adic length scales. Below the Compton lengths dark and p-adically scaled-up weak bosons would behave like massless particles implying that weak interactions have same strength as electromagnetic interactions so that parity breaking effects caused by the axial couplings of weak bosons would be large and could explain chiral selection.

(c) The observation that the irradiation of water by radiowaves "burns" water by inducing a visible flame is not easy to understand ins standard physics framework. If the radio waves involves dark photons with large enough Planck constant, the high energy of radiowave photons induce large energy transfer to the water and can induce the effect.

4.1.3 Evidence For Axonal Supra Currents

Hafedh Abdelmelek and collaborators [**?**] have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The basic finding is that the resistance of the sciatic nerve is reduced by a factor of about ten below a critical temperature at the lower edge of the range of the physiological temperatures. The reduction of the temperature occurs inside a narrow temperature range ΔT, $\Delta T/T_c \sim .04$. This suggests effective super-conductivity. Furthermore, the critical temperature T_c for the breaking of the effective super-conductivity raises from 240 K to 300 K in the transition from poikilotherms (say frog) to endotherms (say rabbit). A TGD inspired model for these currents is discussed.

4.1.4 DC Currents Of Becker

Robert Becker [**?**] 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 way 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.

A TGD inspired model for quantal direct currents is proposed and its possible implications for the model of nerve pulse are discussed.

4.1.5   Two Views About Cell Membrane

I have considered two possible views about cell membrane. First view might apply to sensory receptors and involves in an essential way the classical Z^0 fields which could be present even in cellular length scales if the hierarchy of Planck constants is realized. Second view is inspired by Pollack's findings.

Could cell membrane correspond to almost vacuum extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. It has however become clear that the argument fixing the value of Weinberg angle is however rather weak. The assumption that the membrane potentials through receptors are different for biologically important ions and their Cooper pairs allows to reproduce the photon energies which are absorved maximally by photoreceptors.

Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor.

Pollack's findings about fourth phase of water

Pollack and Zheng discovered what they call exclusions zone in water. Exclusion zone is negatively charged and has rather intriguing properties suggesting its biological relevance. I have considered this finding in TGD context for few years ago and decided to keep the proposed model as an example about how ideas develop. I also discuss the recent model inspired by the lecture of Pollack [L14] about the fourth phase of water.

The discovery of negatively charged exclusion zone formed in water bounded by gel phase was the motivation for Pollack to propose the notion of gel like fourth phase of water.

The TGD inspired proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it. This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to fork dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural ways [K42, L4]. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers, and one can imagine analog of bio-catalysis

with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

This leads to a model of cell membrane as a generalized Josephson junction. Generalized Josephson energy is identified as the sum of the Coulombic part and difference of cyclotron energies at the two sides of the cell membrane. Zero energy ontology inspires a model of cell membrane defined as "square root" of the thermodynamical model of cell membrane. This leads to the identification of EEG and its variants in terms of dark photons with generalized Josephson energies. Biophotons would result as decay produces of these dark photons. This model allows generalization to the case of almost vacuum extremal.

4.1.6   Implications Of Strong Gravimagnetism For TGD Inspired Quantum Biology

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity.

Tajmar *et al* have proposed the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual Thomson field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of Thomson field. The required value of gravimagnetic Thomson field is however 28 orders of magnitude larger than General Relativity suggests. TGD inspired proposal is based on the notion of gravitational Planck constant assignable to the flux tubes connecting to massive objects. It turns out that the TGD estimate for the Thomson field has correct order of magnitude. The identification $h_{eff} = h_{gr}$ at particle physics and atomic length scales emerges naturally.

A vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible and ultraviolet range receives strong quantitative support. Also a mechanism for how magnetic bodies couple bio-chemistry emerges. The vision conforms with Penrose's intuitions about the role of quantum gravity in biology.

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` [L11].

4.2   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 [I54]. 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 [I42, I32, I20, I59, I30]. One of the pioneers in the field has been Gilbert Ling [I42], 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 [I39]) 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 [K2]. Magnetic flux tubes could also act as Josephson junctions between widely separated structures.

4.2.1 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 [I32] 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 [I42]. This cohesion gives rise to liquid [F12] [D4] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I49, I44, I42]. For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K19]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [I43] 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.

4.2.2 Are Channels And Pumps Really There?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electro-chemistry. 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 [I54]. 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 [D4] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [I49, I44, I42].

For me it was quite a surprise to find that pump-channel paradigm is not at all so well-established 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 [I39] 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 [I39] ! 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 [K36] 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 [I42] 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 [I60] (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 [I59] 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 [I30] 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 [I20] 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 [K35]. 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.05-.1 eV associated with cell membrane to.5-10 eVs and one can understand the nominal value.5 eV of metabolic energy currency.

4.2.3   Cytoplasm As Gel

The solution to the above described anomalies proposed by Pollack is that cytoplasm is gel phase [I39]. Pollack describes in detail various aspects of cytoplasm as a gel phase and here only short summary can be given.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(a) 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.

(b) It is possible to drill to cell membrane holes with size of order 1 μm without an appreciable effect on the functioning of the cell and also show that these holes remain as such for long periods of time [I39]. 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 [I39]. 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 [K17].

(c) 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.

(d) 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.

(e) 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 [I39]. 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.

(f) 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.

4.2.4 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.

(a) 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.

(b) 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 super-conductivity 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.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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 [I39]. If wormhole magnetic flux are taken are taken as a basic prerequisite of life, one must ask whether these "artificial proteins" represent artificial life.

(f) 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.

(g) 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.

  i. 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.

  ii. 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.

(h) 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 intra-cellular 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.

(i) 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.

(j) 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.

4.3 Further Experimental Findings

In this section I discuss further experimental findings giving support for the TGD based vision about living cell.

4.3.1 Genes And Water Memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stephane Ferris, Jean-Luc Montagnier, and Claude Lavall'e published in the journal Interdiscip. Sci. Comput. Life Sci. (2009) [I33].

Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

(a) 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.

(b) 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 [K83]. 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.

(c) 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 mu-metal 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.

(d) 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.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(a) 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.

(b) 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.

(a) 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.

(b) 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.

    i. 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.

    ii. 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 [I16] provides experimental support for the notion.

(a) If the matter at given layer of the onion-like structure formed by magnetic bodies has large $\hbar$, one can argue that the layer corresponds to a higher evolutionary level than ordinary matter with longer time scale of memory and planned action. Hence it would not be surprising if the magnetic bodies were able to replicate and use ordinary molecules as kind of sensory receptors and motor organs. Perhaps the replication of magnetic bodies preceded the replication at DNA level and genetic code is realized already at this more fundamental level somehow. Perhaps the replication of magnetic bodies induces the replication of DNA as I have suggested.

(b) The magnetic body of DNA could make DNA a topological quantum computer [K2]. 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.

(c) 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.

(a) 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.

(b) 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.

(c) What could be the magnetic field inducing the kHz radiation as a synchrotron radiation?

    i. 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.

    ii. 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.

(d) 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 [L4], [L4] 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.

(e) 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 [L12] [K79] (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.

4.3.2 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.

(a) 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.

(b) 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 $L(178) \simeq 100$ μm, the length scale assignable to large cells and the thickness of water layers in the experiment of Pollack.

(c) 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 [I66]. This suggests a connection with Pollack-Zheng effect [D75]. 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?

(a) 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.

(b) 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.

(c) 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.

(d) Parity breaking energy $ks \cdot E$ for say dark protons assignable to hydrogen nuclei of bio-molecules in the internal electric field of the molecule or dark protons of water molecules in the electric field induced by Pollack-Zheng effect [D75] 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?

(a) 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.

(b) 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.

(c) 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.

4.3.3 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 [D66, D64, D62, D65] 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" [D66] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D75]. 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?" [D62] 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" [D65] 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 [D63]. 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 [D64]. 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 [K48].

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.

(a) 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 [D60, D58, D70, D36]. This would explain the $H_{1.5}O$ formula explaining the results of neutron diffraction and electron scattering.

(b) 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.

(c) 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.

(d) 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?" [D62] 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.

(a) 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.

(b) 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 $\hbar/\hbar_0 = .920 \times 2^{21}$.

(c) 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) [I26], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K15, K111] 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.

(a) 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.

(b) 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.

(c) 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.

(d) 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 [D8]. 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 [D7] - a very painful sensation that some part of body is burning?

(e) 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.

(f) 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 [H5] 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 [K49] 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.

Free radicals, expanding Earth, water memory, and Cambrian revolution

The title is intentionally chosen to involve notions which one would expect to have absolutely nothing in common. The purpose is to show that this expectation might be wrong. Consider first the free radical theory [I2]. The theory states that free radical produced in mitochondria are responsible for the ageing since they are highly reactive and cause damage for the DNA. One can however wonder what is the mechanism causing the generation of the free radicals.

A TGD based justification for the free radical theory came as unexpected application of the quantum model for how metabolic batteries are loaded in many-sheeted space-time. The kicking of electrons, protons, or ions to smaller space-time sheet loads metabolic batteries in TGD Universe. A more refined model is based on a phase transition which increases p-adic prime and decreases the value of h_{eff} so that the two length scale changes compensate each other. The zero point kinetic energy or cyclotron energy associated with the magnetic flux tube is reduced in the process and liberate. Therefore this kind of process could liberate metabolic energy.

These processes could occur all the time in ADP$\leftrightarrow$ATP "Karma's" cycle. In this case the transfer or protons through the cell membrane would induce the change of Planck constant and therefore a liberation of metabolic energy stored in roughly the same manner as it is stored in battery. Now however the liberated energy is sum of electrostatic energy and difference of cyclotron energies replacing the difference of chemcical potentials in the case of ordinary battery. The quantitative model for the burning of water producing hydrogen peroxide and hydrogen (this process could provide a mechanism of storing solar energy by a mechanism analogous to photosynthesis) would also rely on this mechanism.

Burning water, photo synthesis, and water memory

The burning of water, photons synthesis and water memory are closely interrelated phenomena in TGD Universe. Recall first what was observed in the experiments carried out by the group led by Luc Montagnie.

(a) What was done was filtration of human cells infected by bacteria in sterilization purpose to eliminate the infected cells. Human cells were added to the filtrate. Rather magically, the infection returned to the filtrate within few weeks. Something having size of order of nanoscale leaked through. It was also found that when the filtrate was diluted by water to produce an analog of homeopathic remedy, it produced at multiples of kHz if the dilution factor was in the range $10^{-7} - 10^{-12}$.

(b) The second discovery was that if you have two bottles containing a solute of nanostructures such that for the first one dilution factor is small and for the second in the critical range so that it radiates at kHz frequencies. What was found that in the final situation neither radiates but only if the dilutions correspond to the same bacterial species! I proposed two interpretations. The first one was that the nanoscale systems in the highly diluted system are starving and gain metabolic energy by sending negative energy photons to the low dilution system and this makes them possible to replicate and achieve higher dilution after which the process stops.

(c) One of the most fascinating possibilities suggested by the discovery is that the nanoscale structures identified as certain gene of the bacteria plus possibly something else (the magnetic body of gene in TGD context) might have been able to regenerate the bacteria themselves! This would require a non-chemical representation of genetic code and its translation to DNA or RNA. For about year ago I indeed discovered a realization of genetic code in terms of dark nuclei with states of nucleons representing the code words [L4], [L4].

These findings allow a more detailed interpretation of the findings of the experiments of the group of Luc Montagnie.

(a) The mysterious burning of water induced by radio waves in GHz range and interpreted in terms of a decomposition of water molecules to hydrogen peroxide and hydrogen: $2H_2 \rightarrow H_2O_2 + H_2$ is closely related to the splitting of water to hydrogen and oxygen occurs also in photosynthesis. The interpretation was that radio waves are resonantly transformed to dark photons with same frequency but with very large value of Planck constant and hence of energy followed by a transformation to ordinary IR photons with much higher frequency but same energy energy around.4 eV [K42, K83]. The finding that Raman scattering (non-elastic scattering of photons on molecules) around this energy occurs in the burning water supports this view. The natural guess is that also in the recent case something similar occurs.

(b) This kind of frequency scaling is one of the basic mechanisms of water memory as I learned for the first time from the lecture of Cyril Smith in CASYS conference many years ago. One of the basic findings was that there is an unknown mechanism transforming low frequencies to high ones and vice versa. The low frequencies are scaled up by a factor which has a preferred value $r \simeq 2 \times 10^{11}$ interpreted in TGD framework as the ratio of the dark matter Planck constant to the ordinary one. I christened this correlation as a scaling law of homeopathy.

(c) It is interesting to apply the law to kHz frequency. In this case the law would give frequency $f = 2 \times 10^{14} >$ Hz. The corresponding energy is.826 eV, which is essentially twice the energy quantum associated with burning water and thus has interpretation as a p-adically scaled up frequency (by one octave). Interestingly, Mae-Wan Ho states in [D63] that *"to use water as electron-donor, and hence to produce oxygen, requires the creation of the chlorophyll-a in cyanobacteria and green plants that can be boosted to a higher electrochemical potential of 0.82 V"* . Hence.83 eV is very near to a metabolically interesting energy.

(d) This finding supports the view that kHz radiation produced by nano-structures corresponds to dark phase conjugate photons with energy equal to a metabolic energy quantum. The interpretation would be that the unidentified nanoscale systems in the highly diluted system are starving and get metabolic energy by sending negative energy quanta in the hope that there are metabolic energy reservoirs around able to absorb them. If bio-photons are Bose Einstein condensates of dark cyclotron photons at the flux tubes of magnetic body acting like population reversed lasers, they could serve as metabolic energy reservoir as suggested in on basis of the discovery described by Mae-Wan Ho in [D66].

(e) A continual fight for metabolic resources is raging everywhere in Nature, presumably also at the monocellular level. It would not be surprising if harmful bacteria would try to steal the metabolic energy of other organisms stored (say) as bio-photons by sending phase conjugate light to the bio-photon resources of multicellular organisms. Nor it would be surprising if living organisms would have developed ways to prevent this. The fine tuning of the metabolic frequencies so that only the members of the same species can share the energy could guarantee this. Also password like protocols might have developed and either or both of them might be involved.

In the two-bottle experiments the nanoscale systems in the highly diluted system would gain metabolic energy by sending negative energy photons received by the low dilution system. The gain of metabolic energy would make possible for the nanosystems to replicate and achieve higher dilution after which the process would stop as was indeed observed. That this took place only for the bacteria of same species supports the interpretation that frequency tuning or password mechanism was involved. This metabolic mechanism (quantum credit card as I have called it) could be a completely general mechanism energy sharing mechanism for cells of the same multicellular organism and perhaps even same species in TGD Universe.

4.4 A Model For The Effective Electronic Super-Conductivity In Axons

Also the following model for axonal electronic super-conductivity was constructed before the progress induced by the model of DNA as TQC and the inspiration coming from the model of nerve pulse by Danish researches [**?**] and is not completely consistent with the new model. I however decided to keep the text because it reflects the development of ideas and with a reasonable amount of work could be modified to the new situation.

Hafedh Abdelmelek and collaborators [**?**] have found evidence for effective super-conductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The basic finding is that the resistance of the sciatic nerve is reduced by a factor of about ten below a critical temperature at the lower edge of the range of the physiological temperatures. The reduction of the temperature occurs inside a narrow temperature range ΔT, $\Delta T/T_c \sim .04$. This suggests effective super-conductivity. Furthermore, the critical temperature T_c for the breaking of the effective super-conductivity raises from 240 K to 300 K in the transition from poikilotherms (say frog) to endotherms (say rabbit).

These findings seem to be consistent with the following view.

(a) Nerve pulse generation involves a mechanism inducing a flow of ions between axonal interior and exterior and induces at the same time the breaking of super-conductivity [K83] . At too low temperatures nerve pulses cannot be generated because the breaking of the super-conductivity is not possible. Therefore the critical temperature must be below the range of physiological temperatures and explains the difference between poikiloterms and endotherms.

(b) In myelin sheathed regions the breaking of the effective super conductivity does not occur or the critical temperature is higher and the signal carried by the nerve pulse is

transformed to an effective or genuine supra current. A small pulse like perturbation of the membrane potential could propagate still.

(c) Poikilotherms can survive only if nerve pulse conduction is possible down to about 240 K which represents lower bound for the temperature of environment. Endotherms can keep the body temperature above 300 K and so that T_c can be as high as 300 K. This is good for survival purposes since high T_c minimizes ohmic losses related to nerve pulse conduction.

The recent model for nerve pulse generation favors somewhat different view. The melting temperatures T_m of the axon and microtubular surface and quantum critical temperature T_c of high T_c super-conductivity are the critical parameters. The generation of the nerve pulse is possible only if T is slightly above T_m. T_m can vary in a wide range and can be controlled genetically. Same could be true for T_c since external perturbations amplified by quantum criticality are expected to affect it. This would explain different values of T_c for poikilotherms and endotherms. The critical temperature for super-conductivity would pose only an upper bound for the temperatures at which organisms can survive whereas quantum criticality of various membranes would constrain this temperature to a narrow range.

4.4.1 Many-Sheeted Space-Time And Connection Between Thermal DeBroglie Wavelength And Size Of The Space-Time Sheet

The concept many-sheeted space-time is needed to understand super-conductivity and breaking of super-conductivity. Parallel space-time sheets with distance about 10^4 Planck lengths form a hierarchy. Each material object (..., atom, molecule, ..., cell, ...) corresponds to this kind of space-time sheet. The p-adic primes $p \simeq 2^k$, k prime or power of prime, characterize the size scales of the space-time sheets in the hierarchy. The p-adic length scale $L(k)$ can be expressed in terms of cell membrane thickness as

$$L(k) = 2^{(k-151)/2} \times L(151) \ , \tag{4.4.1}$$

where the p-adic length scale $L(151)$ and all p-adic length scales above electron length scale $L(127)$ were identified erratically in all writings about TGD before 2014. This deserves some comments.

(a) The wrong identification was $L(151) \simeq 10$ nm implying wrong identification of other scales above $L(127)$ since I have calculated them by scaling $L(151)$ by an appropriate power of two. What I have denoted by $L(151)$ is actually obtained by scaling the Compton length $L_e(127) = \hbar/m_e$ by $2^{(151-127)/2}$ and therefore electrons Compton scale if it would correspond to $k = 151$. Since the mass of electron from p-adic mass calculations is given by $m_e = \sqrt{5 + X}\hbar/L(127)$, the correct identification of $L(151)$ would be

$$L(151) = 2^{(151-127)/2}L(127) = 2^{(151-127)/2}L_e(151)/\sqrt{5 + X} = 10/\sqrt{5 + X} \ nm \ , \ \ 0 \leq X \leq 1 \ .$$

Here X denotes the unknown second order contribution of form $X = n/M_{127}$, n integer, to the electron mass, and in the first approximation one can take $X = 0$ - the approximation is excellent unless n is very large. In the sequel I will try to use the shorthand $L_e(k) = \sqrt{5}L(k)$ but cannot guarantee that the subscript "e" is always present when needed: it is rather difficult to identify all places where the earlier erratic definition appears. I can only apologise for possible confusions.

(b) This mistake has no fatal consequences for TGD inspired quantum biology. Its detection however provides a further support for the speculated central role of electron in living matter. Since the scales obtained by scaling the electron Compton scale seem to be important biologically (scaled up Comton scale $\sqrt{5}L(151)$ corresponds to cell membrane

thickness), the conclusion is that electrons - or perhaps their Cooper pairs - play a fundamental role in living matter. The correct value of $L(151)$ is $L(151) = 4.5$ nm, which is slightly below the p-adic length scale $L_e(149) = 5$ nm assigned with the lipid layer of cell membrane.

(c) I have also assigned to electron the time scale $T = .1$ seconds defining a fundamental biorhythm as a secondary p-adic time scale $T_2(127) = \sqrt{M_{127}}T(127)$. The correct assignment of $T = .1$ seconds is as the secondary Compton time $T_{2,e}(127) = \sqrt{M_{127}}T_e(127)$ of electron: secondary p-adic time scale is $T_2(127) = \sqrt{M_{127}}T(127)$ and corresponds to $T_{2,e}(127)/\sqrt{5} = .045$ seconds and to $f(127) = 22.4$ Hz.

These are so called primary p-adic length scales but there are also n-ary p-adic length scales related by a scaling of power of $\sqrt{p}$ to the primary p-adic length scale.

The characteristic temperature scale for particles of mass M in a thermal equilibrium at the space-time sheet characterized by $L(k)$ is given in terms of the zero point kinetic energy associated with the space-time sheet

$$T(k) \;\; = \;\; n \times E_0(k) = n \times n_1 \times \frac{\pi^2}{2ML^2(k)} \;\; , \tag{4.4.2}$$

where n and n_1 are numerical constants not far from unity (for convenience the units $k_B = 1$, $\hbar = 1$, $c = 1$ are used). $T(k)$ decreases very rapidly as a function of the p-adic length scale $L(k)$. This equation relates the p-adic prime of space-time sheet to T and M of particles present in the sheets forming join along boundaries condensate. Of course, the size L of space-time sheet characterized by k can vary in the range $[L(k), L(k_>)]$ and $T \propto 1/L^2$ is an attractive guess for the dependence of the temperature on the size of the space-time sheet. One can interpret $T(k)$ as a critical temperature at which the p-adic prime characterizing the space-time sheet changes.

4.4.2 Magnetic Flux Tubes As Effective Super-Conductors And Breaking Of Super-Conductivity

The model for bio-superconductivity and its breaking relies on the following picture.

(a) Magnetic flux tubes of Earth's magnetic field (in particular) characterized by $k = 169$ and having a minimal thickness about 5 μm correspond to tubular space-time sheets. The magnetic flux tubes of endogenous magnetic field $B = .2$ with $n = 5$ characterizing the value of the scaled up Planck constant $\hbar = n\hbar_0$ [K37] and the unit nh_0 of magnetic field magnetic flux and $k = 169$ characterizing the p-adic length scale define second option consistent with the identification of 15 Hz as cyclotron frequency of Ca^{+2}. In this case the value of magnetic flux is $2h_5$ and the scaled down magnetic field $B_{end}/2$ required by the sleep time EEG would correspond to single flux quantum. Flux tubes would have thickness of about 25 μm corresponding to a size of a large neuron.

In the absence of both larger and smaller space-time sheets, the flux quanta can act as 1-D super-conductors since cyclotron energy scale, which by the quantization of the magnetic flux behaves also as $1/L^2(k)$, is larger than de Broglie temperature for sufficiently high values n of the magnetic flux (implying thicker flux tube). More generally, one can consider the possibility of a hierarchy of magnetic flux tubes inside magnetic flux tubes corresponding to the sequence $k = 167, 163, ...$ as especially interesting candidate since $k = 151, 157, 163, 167$ define Gaussian Mersennes $(1 + i)^k - 1$. Each of these flux tubes can be a super-conductor. Bio-super-conductivity is assumed to be due to this mechanism. Of course, only space-time sheets corresponding to only some of these p-adic length scales could be present and this would be crucial as far as super-conductivity and its breaking is considered. The study of the effects of external magnetic fields on the axonal conductivity might provide valuable information about the role of magnetic fields.

(b) Super-conductivity can be broken by a temporal leakage of the Cooper pairs to larger space-time sheets if present. These Cooper pairs are kicked back by thermal photons. System is an effective super-conductor in the sense that Cooper pairs are not destroyed in the breaking of super-conductivity and an effective ohmic conductor in the sense that dissipation is present. Super-conductivity can be also broken by thermal kicking of the Cooper pairs to smaller space-time sheets. In this case there is however a restriction posed by the fact that the zero point kinetic energy of the particle increases from $E_0(k)$ to $E_0(k_<)$, where $k_<$ ($k_>$) is the largest (smallest) the prime smaller (larger) than k. Thermal energy is needed to achieve this. For the leakage to occur, one must have

$$T > nE_0(k) \quad = \quad T(k) \ . \tag{4.4.3}$$

Some numerical constant n is involved here. Note that the temperature at super-conducting space-time sheets is much lower than the critical temperature and the temperature at atomic space-time sheets.

(c) The prediction is that the conductivity decreases in a stepwise manner at temperatures $T = T(k)$ as the temperature increases, and that the smallest value of k for current carrying space-time sheets gradually decreases as $k = 169 \rightarrow 167 \rightarrow 163 \rightarrow 157 \rightarrow 151 \rightarrow ....$ The behavior of the conductivity in the sciatic nerve seems to represent one particular step of this kind. The primes $k = 167, 163, 157, 151$ are expected to be especially important in living matter since they corresponds to the so called Gaussian Mersennes and p-adic length scales in the range 10 nm-2.56 μm [K17, K18].

(d) For a space-time sheet having $k = k_0$, the leakage of supra-current is induced by the formation of flux tubes between $k = k_0$ space-time sheets and $k \geq k_0$ space-time sheets. The leakage to the smaller space-time sheets can be also induced by radiation with frequency corresponding to the increment of the zero point kinetic energy and the transversal electric field involved with radiation can be regarded as inducing the force driving the particles to smaller space-time sheets or back.

(e) The strange findings indicating that DNA can behave like a super-conductor [I28], an ohmic conductor [I36], or an insulator could be perhaps understood in terms of the local architecture of the many-sheeted space-time. If only atomic space-time sheet is present, DNA would behave as insulator. If larger space-time sheets are present DNA behaves as an effective ohmic conductor in the sense that dissipative effects are present. If only single larger space-time sheet is present, super-conductivity is possible so that the manufacturing of super-conductors should reduce to space-time engineering.

4.4.3 Quantitative Model For The Breaking Of Super-Conductivity

The dropping (or leakage) of electronic Cooper pairs from $k = k_0$ (say $k_0 = 151$ corresponding to cell membrane thickness) space-time sheet to larger space-time sheets possibly present and followed by a thermal kicking back to $k = k_0$ space-time sheet is a good candidate for the mechanism causing the breaking of magnetic super-conductivity.

The conductivity as a function $\sigma(k)$ of the p-adic length scale $L(k)$ should characterize the mechanism quantitatively. If the thermal energy $E_{th} = T$ satisfies the condition

$$E_0(k) - E(k_>) < T < E_0(k_<) - E(k) \ ,$$
$$E_0(k) = n_1 \times \frac{\pi^2}{4m_e L^2(k)} \ , \tag{4.4.4}$$

one can say that the space-time sheet k is the effective carrier of the current.

The mechanism predicts that the increase of the temperature is accompanied by a sequence of phase transitions in which the value of k characterizing the effective carrier of the current

decreases in a stepwise manner: $k = 169 \rightarrow 167 \rightarrow 163 \rightarrow 157 \rightarrow 151 \rightarrow ....$ These transitions occur at temperatures $T(k) = n \times E_0(k)$, n a numerical constant. This picture is consistent with the observation that the reduction of resistance occurs in a very short temperature interval ΔT: $\Delta T/T \sim .04$.

A more concrete picture is obtained by decomposing the friction force to a sum of forces resulting from dropping from say $k = 151$ to $k = 157163, 167, ...$ and being kicked back. This gives

$$
\begin{aligned}
F &= K(k)v \ , \\
K(k) &= \sum_{k_i > k} \kappa(k_i) = \kappa(k_>) + K(k_>) \ .
\end{aligned}
\tag{4.4.5}
$$

The condition $F = qE$, $q = 2e$, gives for the conductivity defined by $j = nv = \sigma(k)E$, E electric field, the expression

$$
\frac{1}{\sigma(k)} = \frac{K(k)}{nq} = \frac{\kappa(k_>)}{nq} + \frac{1}{\sigma(k_>)} \ .
\tag{4.4.6}
$$

What this means that the space-time sheets correspond effectively to resistors in series.

From the experimental findings for frog, for the transition from $k = 157$ to $k = 151$ the term $\kappa(157)$ must be by about a factor 10 larger than the sum of terms term $\kappa(k)$, $k > 157$. The fractal scaling

$$
K(k) \propto \frac{1}{L^\alpha(k)} \propto 2^{-\alpha k/2}
\tag{4.4.7}
$$

with $\alpha \simeq 1.1$, suggests itself.

The standard classical model for the dissipative force implies that the force is inversely proportional to the free path $l(k)$ of the particle and by naïve scaling symmetry l would be naturally proportional to the p-adic length scale $l \propto L(k)$ giving $\alpha = 1$. $\alpha > 1$ for $K(k)$ means that the free path has a fractal dimension slightly larger than one. The anomalous dimension is due to the many-sheeted nature of the free paths implying the presence of the higher order terms in the expansion of $K(k)$. Indeed, in the lowest order the model based on the naïve scaling dimension -1 for $\kappa(k)$ predicts

$$
\frac{\sigma(151)}{\sigma(157)} \simeq 1/8 - 1/64 \simeq .11
\tag{4.4.8}
$$

in consistency with the measured reduction of the resistivity. Needless to say, this prediction provides a strong support for the p-adic length scale hypothesis and the notion of many-sheeted space-time.

4.4.4   Application At Axonal Level

It is interesting to apply the model for the breaking of super-conductivity in the case of axon.

Understanding the critical temperature

The model for the nerve pulse generation predicts that "bridges" are formed between $k = k_0 > 151$ (say $k_0 = 169$) and $k = 151$ space-time sheets making possible the flow of ions between cell interior and exterior. Super conductivity is broken provided that the temperature is sufficiently high. For electron Cooper pairs ($M = 2m_e$) the zero point kinetic energy at the cell membrane space-time sheet is from Eq. 4.4.4

$$E_0(k = 151) = n_1 \times 312.25 \ \text{K} \ .$$ (4.4.9)

n_1 is some numerical constant not too far from unity. $n_1 = 1$ corresponds to a temperature 42.25 C. The identification as the critical temperature gives quite satisfactory agreement with the experimental values varying from 240 K to 300 K. Note that the requirement $T > T_{cr}$ for the physiological temperatures means that $k = 151$ cell membrane space-time sheet is the effective current carrier in the presence of larger space-time sheets.

If the flux tube connecting $k = 169$ and $k = 151$ space-time sheets contains a strong enough transversal electric field, the supra current can flow only in one direction. It seems that in the case of cell membrane the leakage of electronic Cooper pairs to the negatively charged cell interior is forbidden by this mechanism. The absence of the flux tubes between cell membrane and cell exterior assumed to be generated during the nerve pulse in the TGD based model of the nerve pulse [K83] in turn implies that the leakage cannot occur to or from $k = 169$ space-time sheets at all. Therefore both $k = 151$ and $k = 169$ space-time sheet might be genuinely super-conducting and only nerve pulse conduction would be accompanied by the breaking of super-conductivity.

Predictions for the critical temperature and resistance

Fractality allows to make definite quantitative predictions for the critical temperature.

(a) For $k = 163$ conductivity the critical temperature is predicted to be by a factor $2^{157-151} = 64$ lower than for $k = 157$ conductivity. This gives $T_c(163) = 4.9$ K for $T_c(157) = 300$ K. The upper bound $T_c = 4$ K for the critical temperature for super-conductivity in molecular crystals is reported in [D72]. This would correspond to $T(157) = 240$ K measured in the case of frog. The predicted lowering of the resistance at this critical temperature for nerve conduction might be testable.

(b) The observation that DNA attached between carbon and rhenium electrodes becomes super-conducting below the critical temperature of about 1 K for rhenium [I28] allows the possibility that DNA becomes super-conducting already at about $T_c(163) \simeq 4 - 5$ K but that the rhenium acts as the weak link in the super-conducting circuit.

(c) Cell membrane thickness L might vary and the natural guess is that the critical temperature is inversely proportional to $1/L^2$. If this is the case, the ratio of cell membrane thicknesses for frog and rabbit should be

$$\frac{L(frog)}{L(rabbit)} = \sqrt{\frac{T(rabbit)}{T(frog)}} = \sqrt{5/4} = 1.12$$ (4.4.10)

for $T(rabbit) = 300$ K and $T(frog) = 240$ K.

(d) A further prediction following from the fractal model for the conductance (Eq. 4.4.7) is that also the $k = 157 \rightarrow 163$ at about 4-5 K involves a 10-fold reduction of resistance. Also this prediction might be testable for nerves.

What happens in saltation?

An interesting question is what happens in the saltation over the myelin sheathed portions of the nerve. According to the TGD based model of nerve [K80] [K83], the ME ("massless extremal", "topological light ray" moving with effective velocity equal to the conduction velocity of nerve pulse acts as a bridge between cell membrane ($k = 151$) and cell exterior ($k = 169$) space-time sheets and in this manner allows the leakage of ions from cell interior to exterior and vice versa inducing the physiological effects of nerve pulse. ME could propagate along the myelin sheath rather than along the axon inside. Therefore nerve pulse would not be generated. The following picture about saltation suggests itself.

(a) The transformation of the nerve pulse to an electronic $k = 151$ or $k = 169$ supra current propagating rapidly through the myelin sheathed portion would make possible a rapid signal transmission without physiological effects. Inside myelin sheathed portions of the axon the leakage to $k = 169$ space-time sheets would be impossible by the mechanism described above irrespective of the value of the critical temperature.

(b) Nerve pulse conduction involves also communication and interaction between different space-time sheets and therefore necessitates the leakage of electronic Cooper pairs from $k = 151$ cell membrane space-time sheet. Therefore the critical temperature must be below the range of the physiological temperatures. Endotherms have an evolutionary advantage since the higher critical temperature implies that the dissipative effects associated with the nerve pulse conduction are weaker.

Whether electronic supra current in the myelin sheathed portions of the axon propagates along $k = 151$ or $k = 169$ space-time sheet or along both plus possibly along some other space-time sheets, remains unclear. Note that the critical temperature in myelin sheathed regions could be higher than the physiological temperature. The endogenous magnetic field $B = .2$ Gauss suggested by the work of Blackman and others corresponds to a flux tube radius $L = sqrt5/2 \times L_e(169) \simeq 1.58 L_e(169) = 17.7 L(169) \sim L(177) = 2^(5)L(127)$.

It is interesting to notice that Evan Harris [?] [?] has developed a quantitative theory in which the tunnelling of electrons through the synaptic contact is the basic step of synaptic transfer. The theory applies also to ephapses in which electric transfer of the nerve pulse takes place. Theory explains the differences between ephapses and synapses and also the morphology of synapses and ephapses finds natural explanation. This kind of tunnelling might be induced by the formation of 151-169 ME contacts at presynaptic cell and 169-151 ME contacts at the postsynaptic cell.

4.5 Quantum Model For The Direct Currents Of Becker

Robert Becker [?] 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 or even Josephson currents can flow. The condition that both electronic and protonic 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.

4.5.1 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) [**?**], 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.

(a) 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.

(b) 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 [K80]). Propagating potentials were also discovered in glial cells. The interpretation was in terms of electrical currents.

(c) 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.

(d) 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.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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.

(f) 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 [K2].

(g) 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 [**?**] 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" [**?**] 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 reporedt [**?**] 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, micro-organisms, 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 [K2] 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 [K41]), 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.

(a) 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 attrracting 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 [K74] [L14] for the findings of Pollack [L14] 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 II_1 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 [K98, K78].

(a) 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.

(b) 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.

(c) 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.

(d) $\hbar_{gr}$ 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.

(e) 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.

(f) 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 [K42].

(g) 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.

(h) 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 [K35, K73].

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 [K49].

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 [I10]: 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 semi-conductor junction assumed that the electrons of supra current are transferred to smaller space-time sheets.

(a) 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.

(b) The re-charging mechanism should relate directly to ADP$\rightarrow$ 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.

(c) 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 [K49]. 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.

(d) 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".

(a) 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.

(c) 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.

(d) 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.

(e) Nanna Goldman *et al* have provided empirical evidence (see `http://tinyurl.com/4to42pc`) [I27] for the expectation that the healing effect of the acupuncture involves metabolism (see the popular article in Sciencedaily (see `http://tinyurl.com/3734uub`) [I12]).

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?

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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.

(a) 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.

(b) 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.

4.5.2   Quantum Model For Effective Semiconductor Property

Becker [?] 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.

(a) 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).

(b) 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.

(c) 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.

(d) 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.

(a) One can assign complex order parameters Ψ_k to various Bose-Einstein condensates of supra phases and obey Schrödinger equation

$$i\partial_t \Psi_k \quad = \quad (-\frac{\hbar^2}{2m_k}\partial_z^2 + q_k E z)\Psi_k \quad . \tag{4.5.1}$$

Here it is assumed that the situation is effectively one-dimensional. E is the value of constant electric field.

(b) 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

$$\sigma \quad = \quad E = \sum \sigma_i = \sum_i q_i \overline{\Psi}_i \Psi_i \quad . \tag{4.5.2}$$

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

$$E_{tot} \quad = \quad E + E_0 \quad . \tag{4.5.3}$$

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.

(c) The electric currents are given by

$$j_k \;\;=\;\; \frac{i\hbar q_k}{2m_k}\overline{\Psi}_k\partial_z^{\leftrightarrow}\Psi_k \;\;. \tag{4.5.4}$$

In stationary situation the net current must vanish:

$$\sum_k j_k \;\;=\;\; 0 \;\;. \tag{4.5.5}$$

A stronger condition is that individual currents vanish at the plates:

$$j_k \;\;=\;\; 0 \;\;. \tag{4.5.6}$$

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.

(a) 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).

$$\Psi \;\;=\;\; R(a\,exp(iU) + b\,exp(-iU))exp(-iE_n t) \tag{4.5.7}$$

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.

(b) The Schrödinger equation reduces with the change of variable

$$z \;\;\to\;\; \frac{(z - z_0)}{z_1} \equiv x \;\;,$$
$$z_0 \;\;=\;\; \frac{E_n}{qE} \;\;,\;\; z_1 = \Big(\frac{\hbar^2}{2mqE}\Big)^{1/3} \;\;. \tag{4.5.8}$$

to

$$(\partial_x^2 + x)\Psi \;\;=\;\; 0 \;\;. \tag{4.5.9}$$

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.

(c) Using the polar representation $\Psi = R exp(iU)$ Schrödinger equation reduces to two equations

$$\left[(\partial_x^2 - U_x^2 + x)R\right] cos(U) \quad + \quad [U_{xx} + 2\partial_x R\partial_x U] sin(U) = 0 \ ,$$
$$\left[(\partial_x^2 - U_x^2 + x)R\right] sin(U) \quad - \quad [U_{xx} - 2\partial_x R\partial_x U] cos(U) = 0 \ . \tag{4.5.10}$$

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

$$j \quad = \quad \frac{\hbar}{2m}\frac{U_x}{z_1}R^2 \ , \quad z_1 = (\frac{\hbar}{2mqE})^{1/3} \ . \tag{4.5.11}$$

The current vanishes if either U_z is zero or if the solution is of form $\Psi = R sin(U)$.

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

$$\Psi \quad = \quad R_0 exp\left(\frac{i}{\hbar}\int_0^z \sqrt{2m}\sqrt{E - qEz}dz\right) = R_0 exp\left(i\int_0^x x^{1/2}dx\right) \ . \tag{4.5.12}$$

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 $E_0 = qE_0h$.

(a) The semiclassical treatment of the equation leads to Bohr rules

$$\frac{\oint p_z dz}{\hbar} \quad = \quad \frac{2}{\hbar}\int_0^h p_z dz = n \ . \tag{4.5.13}$$

This gives

$$\frac{\oint p_z dz}{\hbar} \quad = \quad \frac{2\sqrt{2m}}{\hbar}\int_0^h \sqrt{E_n - qEz}dz = 2\int_0^{x_0} x^{1/2} = \frac{4}{3}x_0^{3/2} = n \ . \tag{4.5.14}$$

Note that the turning point for classical orbit corresponds to $z_{max} = E_n/qE$.

(b) One obtains

$$E_n \quad = \quad \frac{1}{2}(\frac{nqE\hbar^2}{r\sqrt{m}})^{2/3} \ , \quad r = \int_0^1 (1 - u)^{1/2}du = \frac{2}{3} \ . \tag{4.5.15}$$

The value of z_{max} is

$$z_{max} \quad = \quad \frac{E_n}{qE} = \frac{n^{2/3}}{2r^{2/3}}(\frac{\hbar^2}{qEm})^{1/3} \ . \tag{4.5.16}$$

(c) 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 ($n^{2/3}$ proportionality), if the mass m of the charged particle is small enough ($m^{-1/3}$ proportionality) raising the electron and also the proton to a special position, or if the strength of the electric field is small enough ($E^{-1/3}$ 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.

(a) 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.

(b) 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 [K80] 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.

(a) 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.

(b) 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.

(c) 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.

  i. 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.

ii. 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

$$\frac{x(Ca^{++})}{x(Na^+)} = (\frac{r(Ca^{++})}{r(Na^+)})^2 \times \frac{23}{2 \times 40} \quad . \tag{4.5.17}$$

$r^2(Ca_{++}) \sim 2r^2(Na_+)$ would allow to compensate for the increased weight and charge of Ca_{++} ions.

(d) 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

$$\frac{x(Ca^{++})}{x(2Na^+)} = (\frac{r(Ca^{++})}{r(Na^+)})^2 \times \frac{23}{20} \quad .$$

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 [L4].

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.

(a) 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.

(b) 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 V/μm, which is by order of magnitude larger than the constant longitudinal dipole electric field of order 10^2 eV/μm generated by tubulin dipoles estimated to have strength 337 Debye in [I35] (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.

(c) 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 [**?**]. Even fields of order.14 Tesla are used.

It is interesting to look at the values of basic parameters associated with these fields.

(a) 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

(b) 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.

(c) 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 μm. For the fields in the range .1-1 mTesla it is in the range 3.5 μm- 1.1 μm. 2.5 μm 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 correspondng to $k = 163$ would correspond to p-adic length scale .36 μm. .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 [**?**]. 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 [K124]. 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 [I64]. 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 [K124] 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 [K2].

The place coding by phase shifts was discovered by O'Reefe and Recce [?]. In [?, ?]. 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

[**?**]. 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.

4.5.3 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 [L5]), 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 [K124] 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 [K42]. 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 [K103]).

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 [K124] 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.

(a) 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.

(b) 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).

(c) 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 [L7]. 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 ofa 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`) [L8] 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`) [L6] 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.

4.6 Could Cell Membrane Correspond To Vacuum Extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to $sin^2(\theta_W) = .0295$ instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of CP_2 in a good approximation. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory

qualia and of sensory receptor. Therefore the core of this argument deserves to be represented also here although it has been discussed in [K80].

4.6.1   Cell Membrane As Almost Vacuum Extremal

Although the fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this kind of system.

(a) Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [I43] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.

(b) TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense "square root" of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields. This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about.07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

(a) The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general visiona about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.

(b) There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish [L3], [L3] and the vision has been that it is sensible to speak about two basic configurations.

     i. Almost vacuum extremals (homologically trivial geodesic sphere).

     ii. Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

(c) To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.

    i. The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.

    ii. Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.

    iii. It might not be without importance that for any partonic 2-surface induced electro-weak gauge fields have always U(1) holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.

(d) The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.

(e) From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field [L3] , [L3]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \qquad (4.6.1)$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

(f) The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order $10^7\hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implys $\hbar \sim 10^{13}\hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a larger neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its sourse- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na$^+$ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

Could nuclei and neutrinos couple to light variants of weak gauge fields in the critical phase?

One of the hard-to-kill ideas of quantum TGD inspired model of quantum biology is that neutrinos might have something do with hearing and cognition. This proposal looks however unrealistic in the recent vision. I would be more than happy to get rid of bio-neutrinos but the following intriguing finding does not allow me to have this luxury.

(a) Assume that the endogenous magnetic field $B_{end} = .2$ Gauss is associated with a nearly vacuum extremal and therefore accompanied by $B_Z = 2B_{end}/p$. Assume for definiteness $m_\nu = .3$ eV and $p = sin^2(\theta_W) = .23$. The neutrino cyclotron frequency is given by the following expression

$$ f_\nu = \frac{m_e}{m_\nu} \frac{1}{2sin^2(\theta_W)} f_e \ . $$

From $f_e \simeq .57\times$ MHz and $p = sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7 \times 10^{-2}$ eV, which is roughly one third to the Josephson frequency of electron assignable to cell membrane. Could Josephson frequency of cell membrane excite neutrino cyclotron transitions?

(b) The model for photoreceptors to be discussed below forces to conlude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduces the peak energies of photoreceptors as Josephson frequencies of basic biological ions. This would predict $E_\nu = .41$ eV, which is rather near to the metabolic energy quantum. The non-relativistic formula however fails in this case and one must use the relativistic formula giving

$$ E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \ eV $$

giving the metabolic energy quantum. Does this mean that Z^0 cyclotron frequency for neutrino is related to the transfer of metabolic energy using Z^0 MEs in the phase near vacuum extremals.

(c) Josephson frequency is proportional to $1/\hbar$, whereas neutrino cyclotron frequency does not depend on $\hbar$ at non-relativistic energies. For larger values of $\hbar$ the neutrino becomes relativistic so that the mass in the formula for cyclotron frequency must be replaced with energy. This gives

$$ E = \sqrt{n}r^{1/2}\sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2} \times .48 \ eV \ , \ \ r = \sqrt{\hbar/\hbar_0} \ . $$

Here n refers to the cyclotron harmonic.

These observations raise the question whether the three frequencies with maximum response assignable to the three different types of receptors of visible light in retina could correspond to the three cyclotron frequencies assignable to the three neutrinos with different mass scales? The first objection is that the dependence on mass disappears completely at the relativistic limit. The second objection is that the required value value of Planck constant is rather small and far from being enough to have electroweak boson Compton length of order cell size. One can of course ask whether the electroweak gauge bosons are actually massless inside almost vacuum extremals. If fermions -including neutrino- receive their masses from p-adic thermodynamics then massless electroweak gauge bosons would be consistent with massive fermions. Vacuum extremals are indeed analogous to the unstable extrema of Higgs potential at which the Higgs vacuum expecation vanishes so that this interpretation might make sense.

Ionic Josephson frequencies defined by the resting potential for nearly vacuum extremals

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective resting potential containing also the Z^0 contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [**?**] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large $\hbar$.

 (a) One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.

 (b) For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+, Na_+, and Cl_- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neuron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines an action potential lasting a time of order .1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [J3]. These time scales might relate to the time scales of CDs associated with quarks and electron.

 (c) The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vector coupling is following

$$(\frac{Z - N}{4} - pZ)Z^0 + q_{em}\gamma = Q_{eff}\gamma ,$$
$$Q_{eff} = -\frac{Z - N}{2p} + 2Z + q_{em} . \quad (4.6.2)$$

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{++} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 12.3** below gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range. This is basically due to the large value of weak isospin for nuclei.

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{++}	1.68	2.52	2.94

Table 4.1: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40$ mV corresponds to the resting potential for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

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4.6.2   Are Photoreceptors Nearly Vacuum Extremals?

In Hodgkin-Huxley model ionic currents are Ohmian currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that the dominating parts of the ionic currents are oscillatory Josephson currents so that no metabolic energy would be needed to take care that density gradients for ions are preserved. Also in this case both nearly vacuum extremals and extremals with nearly vanishing Z^0 field can be considered. Since sensory receptors must be highly critical the natural question is whether they could correspond to nearly vacuum extremals. The quantitative success of the following model for photoreceptors supports this idea.

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wave length range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [J10, **?**]. The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes $dI/d\lambda + 2I/\lambda = 0$, which means a shift to a larger value of λ, which is largest for smallest λ. Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From **Table 12.3** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

(a) Na^+ and Ca^{++} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [**?**] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also K^+ current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.

(b) One ends up with the model in the following manner. For Ca^{++} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the **Table 4.2**.

(a) The resting potential for photoreceptors is $V = -40$ mV [**?**]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyper-polarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.

(b) For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{++} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

(c) For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+, Ca^{++}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{++} Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of $\hbar$ the frequency scales is that of EEG).

(d) In a very bright illumination the hyper-polarization is $V = -65$ mV [**?**], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{++}. This would suggests that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.

The model reproduces basic facts about vision assuming that one accepts the small value of Weinberg angle, which is indeed a natural assumption since vacuum extremals are analogous to the unstable extrema of Higgs potential and should correspond to small Weinberg angle. It deserves to be noticed that neutrino Josephson energy is 2 eV for $V = -50$ mV, which correspond to color red. 2 eV energy defines an important metabolic quantum.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions.

(a) The maximum value of the action potential is $+40$ mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

(b) For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{++} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{++} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

(c) The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{++} Josephson frequency corresponds to 4 eV metabolic energy quantum as **Table 12.3** shows.

(d) For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.

(e) For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

Ion	Na^+	Cl^-	K^+	Ca^{++}
$E_J(.04 \ mV, p = .23)/eV$	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	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 4.2: Table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R, G, B, W refers to red, green, blue, white. The values of Weinberg angle parameter $p = sin^2(\theta_W)$ are assumed to be .23 and .0295. The latter value is forced by the fit of Josephson energies to the known peak energies if one allows that ions - rather than their Cooper pairs - are charge carriers.

(f) For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

To sum up, the basic criticism against the model is that the value of Weinberg angle must be by a factor of 1/10 smaller than the standard model value, and at this moment it is difficult to say anything about its value for nearly vacuum extremals.

A possible cure could be that the voltage is not same for different ions. This is possible since at microscopic level the Josephson junctions correspond to transmembrane proteins acting as channels and pumps. The membrane potential through receptor protein is different for color receptors. For this option one would have the correspondences
$Na^+ \leftrightarrow 2.19$ eV (R) and $eV = 86.8$ eV,
$Cl^- \leftrightarrow 2.32$ eV (G) and $eV = 65.8$ eV,
$K^+ \leftrightarrow 2.49$ eV (W) and $eV = 60.2$ eV,
$Ca^{++} \leftrightarrow 3.06$ eV (B) and $eV = 67.3$ meV.
For Na^+ the value of the membrane potential is suspiciously large.

It is interesting to look what happens when the model is generalized so that Josephson energy includes the difference of cyclotron energies at the two sides of the cell membrane and Weinberg angle has its standard model value.

(a) Consider first *near to vacuum extremals*. In the formula for cyclotron frequencies in the effective magnetic field the factor Z/A in the formula of is replaced with

$$\frac{\frac{N-Z}{2p} + 2Z + q_{em}}{A} \quad ,$$

which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic Z^0 fields. Cyclotron frequency would be almost particle independent so that cyclotron

contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

The weak independence of the cyclotron frequency on particle properties does not conform with the idea that EEG bands correspond to bosonic ions or Cooper pairs of fermionic ions.

(b) For *far from vacuum extremals* the proportionality of cyclotron energy to h_{eff} and B_{end} allows easy reproduction the energies for which photon absorption is maximal if one allows the cyclotron energies to differ at the two sides of the membrane for sensory receptors.

A remark about decade later: The model just discussed neglects the fact that superconductivity requires that Cooper pairs of fermionic ions are present unless one assumes that the nuclei are bosonic counterparts of fermionic nuclei with same chemical properties - TGD inspired nuclear physics indeed predicts this kind of exotic nuclei [L4]. 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. These energies could correspond to peak energies for visible photons. The assumption of ionic Cooper pairs is rather attractive since it would allow to avoid two questionable assumptions.

For electron the Josephson energy would be scaled by a factor $-1 + 1/2p$ to $E_J = 1.0859 \times eV_{rest}$ for $p = .2397$. For neutrino the energy would be given by $E_J = -0.0859 \times V_{rest}$: for $p = 1/4$ it would vanish by the vanishing of vectorial part of Z^0 charge. For proton the energy would be $E_J = (3 - 1/2p)V_{rest} = .914 \times V_{rest}$ and for neutron $E_J = V_{rest}/2p = 2.086 \times V_{rest}$.

4.6.3 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" [D66] and "Making Fuel from Water" [D64]. The articles summarize an experimental discovery which could be called Pollack-Zheng effect [D75, D68]. 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.

(a) TGD predicts a hierarchy of metabolic energy quanta [K10, K48]. 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 $E(k, n) = (1 - 2 ⁻ⁿ)E(k)$ 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.

(b) Second idea relies on the hierarchy of Planck constants.

   i. 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.

ii. 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 [I19] : 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 [D66].

Exclusion zones

The article summarizes the sequence of events initiated by the discovery of Gerald Pollack and his student Jian-ming Zheng [D75, D68]. 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.

(a) 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 [D68]. 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.

(b) 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 [K5].

(c) 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.

(d) 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.

(a) 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.

(b) 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.

    i. 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 $k = 141$.

    ii. 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.

(c) 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.

(d) The mechanism of EZ formation is still unknown. But the two wavelengths that expand the EZ most effectively may offer some hint. The UV wavelength 270 nm is close to the 250 nm ($\simeq 5$ eV) required to ionize water under standard state conditions and taking into account the hydration of the resulting ions. The 3 100 nm peak, on the other hand is close to the OH stretch of the ring hexamer identified as the most abundant species in infrared predissociation spectroscopy of large water clusters, and also in neon matrices by infrared spectroscopy. These results suggest that photoexcitation of ring hexamers and photoionisation followed by ejection of protons play synergistic roles in the assembly of the EZ phase. Pollack and colleagues believe that the infrared radiation, though normally insufficient to break OH bonds, can nevertheless work via resonance induced dissociation of large hydrogen-bonded networks.

Comment: Ring hexamers bring in mind the crucial role of aromatic cycles in TGD inspired model of DNA as topological quantum computer which leads also to a model of ADP$\leftrightarrow$ ATP transition involving reconnection of magnetic flux tubes and having also information theoretic interpretation as a change of the topology of the braid structure defining topological quantum computer program [K2]. 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.

(a) 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.

(b) 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 [K2]. 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.

(c) 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 [K17]. Cell membrane acts as a Josephson junction in TGD based model of cell membrane, nerve pulse, and EEG.

4.7 Pollack's Findings About Fourth Phase Of Water And The Model Of Cell

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water. In this article this notion is discussed in TGD framework. The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it.

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

One can find a biographical sketch [I6] (`http://tinyurl.com/ycqtuchp`) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk.

4.7.1 Pollack's Findings

I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [L14].

(a) In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is $H_{1.5}O$. The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [H5, H1].

(b) The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance,

the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.

(c) The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by $H_{1.5}O$.

(d) In the splitting of water producing Brown's gas [H5, H1] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

4.7.2   Dark Nuclei And Pollack's Findings

While listening the lecture of Pollack I realized that a model for dark water in term of dark proton sequences is enough to explain the properties of the exotic water according to experiments done in the laboratory of Pollack. There is no need to assume sequences of half-dark water molecules containing one dark proton each.

Model for the formation of exclusion zones

The data about formation of exclusion zones allows to construct a more detailed model for what might happen in the formation of exclusion zones.

(a) The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King's lectures charge separation is poorly understood.

(b) An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of CP_2.

(c) This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the $H1.5O$ blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K42, L4].

(d) The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the dark proton sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation

corresponds to multiplies of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [**?**].

The phase transition generating dark magnetic flux tubes containing dark proton sequences would be the fundamental step transforming inanimate matter to living matter and the fundamental purpose of metabolism would be to make this possible.

Minimal metabolic energy consumption and the value of membrane potential

This picture raises a question relating to the possible problems with physiological temperature.

(a) The Josephson radiation generated by cell membrane has photon energies coming as multiples of ZeV, where V is membrane potential about .06 V and $Z = 2$ is the charge of electron Cooper pair. This gives $E = .12$ eV.

(b) There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function $x^3/(e^x - 1)$, $x = E/T$ given by $e^{-x} + x/3 - 1 = 0$. The maximum is given approximately by $x = 3$ and thus $E_{max} \simeq 3T$ (in units $c = 1, k_B = 1$). At physiological temperature $T = 310$ K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at $E \simeq 5T$ corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.

(c) One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

   "Electric expansion" of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H5, H1].

   ii. Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with f degrees of freedom for particle ($f = 3$ if there are no other than translational degrees of freedom) is $(T/T_0) = (V/V_0)^{-\gamma}$, $\gamma = (f + 2)/f$. This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.

   iii. The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

4.7.3   Fourth Phase Of Water And Pre-Biotic Life In TGD Universe

Metabolism and fourth phase of water

If the fourth phase of water defines pre-biotic life form then the phase transition generating fourth phase of water and its reversal are expected to be fundamental elements of the ordinary metabolism, which would have developed from the pre-biotic metabolism. The following arguments conforms with this expectation.

(a) Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (`http://tinyurl.com/y8ubjgnc`), which forms the basic element of both photosynthesis (`http://tinyurl.com/yauwzkho`) and cellular respiration `http://tinyurl.com/ybeefxmb`, involves electron transport chain (`http://tinyurl.com/yat3m4vk`) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.

(b) When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (`http://tinyurl.com/yd5ndcyk`) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.

(c) ATP is generated also in glycolysis (`http://tinyurl.com/ybzgdgve`), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (`http://tinyurl.com/y8v7aq9s`)).

(d) Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (`http://tinyurl.com/ybzgdgve`) the net reaction $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l) + heat$ takes place. The Gibbs free energy change is $\Delta G = -2880$ kJ per mole of $C_6H_{12}O_6$ and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce $N = 38$ ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From $Joule = 6.84 \times 10^{18}$ eV and $mol = 6.02 \times 10^{23}$ and for $N = 38$ one would obtain the energy yield .86 eV per single ATP. The nominal value that I have used .5 eV. This is roughly 5 to 8 times higher than $E = ZeV, Z = 2$, which varies in the range .1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

In the thermodynamical approach to metabolism the additional contribution would be due to the difference of the chemical potential μ for cell exterior and interior, which is added to the membrane potential as effective potential energy. The discrepancy is however rather large and this forces the question the feasibility of the model. This forces to reconsider the model of osmosis in the light of Pollack's findings.

Pollack's findings in relation to osmosis and model for cell membrane and EEG

Osmosis (`http://tinyurl.com/yc5dbtzv`) has remained to me poorly understood phenomenon. Osmosis means that solvent molecules move through a semipermeable membrane to another side of the membrane if the concentration of solute is higher at that side. Solute can be water or more general liquid, supercritical liquid, and even gas.

Osmosis is not diffusion: it can occur also towards a higher concentration of water. Water molecules are not attracted by solute molecules. A force is required and the Wikipedia

explanation is that solute molecules approaching pores from outside experience repulsion and gain momentum which is transferred to the water molecules.

The findings of Pollack inspire the question whether the formation of exclusion zone could relate to osmosis and be understood in terms of the fourth phase of water using genuine quantal description.

In the thermodynamical model for ionic concentrations one adds to the membrane resting potential a contribution from the difference of chemical potentials μ_i at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

(a) Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.

(b) The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of h_{eff} could in principle be different. The earlier modelling attempts suggest that $h_{eff}/h = n = 2^k A$, where A is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

The phase transitions changing the value of h_{eff} could induce ionic flows through cell membrane, say that occurring during nerve pulse since the energy difference defining the ratio of square roots of Boltzmann weights at the two sides of the membrane would change. Also the change of the local value of the magnetic field could do the same.

Consider first the simplest model taking into account only membrane potential.

(a) The simplest model for Josephson junction defined by the transmembrane protein is as a two state system (Ψ_1, Ψ_2) obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 \ \ ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_2 \ \ .$$

One can use the decomposition $\Psi_i = R_i exp(i\Phi(t))$ to express the equations in a more concrete form. The basic condition is that the total probability defined as sum of moduli squared equals to one: $R_1^2 + R_2^2 = 1$. This is guaranteed if the hermiticity condition $k_1/\hbar_1 = \overline{k_2}\hbar_2$ holds true. Equations reduce to those for an ordinary Josephson junction except that the frequency for the oscillating Josephson current is scaled down by $1/h_{eff}$.

(b) One can solve for R_2 assuming $\Phi_1 = eVt/\hbar_{eff}$. This gives

$$R_2(t) = sin(\Phi_0) + \frac{k_1}{\hbar_1}sin(\frac{eVt}{\hbar_1}) \ \ .$$

R_2 oscillates around $sin(\Phi_0)$ and the concentration difference is coded by $\Phi0$ taking the role of chemical potential as a phenomenological parameter.

(c) The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = sin(\phi_0) = exp(\frac{ZeV(t)}{2T}) \quad .$$

Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential: $ZeV \rightarrow ZeV + \mu_I$. This would however require a concrete physical interpretation.

(a) The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy $E_c = \hbar_{eff}ZeB_{end}/m$ of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to h_{eff} and can be rather large as assumed in the model for the effects of ELF em fields on brain.

(b) This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on h_{eff} and B_{end}. The scales of ionic chemical potential and ion concentrations would also depend on value of h_{eff}.

(c) The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

The earlier proposal [K39] was that cell membrane can be in near vacuum extremal configuration in which classical Z^0 field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weingerg angle. Second problem is that for proton the Z^0 contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

(d) The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency f_J is at resonance identical with the cyclotron frequency $f_c(MB)$ at particular part of the flux tube of the magnetic body: $(f_c(MB) = f_J$. $f_c(MB)$ corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing $h_{eff} = n \times h$ to h.

In the modified model the sum $f_c + f_{J,n}$ ($f_{J,n} = E_J/n \times h$) of h_{eff}-independent cyclotron frequency and Josephson frequency proportional to $1/h_{eff}$ equals to cyclotron frequency $f_c(MB)$ at "personal" magnetic body varying slowly along the flux tube: $f_c + f_{J,n} = f_c(MB)$. If also the variation of f_J assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} \quad .$$

If dark photons correspond to biophotons the energy is of cyclotron photon is in visible and UV range one has $nf_c = E_{bio}$ and

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} \quad .$$

> The prediction is scale invariant and same for all ions and also electron unless E_{bio} depends on ion. For $eV = .05$ eV, $Z = 1$, and $E_{bio} = 2$ eV ($f \simeq 5 \times 10^{14}$ Hz) one has $\Delta f/f \sim .1$ giving 10 per cent width for EEG bands assumed in the simpler model.

If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of h_{eff} so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing h_{eff} and B_{end} by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibriumion distributions, generation of nerve pulse, and basic metabolic processes leading to the generation of ATP.

One can also model sensory receptors and try to understand the maximal sensitivity of color receptors to specific wavelengths in this framework. The new degrees of freedom make this task easy if one is only interested in reproducing these frequencies. More difficult challenge is to understand the color receptors from the first principles. It is also possible to combine the new view with the assumption that sensory receptor cells are near to vacuum extremals. This would add a cyclotron contribution to the generalized Josephson frequency depending only weakly on particle and being non-vanishing also for em neutral particles.

Why would charge separation generate large h_{eff}?

The basic question is whether and how the separation of electron and proton charges generates large h_{eff}? A possible mechanism emerged from a model [K98] explaining anomalously large gravimagnetic effect claimed by Tajmar *et al* [E7, E9] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order 10^{-4} and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional h_{eff}^2 in TGD and if one uses h_{gr} for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

(a) By Equivalence Principle h_{gr} has the general form $h_{gr} = GMm/v_0$, where M and m are the interacting masses and v_0 is a parameter with dimensions of velocity. For 4 inner planets one has $v_0/c \simeq 2^{-11}$.

(b) The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.

(c) Since the natural expansion parameter of perturbative expansion is the $g^2/4\pi\hbar$, one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

h_{em} might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

(a) EZ carries very large negative charge with positive charge outside the exclusion zone.

(b) TGD interpretation is in terms of $H_{1.5}O$ phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of h_{eff}. The proposal is that primitive life form is in question.

(c) The pair formed by EZ and its complement could have large value of $h_{eff} = h_{em} = Z^2 e^2 / v_0$.

(d) The velocity parameter v_0 should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and v_0 is the rotation velocity at the surface of Earth. The prediction for h_{eff} would be of order $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$.

(e) Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large h_{em} or h_{gr} could be formed.

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

(a) I have speculated earlier [K49] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity v_0 of the shaft appears in the formula for h_{em}. Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge Z associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving $h_{em} = 2e \times Z/v_0$.

(b) The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for h_{em} could be same as for h_{gr} associated with Earth-particle system.

$h_{eff}(ATP synthase) = h_{gr}(2e, Earth)$ would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K78].

Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

(a) The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.

(b) There is very interesting article (see `http://tinyurl.com/ycdhd4fd`) [**?**]eporting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.

(c) In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K42, L4] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

4.7.4   Could Pollack effect make cell membrane a self-loading battery?

The so called Clarendon dry pile is 175 years old battery still working. The current is very weak (nano Ampere) but the working of the battery is claimed to be not well-understood. The TGD inspired model for cold fusion leads to the proposal that Pollack effect is part of electrolysis. This inspires the idea that Pollack effect and possibly also the associated cold fusion could make Clarendon dry pile a self-loading battery. Cell membrane can be regarded as the analog of self-loading battery, and in TGD framework also as a generalised Josephson junction. Hence one can ask whether also cell membrane could be seen as a self-loading battery utilizing Pollack's mechanism. This would also allow to understand why hyperpolarization stabilizes the membrane potential and why depolarization generates nerve pulse.

Clarendon pile: 175 years old battery still working

Elemer Rosinger had a Facebook link to an article telling about Clarendon dry pile, a very long-lived battery providing energy for an electric clock (see `http://tinyurl.com/zeut69y`, `http://tinyurl.com/jhrww2a`, and `http://tinyurl.com/gvbrhra`). This clock known also as Oxford bell has been ringing for 175 years now and the article suggests that the longevity of the battery is not really understood. The bell is not actually ringing so loud that human ear could hear it but one can see the motion of the small metal sphere between the oppositely charged electrodes of the battery in the video.

The function principle of the clock is simple. The gravitational field of earth is also present. When the sphere touches the negative electrode, it receives a bunch of electrons and gives the bunch away as it touches positive electrode so that a current consisting of these bunches is running between electrons. The average current during the oscillation period of 2 seconds is nanoampere so that nanocoulomb of charge is transferred during each period (Coulomb corresponds to a 6.242×10^{18} elementary charges (electrons)).

The dry pile was discovered by priest and physicist Giuseppe Zamboni at 1812 (see `http://tinyurl.com/jkvtj6f`). The pile consists of 2,000 pairs of pairs of discs of tin foil glued to paper impregnated with Zinc sulphate and coated on the other side with manganese dioxide: 2,000 thin batteries in series. The operation of battery gradually leads to the oxidation of Zinc and the loss of magnase dioxide but the process takes place very slowly. One might actually wonder whether it takes place too slowly so that some other source of energy than the electrostatic energy of the battery would be keep the clock running. Karpen pile is analogous battery discover by Vasily Karpen (see `http://tinyurl.com/jpzcs32`). It has now worked for 50 years.

Cold fusion is associated with electrolysis. Could the functioning of this mystery clock involve cold fusion taken seriously even by American Physical Society thanks to the work of the group of prof. Holmlid. Electrolytes have of course been "understood" for aeons. Ionization leads to charge separation and current flows in the resulting voltage. With a feeling of deep shame I must confess that I cannot understand how the ionization is possible in standard physics. This of course might be just my immense stupidity - every second year physics student would immediately tell that this is "trivial" - so trivial that he would not even bother to explain why. The electric field between the electrodes is immensely weak in the scale of molecules. How can it induce the ionisation? Could ordinary electrolytes involve new physics involving cold fusion liberating energy? These are the questions which pop up in my stupid mind. Stubborn as I am in my delusions, I have proposed what this new physics might be with inspiration coming from strange experimental findings of Gerald Pollack, cold fusion, and my own view about dark matter has phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant. Continuing with my weird delusions I dare ask: Could cold fusion provide the energy for the "miracle" battery?

What batteries are?

To understand what might be involved one must first learn some basic concepts. I am trying to do the same.

(a) Battery (see `http://tinyurl.com/8xqsnab`) consistes of two distinct electrochemical cells (see `http://tinyurl.com/jq8ljmo`). Cell consists of electrode and electrolyte. The electrodes are called anode and catode. By definition electron current along external wire flows to catode and leaves anode.

(b) There are also ionic currents flowing inside the battery. In absence of the ionic currents the electrodes of the battery lose their charge. In the loading the electrodes get their charges. In the ideal situation the ionic current is same as electron current and the battery does not lose its charging. Chemical reactions are however taking place near and at the electrodes and in their reversals take place during charging. Chemical changes are not completely reversible so that the lifetime of the battery is finite.

The ionic current can be rather complex: the carriers of the positive charge from anode can even change during the charge transfer: what matters that negative charge from catode is transferred to anode in some manner and this charge logistics can involve several steps. Near the catode the currents of positive ions (cations) and electrons from the anode combine to form neutral molecules. The negative current carriers from catode to the anode are called anions.

(c) The charge of the clectrochemical cell is in the electrolyte near the surface of the electrode rather than inside it as one might first think and the chemical processes involve neutralization of ion and the transfer of neutral outcome to or from the electrode.

(d) Catode - or better, the electrochemical cell containing the catode - can have both signs of charge. For positive charge one has a battery liberating energy as the electron current connecting the negative and positive poles goes through the load, such as LED. For negative charge current flows only if there is external energy feed: this is loading of the battery. External voltage source and thus energy is needed to drive the negative charges and positive charges to the electrodes. The chemical reactions involved can be rather complex and proceed in reverse direction during the loading process. Travel phone battery is a familiar example.

During charging the roles of the anode and catode are changed: understanding this helps considerably.

Could dark cold fusion make possible self-loading batteries?

Could cold fusion help to understand why the Clarendon dry pile is so long lived?

(a) The battery is series of very many simpler batteries. The mechanism should reduce to the level of single building brick. This is assumed in the following.

(b) The charge of the battery tends to be reduced unless the ionic and electronic currents are identical. Also chemical changes occur. The mechanism involved should oppose the reduction of the charging by creating positive charge to the catode and negative charge to the anode or induce additional voltage between the electrodes of the battery inducing its loading. The energy feed involved might also change the direction of the basic chemical reactions as in the ordinary loading by raising the temperature at catode or anode.

(c) Could be formation of Pollack's exclusion zones (EZs) in the elecrolytic cell containing the anode help to achieve this? EZs carry a high electronic charge. According to TGD based model protons are transformed to dark protons at magnetic flux tubes. If the positive dark charge at the flux tubes is transferred to the electrolytic cell containing catode and transformed to ordinary charge, it would increase the positive charge of the catode. The effect would be analogous to the loading of battery. The energy liberated in the process would compensate for the loss of charge energy due to electronic and ionic currents.

(d) In the ordinary loading of the battery the voltage between batteries induces the reversal of the chemical processes occurring in the battery. This is due to the external energy feed. Could the energy feed from dark cold fusion induce similar effects now? For instance, could the energy liberated at the catode as positively charged dark nuclei transform to ordinary ones raise the temperature and in this manner feed the energy needed to change the direction of the chemical reactions.

Cell membrane as self-loading battery and how nerve pulse is generated?

This model might have an interesting application to the physics of cell membrane.

(a) Cell membrane consisting of two lipid layers defines the analog of a battery. Cell interior plus inner lipid layer (anode) and cell exterior plus outer lipid layer (catode) are analogs of electrolyte cells.

What has been troubling me for two decades is how this battery manages to load itself. Metabolic energy is certainly needed and ADP-ATP mechanism is essential element. I do not however understand how the membrane manages to keep its voltage.

Second mystery is why it is hyperpolarization rather than polarization, which tends to stabilize the membrane potential in the sense that the probability for the spontaneous generation of nerve pulse is reduced. Neither do I understand why depolarization (reduction of the membrane voltage) leads to a generation of nerve pulse involving rapid change of the sign of the membrane voltage and the flow of various ionic currents between the interior and exterior of the cell.

(b) In the TGD inspired model for nerve pulse cell interior and cell exterior or at least their regions near to lipid layers are regarded as super-conductors forming a generalized Josephson junction. For the ordinary Josephson junction the Coulombic energy due to the membrane voltage defines Josephson energy. Now Josephson energy is replaced by the ordinary Josephson energy plus the difference of cyclotron energies of the ion at the two sides of the membrane. Also ordinary Josephson radiation can be generated. The Josephson currents are assumed to run along magnetic flux tubes connecting cell interior and exterior. This assumption receives support from the strange finding that the small quantal currents associated with the membrane remain essentially the same when the membrane is replaced with polymer membrane.

(c) The model for Clarendon dry pile suggests an explanation for the self-loading ability. The electrolytic cell containing the anode corresponds to the negatively charged cell interior, where Pollack's EZs would be generated spontaneously and the feed of protonic charge to the outside of the membrane would be along flux tubes as dark protons to minimize dissipation. Also ions would flow along them. The dark protons driven to the outside of the membrane transform to ordinary ones or remain dark and flow spontaneously back and provide the energy needed to add phosphate to ADP to get ATP.

(d) The system could be quantum critical in the sense that a small reduction of the membrane potential induces nerve pulse. Why the ability to generate Pollack's EZs in the interior would be lost for a few milliseconds during nerve pulse? The hint comes from the fact that Pollack's EZs can be generated by feeding infrared radiation to a water bounded by gel. Also the ordinary Josephson radiation generated by cell membrane Josephson junction has energy in infrared range!

Could the ordinary Josephson radiation generate EZs by inducing the ionization of almost ionized hydrogen bonded pairs of water molecules. The hydrogen bonded pairs must be very near to the ionization energy so that ordinary Josephson energy of about .06 eV assignable to the membrane voltage is enough to induce the ionization followed by the formation of $H_{3/2}O$. The resulting EZ would consist of layers with the effective stoichiometry $H_{3/2}O$.

As the membrane voltage is reduced, Josephson energy would not be anymore enough to induce the ionization of hydrogen bonded pair of water molecules, EZs are not generated,

and the battery voltage is rapidly reduced: nerve pulse is created. In the case of hyperpolarization the energy excees the energy needed for ionization and the situation becomes more stable.

(e) This model could also allow to understand the effect of anesthetes [K76] [L26]. Anesthetes could basically induce hyperpolarization so that Josephson photons would continually generate Pollack's EZ:s and creating of dark particles at the magnetic flux tubes. This need not mean that consciousness is lost at the cell level. Only sensory and motor actions are prevented because nerve pulses are not possible. This prevents formation of sensory and motor mental images at our level of hierarchy.

Meyer-Overton correlation states that the effectiveness of the anesthete correlates with its solubility to the lipid membrane. This is the case if the presence of anesthete in the membrane induces hyperpolarization so that the energies of the photons of Josephson radiation would be higher than needed for the generation of EZs accompanied by magnetic flux tubes along which ionic Josephson currents would flow between cell interior and exterior. For these quantal currents evidence exists [K80]. In the case of battery these dark ions would flow from the cell containing anode to that containing catode. For depolarization the energy of Josephson photons would be too low to allow the kicking off protons from hydrogen bonded pairs of water molecules so that EZs would not be created and self-loading would stop and nerve pulse would be generated.

4.8 Implications Of Strong Gravimagnetism For TGD Inspired Quantum Biology

Physicists M. Tajmar and C. J. Matos and their collaborators working in ESA (European Satellite Agency) have made an amazing claim of having detected strong gravimagnetism with gravimagnetic field having a magnitude which is about 20 orders of magnitude higher than predicted by General Relativity [E7]. If the findings are replicable they mean a revolution in the science of gravity and, as one might hope, force a long-waited serious reconsideration of the basic assumptions of the dominating super-string approach.

Tajmar *et al* have proposed [E9] the gravimagnetic effect as an explanation of an anomaly related to the superconductors. The measured value of the mass of the Cooper pair is slightly larger than the sum of masses whereas theory predicts that it should be smaller. The explanation would be that actual London field is larger than it should be because of gravimagnetic contribution to quantization rule used to deduce the value of London field.

TGD explanation of the discrepancy accepting the theory of Tajmar *et al* comes from the proposal inspired by Nottale's observations [E3] suggesting that Bohr's rules apply in planetary system with Planck constant replaced by $\hbar_{gr} = GMm/v_0$. Here M and m are the masses of Sun and planet. $v_0/c \simeq 2^{-11}$ holds true for the 4 inner planets Mercury, Venus, Earth, Mars and $v_0 \to v_0/5$ and principal quantum number $n_P \geq 2$ for the outer planets. Mars could be also though of as having $v_0/5$ and $n_P = 1$. The rotation velocities of the planets are related to v_0 by Bohr rules. h_{gr} clearly characterizes the pair Sun-planet rather than being fundamental constant whereas the gravitational Compton length GM/v_0 depends on M only. In the TGD framework one assigns gravitational Planck constant to the flux tube connecting the masses and along which the gravitational massless extremals mediating the gravitational interaction are mediated. By Equivalence Principle it is possible to apply the hypothesis only in elementary particle length scales (this does not exclude its application in longer scales) and in these scales $h_{eff} = h_{gr}$ makes sense.

Gravimagnetic London field is proportional to the square of Planck constant and the obvious guess is that the replacement h with h_{gr} could explain the enormous discrepancy with GRT if gravimagnetism is in question. This predicts correctly the magnitude of the effect and one also ends up with the identification of the $h_{gr} = h_{eff}$ in elementary particle scales.

Also a vision about the fundamental role of quantum gravitation in living matter emerges. The earlier hypothesis that dark EEG photons decay to biophotons with energies in visible

and ultraviolet range [K22, K12] receives strong quantitative support. This leads also to a simple model for how magnetic bodies control molecular transitions via dark cyclotron radiation with varying frequencies vary but universal energy spectrum since for a given magnetic field all charged particles gives rise to biophotons with same energy. The values of h_{gr}/m and endogenous magnetic field $B_{end} \simeq .2$ Gauss are such that the spectrum of biophotons is in the range of molecular binding energies. This vision would conform with Penrose intuitions about the fundamental role of gravitation in quantum biology.

4.8.1 The Theory fof Tajmar *et al* for fhe Anomaly ff Cooper Pairs Mass

The starting point of the theory of Tajmar and Matos [E9] is the so called London magnetic moment generated in rotating charged super-conductors adding a constant contribution to the exponentially damped Meissner contribution to the magnetic field. This contribution can be understood as being due to the massivation of photons in super-conductors. The modified Maxwell equations are obtained by just adding scalar potential mass term to Gauss law and vector potential mass term to the equation related the curl of the magnetic field to the em current.

The expression for the London magnetic field is given by

$$B = 2\omega_R n_s \times \lambda_\gamma^2 \ , \tag{4.8.1}$$

where ω_R is the angular velocity of superconductor, n_s is charge density of super-conducting particles and $\lambda_\gamma = \hbar/m_\gamma$ is the wave length of a massive photon at rest. In the case of ordinary superconductor one has $\lambda_\gamma = \sqrt{m^*/q^* n_s}$, where $m^* \simeq 2m_e$ and $q^* = -2e$ are the mass and charge of Cooper pair. Hence one has

$$B = -2\frac{m^*}{2e}\omega_R \ . \tag{4.8.2}$$

Magnetic field extends also outside the super-conductor and by measuring it with a sufficient accuracy outside the super-conductor one can determine the value of the electron mass. Instead of the theoretical value $m^*/2m_e = .999992$ which is smaller than one due to the binding energy of the Cooper pair the value $m^*/2m_e = 1.000084$ was found by Tate [E8]. This inspired the theoretical work generalizing the notion of London field to gravimagnetism and the attempt to explain the anomaly in terms of the effects caused by the gravimagnetic field.

Note that in the case of ordinary matter the equations would lead to an inconsistency at the limit $m_\gamma = 0$ since the value of London magnetic field would become infinite. The resolution of the problem proposed in [E9] is based on the replacement of rotation frequency ω with electron's spin precession frequency $\omega_L = -eB/2m$ so that the consistency equation becomes $B = -B = 0$ for a unique choice $1/\lambda_\gamma^2 = -\frac{q}{m}n$. One could also consider the replacement of ω with electron's cyclotron frequency $\omega_c = 2\omega_L$. To my opinion there is no need to assume that the modified Maxwell's equations hold true in the case of ordinary matter.

Gravimagnetic field

The perturbative approach to the Einstein equations leads to equations, which are essentially identical with Maxwell's equations. The g_{tt} component of the metric plays the role of scalar potential and the components g_{ti} define gravitational vector potential. Also the generalization to the super-conducting situation in which graviphotons develop a mass is straightforward. Just add the scalar potential mass term to the counterpart of Gauss law and vector potential

mass term to the equation relating the curl of the gravimagnetic field to the gravitational mass current.

In the case of a rotating superconductor London magnetic field is replaced with its gravimagnetic counterpart

$$B_{gr} \quad = \quad -2\omega_R \rho_m \lambda_{gr}^2 \quad . \tag{4.8.3}$$

Obviously this formula would give rise to huge gravimagnetic fields in ordinary matter approaching infinite values at the limit of vanishing gravitational mass. Needless to say, these kind of fields have not been observed.

Equivalence Principle however suggests that the gravimagnetic field must be assigned with the rotating coordinate frame of the super-conductor. Equivalence principle would state that seing the things in a rotating reference frame is equivalent of being in a gravimagnetic field $B_{gr} = -2\omega_R$ in the rest frame. This fixes the graviphoton mass to

$$\frac{1}{\lambda_{gr}^2} \quad = \quad (\frac{m_{gr}}{\hbar})^2 = G\rho_m \quad . \tag{4.8.4}$$

For a typical condensed matter density parameterized as $\rho_m = Nm_p/a^3$, $a = 10^{-10}$ m this gives the order of magnitude estimate $m_{gr} \sim N^{1/2} 10^{-21}/a$ so that graviton mass would be extremely small.

If this is all what is involved, gravimagnetic field should have no special effects. In [E9] it is however proposed that in superconductors a small breaking of Equivalence Principle occurs. The basic assumptions are following.

(a) Super-conducting phase and the entire system obey separately the gravitational analogs of Maxwell field equations.

(b) The ad hoc assumption is that for super-conducting phase the sign of the gravimagnetic field is opposite to that for the ordinary matter. If purely kinematic effect were in question so that graviphotons were pure gauge degrees of freedom, the value of m_{gr}^2 should should be proportional to ρ_m and $\rho_m - \rho_m^*$ respectively.

(c) Graviphoton mass is same for both ordinary and super-conducting matter and corresponds to the net density ρ_m of matter. This is essential for obtaining the breaking of Equivalence Principle.

With these assumptions the gravimagnetic field giving rise to acceleration field detected in the rest system would be given by

$$B_{gr}^* = \frac{\rho_m^*}{\rho} \times 2\omega \tag{4.8.5}$$

This is claimed to give rise to a genuine acceleration field

$$g^* \quad = \quad -\frac{\rho_m^*}{\rho}a \tag{4.8.6}$$

where a is the radial acceleration due to the rotational motion.

Explanation for the too high value of measured electron mass in terms of gravi-magnetic field

A possible explanation of the anomalous value of the measured electron mass [E8] is in terms of gravimagnetic field affecting the flux Bohr quantization condition for electrons by adding to the electromagnetic vector potential term $q^* A_{em}$ gravitational vector potential $m^* A_{gr}$. By requiring that the quantization condition

$$\oint (m^* v + q^* A_{em} + m^* A_{gr})dl \quad = \quad 0 \tag{4.8.7}$$

is satisfied for the superconducting ring, one obtains

$$B \quad = \quad -\frac{2m}{e}\omega - \frac{m}{e}B_{gr} \quad . \tag{4.8.8}$$

This means that the magnetic field is slightly stronger than predicted and it has been known that this is indeed the case experimentally.

The higher value of the magnetic field could explain the slightly too high value of electron mass as determined from the magnetic field. This gives

$$B_{gr} \quad = \quad \frac{\Delta m_e}{m_e} \times 2\omega = \frac{\Delta m_e}{m_e} \times em_e \times B \quad . \tag{4.8.9}$$

The measurement implies $\Delta m_e/m_e = 9.2 \times 10^{-5}$. The model discussed in [E9] predicts $\Delta m_e/m_e \sim \rho^*/\rho$. The prediction is about 23 times smaller than the experimental result.

4.8.2 Is The Large Gravimagnetic Field Possible In TGD Framework?

TGD allows top consider several alternative solutions for the claimed effect.

Many-sheeted space-time could be an essential part of the effect (if real!).

(a) In TGD framework both induced metric and various gauge fields are expressible in terms of CP_2 coordinates and their gradients. Hence the gravimagnetic field would be very probably accompanied by an ordinary magnetic field and could be even proportional to it.

(b) The ordinary London magnetic field could be accompanied by analogous magnetic field at different space-time sheet playing the same role as gravimagnetic field in the proposed model. Cooper pair would experience both fields by forming topological sum contacts to both space-time sheets carrying ordinary London magnetic field $B = m_e/e\omega_R$ and much smaller London magnetic field $\Delta B = \Delta m/e\omega_R$? There would be no need to introduce gravitation but one should explain why the value of the parameter $\epsilon = \Delta m_e/m_e$ is what it is.

(c) In many-sheeted space the gravimagnetic field and accompanying magnetic field would be associated with the flux tubes mediating gravitational interaction with dark matter fraction of Earth's mass. It would not be surprising if the size of the parameter ϵ might be determined by this fraction. Pioneer and Flyby effects [K93] allow to make a rough estimate for the size of this fraction and the outcome is about 2×10^{-4} which is not far from $\epsilon.9 \times 10^{-4}$.

An alternative explanation is that the experiments probe single space-time sheet and that also other Z^0 magnetic field contributes below weak scale which is scaled up for $h_{eff} = n \times h$ and can be macroscopic.

(a) TGD predicts the possibility of classical electro-weak fields at larger space-time sheets. If these couple to Cooper pairs generate exotic weak charge at super-conducting space-time sheets the Bohr quantization conditions modify the value of the magnetic field. Exotic weak charge would however mean also exotic electronic em charge so that this option is excluded. It would also require that the Z^0 charge of test bodies used to measure the acceleration field is proportional to their gravitational mass.

(b) According to the simplest recent view about Kähler-Dirac action [K119] the modes of Dirac operator are confined to 2-D string world sheets at which classical W boson fields vanish. This guarantees that em charge is well-defined for the modes. The stronger condition that also classical Z^0 field vanishes makes also sense and should hold at least in the length scales in which weak bosons do not appear. This guarantees the absence of axial couplings and parity breaking effects. In living matter parity breaking effects are large and one could consider the possibility that weak length scale is scaled up for $h_{eff} > h$ and that classical Z^0 fields are present below the weak scale.

(c) One cannot exclude the possibility that the classical weak fields vanish for entire space-time surface. In this case spinor modes can still be seen as continuous superpositions of 2-D ones. In principle one can consider also other options - such as vanishing of induced Kḧler form or classical em field besides that of W fields.

The conservative option is that classical weak fields vanish in the situation considered so that there is room for the strong gravimagnetic field. The following model starts from the model of Tajmar *et al* and generalizes it by replacing Planck constant with its gravitational counterpart.

Modification of the model of Tajmar *et al* by replacing h with h_{gr}

Gravimagnetic London field is proportional to the square of Planck constant and the obvious guess is that the replacement h with h_{gr} could explain the enormous discrepancy with GRT if gravimagnetism is in question. This predicts correctly the magnitude of the effect and one also ends up with the identification of the $h_{gr} = h_{eff}$ in elementary particle scales.

One can of course develop an objection against the gravimagnetic field proportional h_{eff}^2: also ordinary London magnetic field should be scaled in the same manner due to the proportionality to λ_γ^2. The resulting magnetic field would be enormous. One can however argue that the increase of Planck constant cannot affect the value of the ordinary London magnetic field. The scaling up of length scales by h_{eff} and flux conservation suggest that the value of B scales down like $1/h_{eff}^2$. This factor is compensated by the h_{eff}^2 factor in the expression of London magnetic field coming from the expression of magnetic penetration length in terms of mass of photon. One can of course ask why magnetic and gravimagnetic London field are different.

(a) The formula used by Tajmar *et al* [E9] for the gravimagnetic variant of London magnetic field is direct generalization for the London field for ordinary super-conductor. The gravimagnetic field is proportional to the product $B_g = \omega_R r^2$ of the rotation frequency ω_R of super-conductor and square of the ratio $r = (\lambda_g / \lambda_{g,T})$, where $\lambda_g = \hbar / m_g$ is graviton wave length and $\lambda_{g,T}$ is gravimagnetic penetration length obtained as generalization of the magnetic penetration length for super-conductors by replacing charge with mass. The latter is purely classical quantity whereas graviton wave length depends on Planck constant. Graviton mass can be argued to result in gravitational Meissner effect and can be estimated from the value of cosmological constant Λ being essentially its square root. The resulting value of B_g is too small by 28 orders of magnitude.

(b) Tajmar *et al* [E9] suggests that graviton mass is larger by a factor of order 10^{14} in conflict with the experimental upper bound of order 10^{55} kg for m_g. TGD proposal is that

it is Planck constant which should be replaced with effective Planck constant $h_{eff} = nh$ equal to gravitational Planck constant h_{gr} for electron Cooper pair in Earth's gravitational field. The model for planetary orbits as Bohr orbits together with Equivalence Principle implies $\hbar_{gr} = GMm/v_0$ at flux tubes connecting particle with mass m to Sun with mass M. v_0 has dimensions of velocity and has order of magnitude correlating with a typical rotation velocity of planetary orbit by Bohr quantization rules.

(c) In the recent case the rotation velocity v_0 is the rotation velocity of Earth at its surface: $v_0(E)/c = 2.16 \times 10^{-6}$ to be compared with $v_0(S)/c \simeq .5 \times 10^{-3}$ for Sun-Earth system. The scaling of λ_g is given by $h_{gr}(E, pair)/h = (h_{gr,S,pair}/h) \times (M_E/M_S) \times v_0(S)/v_0(E)$. This gives

$$ r \equiv \frac{h_{gr,S,pair}}{h} = \frac{\lambda(h_{gr,S,pair})}{\lambda(h, pair)} = \frac{\frac{GM}{v_0(S)}}{\lambda_c(pair)} = \frac{\frac{r_S}{v_0(S)}}{\lambda_c(e)} \quad . $$

Using $r_S = 3km$ and $\lambda_e = .243 \times 10^{-12}$ m and $v_0(S) \simeq 2^{-11}$, $M_E/M_S = 3.0 \times 10^{-6}$ one obtains $r \simeq 3.6 \times 10^{14}$. This happens to be correct order of magnitude! Maybe the model might have something to do with reality. Even better, also the value of h_{eff} is consistent with its value spectrum appearing in EEG if one requires that the energy of dark EEG photon with frequency of order 10 Hz is that of biophoton with frequency of about 5×10^{14} Hz. If this picture is correct the values of $h_{eff} = h_{gr}$ would comes as proportional to the masses of particles and cyclotron energies proportional to heB/m would not depend on the mass of the particle at all.

(d) What is nice that the model unifies the notions of gravitational Planck constant and dark Planck constant. The basic observation is that Equivalence Principle allows to understand the effects of h_{gr} by reducing it to elementary particle level interpreted in terms of flux tubes connecting particle to the bigger system. This allows to avoid gigantic values of h_{gr} and gives connection with TGD inspired quantum biology. The new quantum physics associated with gravitation would also become key part of quantum biology.

Could $h_{gr} = h_{eff}$ hold true?

The obvious question is whether the gravitational Planck constant deduced from the Nottale's considerations and the effective Planck constant $h_{eff} = nh$ 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 gigantic value.

It is however essential to realize that by Equivalence Principle one 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* [E7, E9] discussed in [K98] 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.

(a) 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.

(b) 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.

(c) The model for quantum biology relying on the notions of magnetic body and dark matter as hierarchy of phases with $h_{eff} = n \times h$, and biophotons [K22, K12] 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.

   i. 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 [K35] 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.

   ii. 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 magnetic body. Each ion has its own cyclotron frequency but same energy for the corresponding biophoton.

   iii. 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/bfsy4ft). If one replaces v_0 with $2v_0$ 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.

   iv. The hypothesis means that the scale of energy spectrum of biophotons depends on the ratio M/v_0 of the planet and on the strength of the endogenous magnetic field, which is.2 Gauss for Earth (2/5 of the nominal value of the Earth's magnetic field). Therefore the astrophysical characteristics of planets should be tuned for molecular life. Taking v_0 to be rotational velocity one obtains for the ratio $M(planet)/v_0(planet)$ using the ratio for Earth as unit the following numbers for the planets (Mercury, Venus, Earth, Mars, Jupiter, Saturnus, Uranus, Neptune): $M/v_0 = (8.5, 209, 1, .214223, 1613, 6149, 9359)$. If the energy scale of biophotons is required to be the same, the scale of endogenous magnetic field should be divided

by this ratio in order to obtain the same situation as in Earth. For instance, in Mars the magnetic field should be roughly 5 times stronger: in reality the magnetic field of Mars is much weaker. Just for fun one can notice that for Sun the ratio is 1.4×10^6 so that magnetic field should be by the inverse of this factor weaker.

(d) 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.

(e) The Universal gravitational Compton wave length of $GM/v_0 \simeq 864$ meters gives an idea about largest possible living matter system if Earth is the second body. Of course, also other large bodies are possible.In the case of solar system this length is 3×10^3 km. The radius of Earth is 6.37×10^3 km - roughly twice the Compton length. The radii of Mercury, Venus, Earth, Mars, Jupiter, Saturnus, Uranus, Neptunus are (.38, .99, .533, 1, 10.6, 8.6, 4.0, 3.9) using Earth radius as unit the value of h_{gr} is by factor 5 larger than for 4 inner planets so that the values are reasonably near to gravitational Compton length or twice it. Does this mean that dark matter associated with Earth and maybe also other planets is in macroscopic quantum state at some level of the hierarchy of space-time sheets? Does this mean that Mother Gaia as conscious entity might make sense. One can of course make same question in the case of Sun. The universal gravitational Compton length in Sun would be 18 per cent of the radius of Sun if v_0 is taken to be the rotational velocity at the surface of Sun. The radius of solar core, where fusion takes place, is 20-25 per cent of solar radius.

(f) There are further interesting numerical co-incidences. One can for a moment forget the standard hostility of scientist towards horoscopes and ask whether Sun and Moon could have somehow affect our life via astrocopic quantum coherence. The gravitational Compton length for particle-Moon or particle-Sun system multiplied by the natural value of magnetic field is the relevant parameter. For Sun the parameters in question are mass of Sun, and rotational velocity of Earth with respect to Sun, plus magnetic fields of Sun at flux tubes associated with solar magnetic field measured to be about 5 nT at the position of Earth and 100 times stronger than expected from dipole field behavior. This gives that the range of biophoton energies is scaled down with factor of 1/4 in good approximation so that Father Sun might affect terrestrial biology! If one uses for the rotational velocity of particle at surface of Moon as parameter v_0 (particle would be at Moon), biophoton energy scaled scaled up by factor 1.2.

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.

What about $h_{em} = h_{eff}$?

The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone [L14] (`http://tinyurl.com/oyhstc2`) and its complement define this kind of system and TGD inspired identification is as prebiotic life form. I have proposed a TGD inspired model for the fourth phase of water [K57] [L14].

I have proposed that metabolic machinery generates large h_{eff} phase somehow. $h_{eff} = h_{em}$ hypothesis allows to develop this hypothesis in more detail.

(a) The rotating shaft of a molecular motor associated with ATP synthase is proposed to play a key role.

(b) What comes in mind is that the rotational velocity v_0 of the shaft appears in the formula for h_{em}. The electric field over the mitochondrial membrane generates charge separation and the product of charges of shaft and its complement should appear in the expression for h_{em}.

(c) The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The lower bound for the magnitude for h_{em} is same as for h_{gr} associated with Earth-particle system.

Rotating magnetic systems are claimed to exhibit anomalous effects such as spontaneous acceleration and over unity energy production. I have discussed these in [K9].

(a) The proposal is that rotating magnetic systems give rise to dark matter at magnetic flux tubes and sheets associated with the system and that the metabolic energy is needed to rotate the motor to generate the dark matter, which in turn makes possible negentropic entanglement characterized the density matrix proportional to unit matrix. This kind of matrix results if entanglement coefficients form a unitary S-matrix characterizing also quantum computation as unitary process.

(b) The parameter v_0 appearing in the general formula for h_{eff} assigned with either em - or gravitational flux tubes is identifiable as the rotation velocity. One has $v_0/c \simeq 3 \times 10^{-8}$.

(c) Since these systems are strongly charged, a natural guess is that large h_{em} system is in question.

4.8.3 Gravitational Mother Gaia And Life

Negentropic entanglement (NE) is one of the key notions of TGD inspired quantum biology. For instance, it would seem that NE would look more natural metabolic resource than energy. Nutrients should carry it. NE is however not single particle property but between nutrient and some other system in the recent case. What can one say about this system? Can it be part of nutrient? Could it correspond to oxygen molecules? Or could it be Mother Gaia identified in some sensible manner?

If one believes on the presence of gravimagnetic flux tubes and their role as generator of macroscopic quantum coherence in biology then one is forced to consider seriously also NE between its ends. If this is the case then the view of religions about life might be nearer to truth than that of hard-born materialists.

To make this more concrete, let us first look what the transfer of NE could mean.

(a) Suppose that nutrient N has NE with unknown system A which a priori could be part of nutrient. Assume that the transfer of NE of nutrient with A is formed by reconnection of U-shaped flux tubes associated with N (or glucose G produced from it) and A so that two parallel flux tubes connecting N and A are formed.

(b) The basic operation allowing transformation of $N-A$ NE to $P-A$ NE is following. The two flux tube portions of U-shaped flux associated with the receiver R are reconnected with the two parallel flux tubes connecting N and A so that two flux tubes connecting R to A are formed. NMP strongly suggests that the entanglement remains negentropic in the process.

(c) NE is first transferred to P using this process so that P and A are now NE-connected. After this P attaches to ADP to yield ATP and ATP attaches to B and the transfer process leads to NE between B and A.

For ATP synthase the h_{em} consisting two elementary charges is of the same order as h_{gr}. This is probably not an accident. Could this mean that this kind of flux tube can reconnect with gravitational flux tube? Could this make possible a reconnection transforming N-Earth NE to P-Earth NE? This looks plausible.

Consider now the identification of A.

(a) If one assumes that the negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) corresponds to gravitational flux tubes for N-Earth system then A should be gravitational Mother Gaia, whatever its precise definition might be. N (and glucose) molecules would be alive in the sense that they have NE with Mother Gaia.

(b) Could oxygen have some deeper role? For instance, could O_2 molecules serve as analogs of cell membrane receptors for Mother Gaia meaning that gravitational flux tubes go through O_2 molecules? This does not look plausible since metabolism is possible also as fermentation involving no oxygen.

(c) In this picture the role of breathing and fermentation would be to make possible the transfer of NE from nutrients to the living system.

This picture allows to imagine about what might happen in biological death. Biological death takes first place only at the highest level of self hierarchy assignable to the our biological body. Cells continue for some time their life even after the last breath. The notion of h_{gr} together with Equivalence Principle suggests that the living biological body has negentropic flux tube connections to both electromagnetic magnetic body (personal magnetic body) and to gravitational Mother Gaia (MG) representing collective consciousness in the scale of Earth. Also personal magnetic body has flux tube connections to MG. The latter especially during sleep. Also connections to higher levels in hierarchy are possible. At the moment of biological death the negentropic flux tube pairs connecting the personal magnetic body to biological body are split and only those with MG remain or are generated in this process. This would happen later at lower levels of biological self hierarchy such as organ and organelles and eventually for cells and biopolymers. On the other hand, new life forms using the decay products as nutrients would take the available NE to use during the decay process.

The quantum model for metabolism allows to understand life as a process in which negentropic entanglement of gravitational Mother Gaia with nutrients is transformed to that of molecules of biological body with personal magnetic body and further processed and enriched. At the moment of biological death this information returns to the gravitational Mother Gaia. By NMP information is not lost but increases steadily giving rise to "Akashic records". This view conforms with the core ideas of spiritual and religious teachings.

4.9 Quantitative Model Of High T_c Super-Conductivity And Bio-Super-Conductivity

I have developed already earlier [K17, K18, K77, K78] a rough model for high T_c super conductivity [D54, D56, D57, D15, D9, D59]. The members of Cooper pairs are assigned with parallel flux tubes carrying fluxes which have either same or opposite directions. The essential element of the model is hierarchy of Planck constants defining a hierarchy of dark matters.

(a) In the case of ordinary high T_c super-conductivity bound states of charge carriers at parallel short flux tubes become stable as spin-spin interaction energy becomes higher than thermal energy.

The transition to super-conductivity is known to occur in two steps: as if two competing mechanisms were at work. A possible interpretation is that at higher critical temperature Cooper pairs become stable but that the flux tubes are stable only below rather short scale: perhaps because the spin-flux interaction energy for current carriers is below thermal energy. At the lower critical temperature the stability would is achieved and supra-currents can flow in long length scales.

(b) The phase transition to super-conductivity is analogous to a percolation process in which flux tube pairs fuse by a reconnection to form longer super-conducting pairs at the lower critical temperature. This requires that flux tubes carry anti-parallel fluxes: this is in accordance with the anti-ferro-magnetic character of high T_c super conductivity.

The stability of flux tubes very probably correlates with the stability of Cooper pairs: coherence length could dictate the typical length of the flux tube.

(c) A non-standard value of h_{eff} for the current carrying magnetic flux tubes is necessary since otherwise the interaction energy of spin with the magnetic field associated with the flux tube is much below the thermal energy.

There are two energies involved.

(a) The spin-spin-interaction energy should give rise to the formation of Cooper pairs with members at parallel flux tubes at higher critical temperature. Both spin triplet and spin singlet pairs are possible and also their mixture is possible.

(b) The interaction energy of spins with magnetic fluxes, which can be parallel or antiparallel contributes also to the gap energy of Cooper pair and gives rise to mixing of spin singlet and spin triplet. In TGD based model of quantum biology antiparallel fluxes are of special importance since U-shaped flux tubes serve as kind of tentacles allow magnetic bodies form pairs of antiparallel flux tubes connecting them and carrying supra-currents. The possibility of parallel fluxes suggests that also ferro-magnetic systems could allow super-conductivity.

One can wonder whether the interaction of spins with magnetic field of flux tube could give rise to a dark magnetization and generate analogs of spin currents known to be coherent in long length scales and used for this reason in spintronics (`http://tinyurl.com/5cu3qh`). One can also ask whether the spin current carrying flux tubes could become stable at the lower critical temperature and make super-conductivity possible via the formation of Cooper pairs. This option does not seem to be realistic.

In the following the earlier flux tube model for high T_c super-conductivity and bio-super-conductivity is formulated in more precise manner. The model leads to highly non-trivial and testable predictions.

(a) Also in the case of ordinary high T_c super-conductivity large value of $h_{eff} = n \times h$ is required.

(b) In the case of high T_c super-conductivity two kinds of Cooper pairs, which belong to spin triplet representation in good approximation, are predicted. The average spin of the states vanishes for antiparallel flux tubes. Also super-conductivity associated with parallel flux tubes is predicted and could mean that ferromagnetic systems could become super-conducting.

(c) One ends up to the prediction that there should be a third critical temperature T^{**} not lower than $T^{**}_{min} = 2T^*/3$, where T^* is the higher critical temperature at which Cooper pairs identifiable as mixtures of $S_z = \pm 1$ pairs emerge. At the lower temperature $S_z = 0$ states, which are mixtures of spin triplet and spin singlet state emerge. At temperature T_c the flux tubes carrying the two kinds of pairs become thermally stable by a percolation type process involving re-connection of U-shaped flux tubes to longer flux tube pairs and supra-currents can run in long length scales.

(d) The model applies also in TGD inspired model of living matter. Now however the ratio of critical temperatures for the phase transition in which long flux tubes stabilize is roughly by a factor 1/50 lower than that in which stable Cooper pairs emerge and corresponds to thermal energy at physiological temperatures which corresponds also the cell membrane potential. The higher energy corresponds to the scale of bio-photon energies (visible and UV range).

4.9.1   A More Detailed Flux Tube Model For Super-Conductivity

The following little calculations support the above vision and lead to quite predictive model.

4.9.2   Simple Quantitative Model

It is best to proceed by building a quantitative model for the situation.

(a) Spin-spin interaction energy for electron pair with members de-localized at parallel magnetic flux tubes must be deduced from the standard expression for the magnetic field created by the second charge and from the expression for the magnetic interaction energy of magnetic moment with external magnetic field.

The magnetic field created by dipole μ outside the dipole is given by

$$B = \frac{\mu_0}{4\pi a^3} \times (3nn \cdot \mu - \mu) \ . \tag{4.9.1}$$

The factor $\frac{\mu_0}{4\pi}$ can be taken equal to $1/4\pi$ as unity in the units in which $\mu_0 = \epsilon_0 = c = 1$ holds true. n is direction vector associated with the relative position vector a.

The magnetic interaction energy reads as $E = -\mu \cdot B$ and in the case of identical magnetic moments reads as

$$E = \frac{1}{4\pi a^3} \times (-3\mu_1 \cdot n\mu_2 \cdot n + \mu_1 \cdot \mu_2) \ . \tag{4.9.2}$$

(b) The magnetic dipole moment of electron is $\mu = -(ge/2m)S$, $S = \hbar/2$, $g \simeq 2$. For proton analogous expression holds with Lande factor $g = 5.585694713(46)$.

A simple model is obtained by assuming that the distance between the members of Cooper pair is minimal so that the relative position vector is orthogonal to the flux tubes.

(a) This gives for the spin-spin interaction Hamiltonian the expression

$$H_{s-s} = \tfrac{1}{4\pi a^3} \times (\tfrac{ge\hbar}{2m})^2 \times O \ , \quad O = -3(m_1)_x(m_2)_x + m_1 \cdot m_2 \ . \tag{4.9.3}$$

m_i refers to spin in units of $\hbar$. x referes to the direction in the plane defined by flux tubes and orthogonal to them. m_x can be expressed in terms of spin raising and lowering operators as $m_x = (1/2)(m_+ + m_-)$, $m_\pm = m_x \pm im_y$. This gives

$$(m_1)_x(m_2)_x = \tfrac{1}{4} \sum_{i=\pm, j=\pm}(m_i)_1(m_j)_2 \ . \tag{4.9.4}$$

$m_1 \cdot m_2$ can be expressed as $(1/2) \times [(m_1 + m_2)^2 - m_1^2 - m_2^2]$. In the case of spin $1/2$ particles one can have spin singlet and spin triplet and the value of $m_1 \cdot m_2$ is in these cases given by $m_1 \cdot m_2(singlet) = -3/4$ and $m_1 \cdot m_2(triplet) = 1/4$

The outcome is an expression for the spin-spin interaction Hamiltonian

$$H_{s-s} = E_{s-s} \times O \ , \quad E_{s-s} = \tfrac{1}{4\pi a^3} \times (ge\hbar/2m)^2 \times O \ ,$$

$$O = O_1 + O_2(S) \ , \quad O_1 = -\tfrac{3}{4} \sum_{i=\pm, j=\pm}(m_i)_1(m_j)_2 \ ,$$

$$O_2(singlet) = -\tfrac{3}{4} \ , \quad O_2(triplet) = \tfrac{1}{4} \ .$$
$$\tag{4.9.5}$$

(b) The total interaction Hamiltonian of magnetic moment with the magnetic field of flux tube can be deduced as

$$H_{s-flux} = -(\mu_Z)_1 B_1 - (\mu_Z)_2 B_2 = \tfrac{ge}{\hbar 2m}(m_1)_z B_1 + (m_2)_z B_2$$

$$= E_{s-flux} \times ((m_1)_z + \epsilon(m_2)_z) \ , \quad E_{s-flux} = \tfrac{ge\hbar B}{2m} \ .$$
$$\tag{4.9.6}$$

(c) For the diagonalization of spin-spin interaction Hamiltonian the eigenbasis of S_z is a natural choice. In this basis the only non-diagonal terms are O_1 and E_{s-flux}. O_1 does not mix representations with different total spin and is diagonal for the singlet representation. Also the $S_z(tot) = 0$ state of triplet representation is diagonal with respect to O_1: this is clear from the explicit representation matrices of spin raising and lowering operators (the non-vanishing elements in spin $1/2$ representation are equal to 1). $S_z(tot) = 0$ states are eigenstates of O_1 with eigenvalue $+3/4$ for singlet and $-3/4$ for triplet. For singlet one therefore has eigenvalue $o = 0$ and for triplet eigenvalue $o = -1/2$. Singlet does not allow bound state whereas triplet does.

$S_z(tot) = 1$ and $S_z(tot) = -1$ states are mixed with each other. In this case the O_1 has non-diagonal matrix elements equal to $O_1(1, -1) = O_1(-1, 1) = 1$ so that the matrix representing O is given by

$$O = \begin{pmatrix} \frac{1}{4} & 1 \\ 1 & \frac{1}{4} \end{pmatrix} \ . \tag{4.9.7}$$

The eigenvalues are $o_+ = 5/4$ and $o_- = -3/4$. Cooper pairs states are linear combinations of $S_z = \pm 1$ states with coefficients with have either same or opposite sign so that a maximal mixing occurs and the average spin of the pair vanishes.

To sum up, there are two bound states for mere spin-spin interaction corresponding to $o = -1/2$ spin 0 triplet state and $o = -3/4$ state for which spin 1 and spin -1 states are mixed.

(d) For spin singlet at parallel flux tubes the spin-flux interaction vanishes: $H(para, singlet) = 0$. Same holds true for $S_z = \pm 1$ states at biologically especially interesting antiparallel flux tubes: $H(anti, S_z = \pm 1) = 0$. For antiparallel flux tubes $S_z = 0$ states in singlet and triplet are mixed by $H(anti, S_z = 0)$. The two resulting states must have negative binding energy so that one obtains 3 bound states altogether and only one state remains unbound. The amount of mixing and thermal stability of possibly slightly perturbed singlet state is determined by the ratio x of the scale parameters of H_{s-flux} and H_{s-s}.
The explicit form of $H(anti, S_z = 0)$ is

$$H(anti, S_z = 0) = -\frac{E_{s-s}}{2} \begin{pmatrix} 1 & x \\ x & 0 \end{pmatrix}$$
$$x = -\frac{4E_{s-flux}}{E_{s-s}} = -32\pi \frac{ma^3}{ge\hbar B} \ ,$$
$$E_{s-s} = \frac{1}{8\pi} (\frac{ge\hbar}{2m})^2 \frac{1}{a^3} \ . \tag{4.9.8}$$

The eigenvalues $H(anti, S_z = 0)$

$$E_\pm = -\frac{E_{s-s}}{4}(1 \pm \sqrt{1 + 4x^2}) \ . \tag{4.9.9}$$

What is remarkable is that both parallel antiparallel flux tubes give rise to 2 bound states assignable to spin triplet. Singlet does not allow bound states.

(e) The Planck constant appearing in the formulas can be replaced with $\hbar_{eff} = n\hbar$. Note that the value of the parameter x is inversely proportional to h_{eff} so that singlet approximation improves for large values of h_{eff}.

4.9.3 Fermionic Statistics And Bosons

What about fermionic statistics and bosons?

(a) The total wave function must be antisymmetric and the manner to achieve this for spin triplet state is anti-symmetrization in longitudinal degrees of freedom. In 3-D model for Cooper pairs spatial antis-ymmetrization implies $L = 1$ spatial wave function in the relative coordinate and one obtains $J = 0$ and $J = 2$ states. Now the state could be antisymmetric under the exchange of longitudinal momenta of fermions. Longitudinal momenta cannot be identical and Fermi sphere is replaced by its 1-dimensional variant. In 3-D model for Cooper pairs spatial anti-symmetrization implies $L = 1$ spatial wave function in the relative coordinate. Antisymmetry with respect to longitudinal momenta would be the analog for the odd parity of this wave function. Ordinary super-conductivity is located at the boundary of Fermi sphere in a narrow layer with thickness defined by the binding energy. The situation is same now and the thickness should correspond now to the spin-flux interaction energy.

(b) Second possibility is more exotic and could be based on antisymmetric entanglement in discrete dark degrees of freedom defined by the sheets of the singular covering assignable to the integer $n = h_{eff}/h$. For $n = 2m$ one can decompose the n discrete degrees of freedom to the discrete analogs of m spatial coordinates q_i and m canonical momenta p_i and assume that the entanglement matrix proportional to a unitary matrix (negentropic entanglement) is proportional to the standard antisymmetric matrix defining symplectic structure and expressible as a direct sum of 2×2 permutation symbols ϵ_{ij}. $J_{p_i,q_i} = -J_{q_i p_i} = 1/\sqrt{2m}$. This matrix is antisymmetric and unitary in standard sense and quaternionic sense.

(c) What about bosons? I have proposed that bosonic ions (such as Ca^{++}) associated with single flux tube form cyclotron Bose Einstein condensates giving rise to spontaneous dark magnetization. Bosonic supra currents can indeed run independently along single flux tube as spin currents. Also now the thermal stability of cyclotron states require large h_{eff}. The supra-currents (spin currents) of bosonic ions could be associated with flux tubes and fermionic supra-currents with their pairs. Even dark photons could give rise to spin currents.

At the formal level the model applies in the case of bosons too. Symmetrization/anti-symmetrization for spin singlets/triplets would be replaced with anti-symmetrization/symmetrization. The analog of Fermi sphere would be obtained for spin singlet states requiring anti-symmetrization in longitudinal degrees of freedom.

4.9.4 Interpretation In The Case Of High T_c Super-Conductivity

It is interesting to try to interpret the results in terms of high T_c super-conductivity (`http://tinyurl.com/yd8vj9g`).

(a) The four eigen values of total Hamiltonian are

$$E = E_{s-s} \times \lambda \ ,$$

$$\lambda \in \{\frac{5}{4}, -\frac{3}{4}, -\frac{1}{4}(1 \pm \sqrt{1 + 4x^2})\} \ . \tag{4.9.10}$$

Two bound states with different binding energies are obtained which should be an empirically testable prediction in the case of the ordinary high T_c superconductivity since it predicts two critical temperatures. Cooper pairs are apart from possible small mixing with singlet state triplet states. The average spin is however vanishing also for $S_z = \pm 1$ states-

(b) Two phase transitions giving rise to Cooper pairs are predicted. The simplest interpretation would be that super-conductivity in short scales is already present below the higher critical temperature and corresponds to the currents carries forming a mixture of $S_z = \pm 1$ states. These supra currents would stabilize flux tubes below some rather short scale. At the lower critical temperature the super-conductivity assignable to $S_z = 0$ spin

triplets slightly mixed with singlet would become possible and the scale in which supra-currents can run would increase due to the occurrence of the percolation phenomenon. Below the lower critical temperature the interaction with flux tubes is indeed involved in an essential manner as a mixing of singlet and triplet states. One could perhaps say that $S_z = 0$ states stabilize the flux tube pair.

(c) The critical temperatures for the stability of Cooper pairs are predicted to be in ratio $3/1+\sqrt{1+4x^2}$ roughly equal the upper bound $3/2$ for small x. The critical temperatures are identical for $x = \sqrt{63/4} \simeq 4$. In the ordinary high T_c super-conductivity in cuprates the two critical temperatures are around $T^* = 300K$ and $T_c = 80K$. The ratio $T^*/T_c = 3.75$ fails to be consistent with the upper bound $3/2$.

(d) If one takes the model deadly seriously despite its strong simplifying assumptions one is forced to consider a more complex interpretation. What comes in mind is that both kind of Cooper pairs appear first and super-conductivity becomes possible at T_c. T^* would correspond to the emergence of $S_z = \pm 1$ mixtures. The critical temperature T^{**} for the emergence $S_z = 0$ pairs would not be lower than $T^{**}_{min} = (2/3) \times 300 = 200$ K. At temperature T_c the flux tubes carrying the two kinds of pairs become thermally stable by a percolation type process involving re-connection of U-shaped flux tubes to longer flux tube pairs and supra-currents can run in long length scales. This model conforms with the interpretation of pseudo-gap in terms o pre-formed Cooper pairs not able to form coherent supra-currents (http://tinyurl.com/yc543vbl).

One ends up to the prediction that there should be a third critical temperature T^{**} not lower than $T^{**}_{min} = 2T^*/3$, where T^* is the higher critical temperature at which Cooper pairs identifiable as mixtures of $S_z = \pm 1$ pairs emerge. At the lower temperature $S_z = 0$ states, which are mixtures of spin triplet and spin singlet state emerge.

4.9.5 Quantitative Estimates In The Case Of TGD Inspired Quantum Biology

Using the formulas obtained above one can make rough quantitative estimates and get grasp about bio-super-conductivity as predicted by the model.

(a) To get grasp to the situation it is good to consider as starting point electron with nanometer scale $a = a_0 = 1$ nm taken as the distance between flux tubes. For $h_{eff} = n \times h$ value of Planck constant one obtains $E_{s-s} = n^2(a/a_0)^3 \times E_0$. $E_0 = 1.7 \times 10^{-7}$ eV.

Taking $B = 1$ Tesla one obtains for E_{s-flux} $E_{s-flux} = n \times E_{s-flux,0}$, $E_{s-flux,0} = 6.2 \times 10^{-7}$ eV. For $B = B_{end} = .2$ Gauss suggested as an important value of dark endogenous magnetic field one obtains $E_{s-flux,0} = 2.5 \times 10^{-11}$ eV.

(b) It seems reasonable to require that the two interaction energies are of same order of magnitude. Spin-flux interaction energy is rather small. For instance, for B=1 Tesla its magnitude for electron is about $E_{s-flux,0} = 6.2 \times 10^{-7}$ eV so that a large value of h_{eff} seems to be necessary.

(c) The hypothesis that bio-photons result in the transformations of dark photons to ordinary photons suggests that the energy scale is in the range of visible and UV photons and therefore above eV. This suggests for electron $h_{eff}/h = n \geq 10^7$. The condition that the value of E_{s-s} is also in the same range requires that a scales like $n^{1/3}$. This would give scaling, which is larger than $10^{7/3} \simeq 215$: this would mean $a \geq 2 \times 10^{-7}$ m which belongs to the range of biologically most important length scales between cell membrane thickness and nucleus size.

(d) The hypothesis $\hbar_{eff} = n \times \hbar = \hbar_{gr} = GMm/v_0$ [K71, ?] implies that cyclotron energy spectrum is universal (no dependence on the mass of the charged particle. Same would hold true for the spin-flux interaction energy. Spin spin interaction energy is proportional to h^2_{eff}/m^2a^3, where a is minimum distance between members of the Cooper pair. It is invariant under the simultaneous scaling of h_{eff} and m so that all charged

particles can form Cooper pairs and spin currents for flux tubes with same distance and same magnetic field strength. This would correspond to the universality of the bio-photons [K12]. This would be also consistent with the earlier explanation for the finding of Hu and Wu [**?**] that proton spin-spin interaction frequency for the distance defined by cell membrane thickness is in ELF frequency scale. The proposal was that dark proton sequences are involved at both sides of the membrane.

Universality of Cooper pair binding energies implies universality of super-conductivity all fermionic ions can form superconducting Cooper pairs as has been assumed in the models for strange effects of ELF em fields on vertebrate brain, for cell membrane as Josephson junction, and for EEG [K35], and in the model for nerve pulse [K80]. As found, Bose-Einstein condensates of bosonic ions could give rise to spontaneous dark magnetization and spin currents along single flux tube so that bosons would be associated with flux tubes and fermions with pairs of them.

The value of h_{eff} for proton would satisfy $n \geq 2 \times 10^{10}$. This would guarantee that proton cyclotron frequency for $B = B_{end}$ corresponds to thermal energy 2.5×10^{-2} eV at room temperature.

Note that I have considered also the option that the values of h_{eff} are such that the universal cyclotron energy scale in magnetic field of $B \simeq .2$ Gauss is in the range of bio-photon energies so that h_{eff} would be by a factor of order 50 higher than in the estimate coming from spin temperature.

(e) This observation raises the question whether there are two widely different energy scales present in living matter. The first scale would be associated with spin-spin interaction and would correspond to the energy scale of bio-photons. Second scale would be associated with spin-flux interaction and correspond to the energy scale of resting potential just above the thermal energy at physiological temperatures.

If this is the case, the parameter x would be of order $x \simeq 10^{-2}$ and spin-spin interaction energy would dominate. The somewhat paradoxical earlier prediction was that Cooper pairs in bio-super-conductivity would be stable at temperatures corresponding to energy of eV or even higher but organisms do not survive above physiological temperatures. The critical temperature for living matter could be however understood in terms of the temperature sensitivity of the dark magnetization at magnetic flux tubes. Although the binding energies of Cooper pairs are in bio-photon energy range this does not help since the quantum wires along, which they can propagate are unstable above room temperatures.

(f) From the estimate of order 10^{-7} eV for energy scales for $a = 1$ nm and $B = 1$ Tesla and from the binding energy of Cooper pairs of order 10^{-2} eV it is clear that ordinary high T_c super-conductivity cannot correspond to the standard value of Planck constant: $h_{eff}/h \simeq 10^5$ is required. The interpretation would be that at the higher critical temperature Cooper pairs become stable but flux tubes are not stable. At the lower critical temperature also flux tubes become stable. This would correspond to the percolation model that I have proposed earlier.

These two energy scales would be the biological counterparts of the two much lower energy scales in the ordinary high T_c super-conductivity. There ratio of these scales would be roughly 50.

4.9.6 Does Also Low Tc Superconductivity Rely On Magnetic Flux Tubes In TGD Universe?

Discussions with Hans Geesink have inspired sharpening of the TGD view about bio-superconductivity (bio-SC), high Tc superconductivity (SC) and relate the picture to standard descriptions in a more detailed manner. In fact, also standard low temperature super-conductivity modelled using BCS theory could be based on the same universal mechanism involving pairs of magnetic flux tubes possibly forming flattened square like closed flux tubes and members of Cooper pairs residing at them.

A brief summary about strengths and weakness of BCS theory

First I try to summarize basics of BCS theory.

(a) BCS theory is successful in 3-D superconductors and explains a lot: supracurrent, diamagnetism, and thermodynamics of the superconducting state, and it has correlated many experimental data in terms of a few basic parameters.

(b) BCS theory has also failures.

  i. The dependence on crystal structure and chemistry is not well-understood: it is not possible to predict, which materials are super-conducting and which are not.

  ii. High-Tc SC is not understood. Antiferromagnetism is known to be important. The quite recent experiment demonstrates conductivity- maybe even conductivity - in topological insulator in presence of magnetic field [L22]. This is compete paradox and suggests in TGD framework that the flux tubes of external magnetic field serve as the wires [L22].

(c) BCS model based on crystalline long range order and k-space (Fermi sphere). BCS-difficult materials have short range structural order: amorphous alloys, SC metal particles 0-down to 50 Angstroms (lipid layer of cell membrane) transition metals, alloys, compounds. Real space description rather than k-space description based on crystalline order seems to be more natural. Could it be that the description of electrons of Cooper pair is not correct? If so, k-space and Fermi sphere would be only appropriate description of ordinary electrons needed to model the transition to to super-conductivity? Super-conducting electrons could require different description.

(d) Local chemical bonding/real molecular description has been proposed. This is of course very natural in standard physics framework since the standard view about magnetic fields does not provide any ideas about Cooper pairing and magnetic fields are only a nuisance rather than something making SC possible. In TGD framework the situation is different.

TGD based view about SC

TGD proposal for high Tc SC and bio-SC relies on many-sheeted space-time and TGD based view about dark matter as $h_{eff} = n \times h$ phase of ordinary matter emerging at quantum criticality [K78].

Pairs of dark magnetic flux tubes would be the wires carrying dark Cooper pairs with members of the pair at the tubes of the pair. If the members of flux tube pair carry opposite B:s, Cooper pairs have spin 0. The magnetic interaction energy with the flux tube is what determines the critical temperature. High Tc superconductivity, in particular the presence of two critical temperatures can be understood. The role of anti-ferromagnetism can be understood.

TGD model is clearly x-space model: dark flux tubes are the x-space concept. Momentum space and the notion of Fermi sphere are certainly useful in understanding the transformation ordinary lattice electrons to dark electrons at flux tubes but the super conducting electron pairs at flux tubes would have different description.

Now come the heretic questions.

(a) Do the crystal structure and chemistry define the only fundamental parameters in SC? Could the notion of magnetic body - which of course can correlate with crystal structure and chemistry - equally important or even more important notion?

(b) Could also ordinary BCS SC be based on magnetic flux tubes? Is the value of $h_{eff} = n \times h$ only considerably smaller so that low temperatures are required since energy scale is cyclotron energy scale given by E= $h_{eff} = n \times f_c$, $f_c = eB/m_e$. High Tc SC would only have larger h_{eff} and bio-superconductivity even larger h_{eff}!

(c) Could it be that also in low Tc SC there are dark flux tube pairs carrying dark magnetic fields in opposite directions and Cooper pairs flow along these pairs? The pairs could actually form closed loops: kind of flattened O:s or flattened squares.

One must be able to understand Meissner effect. Why dark SC would prevent the penetration of the ordinary magnetic field inside superconductor?

(a) Could B_{ext} actually penetrate SC at its own space-time sheet. Could opposite field B_{ind} at its own space-time sheet effectively interfere it to zero? In TGD this would mean generation of space-time sheet with $B_{ind} = -B_{ext}$ so that test particle experiences vanishing B. This is obviously new. Fields do not superpose: only the effects caused by them superpose.

Could dark or ordinary flux tube pairs carrying B_{ind} be created such that the first flux tube portion B_{ind} in the interior cancels the effect of B_{ext} on charge carriers. The return flux of the closed flux tube of B_{ind} would run outside SC and amplify the detected field B_{ext} outside SC. Just as observed.

(b) What happens, when B_{ext} penetrates to SC? $h_{eff} \to h$ must take place for dark flux tubes whose cross-sectional area and perhaps also length scale down by h_{eff} and field strength increases by h_{eff}. If also the flux tubes of B_{ind} are dark they would reduce in size in the transition $h_{eff} \to h$ by $1/h_{eff}$ factor and would remain inside SC! B_{ext} would not be screened anymore inside superconductor and amplified outside it! The critical value of B_{ext} would mean criticality for this $h_{eff} \to h$ phase transition.

(c) Why and how the phase transition destroying SC takes place? Is it energetically impossible to build too strong B_{ind}? So that effective field $B_{eff} = B_{dark} + B_{ind} + B_{ext}$ experienced by electrons is reduced so that also the binding energy of Cooper pair is reduced and it becomes thermally unstable. This in turn would mean that Cooper pairs generating the dark B_{dark} disappear and also B_{dark} disappears. SC disappears.

Wee after writing the above text came the newest news concerning high Tc superconductivity. Hydrogen sulfide - the compound responsible for the smell of rotten eggs - conducts electricity with zero resistance at a record high temperature of 203 Kelvin (–70 degrees C), reports a paper published in Nature. This super-conductor however suffers from a serious existential crisis: it behaves very much like old fashioned super-conductor for which superconductivity is believed to be caused by lattice vibrations and is therefore not allowed to exist in the world of standard physics! To be or not to be!

TGD Universe allows however all flowers to bloom: the interpretation is that the mechanism is large enough value of $h_{eff} = n \times h$ implying that critical temperature scales up. Perhaps it is not a total accident that hydrogen sulfide H2S - chemically analogous to water - results from the bacterial breakdown of organic matter, which according to TGD is high temperature super-conductor at room temperature and mostly water, which is absolutely essential for the properties of living matter in TGD Universe.

As a matter fact, H_2S is used by some bacteria living in deep ocean volcanic vents as a nutrient and also in our own gut: chemically this means that H_2S acts as electron donor in primitive photosynthesis like process to give ATP. That sulfur is essential for growth and physical functioning of plants might be due to the fact that it preceded oxygen based life [F1]. For instance, Cys and met containing sulphur are very important amino-acids.

Indications for high T_c superconductivity at 373 K with $h_{eff}/h = 2$

Some time ago I learned about a claim of Ivan Kostadinov [D51] about superconductivity at temperature of 373 K (100 C) (see `http://tinyurl.com/y9hk83ak`). There is also claims by E. Joe Eck about superconductivity: the latest at 400 K [D14] (see `http://tinyurl.com/yc483hsf`). I am not enough experimentalist to be able to decide whether to take the claims seriously or not.

The article of Kostadinov provides a detailed support for the claim. Evidence for diamagnetism (induced magnetization tends to reduce the external magnetic field inside superconductor) is represented: at 242 transition reducing the magnitude of negative susceptibility but keeping it negative takes place. Evidence for gap energy of 15 mV was found at 300 K temperature: this energy is same as thermal energy $T/2 = 1.5$ eV at room temperature. Tape tests passing 125 A through superconducting tape supported very low resistance (for Copper tape started burning after about 5 seconds).

I-V curves at 300 K are shown to exhibit Shapiro steps (see `http://tinyurl.com/y7qkmubj`) with radiation frequency in the range [5 GHz, 21 THz]. Already Josephson discovered what - perhaps not so surprisingly - is known as Josephson effect (see `http://tinyurl.com/mo8549n`). As one drives super-conductor with an alternating current, the voltage remain constant at certain values. The difference of voltage values between subsequent jumps are given by Shapiro step $\Delta V = hf/Ze$. The interpretation is that voltage suffers a kind of phase locking at these frequencies and alternating current becomes Josephson current with Josephson frequency $f_J = ZeV/h$, which is integer multiple of the frequency of the current. This actually gives a very nice test for $h_{eff} = n \times h$ hypothesis: Shapiro step ΔV should be scaled up by $h_{eff}/h = n$. The obvious question is whether this occurs in the recent case or whether $n = 1$ explains the findings.

The data represented by Figs. 12, 13,14 of [D51] (see `http://tinyurl.com/y9hk83ak`) suggest $n = 2$ for $Z = 2$. The alternative explanation would be that the step is for some reason $\Delta V = 2hf/Ze$ corresponding to second harmonic or that the charge of the charge carrier is $Z = 1$. I have not been able to find any error in my calculation.

(a) Fig 12 shows I-V curve at room temperature T=300 K. Shapiro step is now 45 mV. This would correspond to frequency $f = Ze\Delta V/h = 11.6$ THz. The figure text tells that the frequency is $f_R = 21.762$ THz giving $f_R/f \simeq 1.87$. This would suggest $h_{eff}/h = n \simeq f_R/f \simeq 2$.

(b) Fig. 13 shows another at 300 K. Now Shapiro step is 4.0 mV and corresponds to a frequency 1.24 THz. This would give $f_R/f \simeq 1.95$ giving $h_{eff}/h = 2$.

(c) Fig. 14 shows I-V curve with single Shapiro step equal to about .12 mV. The frequency should be 2.97 GHz whereas the reported frequency is 5.803 GHz. This gives $f_R/f \simeq 1.95$ giving $n = 2$.

Irrespectively of the fate of the claims of Kostadinov and Eck, Josephson effect could allow an elegant manner to demonstrate whether the hierarchy of Planck constants is realized in Nature.

Room temperature superconductivity for alkanes

Super conductivity with critical temperature of 231 C for n-alkanes containing n=16 or more carbon atoms in presence of graphite has been reported (see `http://tinyurl.com/hnefqv9`).

Alkanes (see `http://tinyurl.com/6pm7mz6`) can be linear (C_nH_{2n+2}) with carbon backbone forming a snake like structure, branched (C_nH_{2n+2}, $n \geq 2$) in which carbon backbone splits in one, or more directions or cyclic (C_nH_{2n}) with carbon backbone forming a loop. Methane CH_4 is the simplest alkane.

What makes the finding so remarkable is that alkanes serve as basic building bricks of organic molecules. For instance, cyclic alkanes modified by replacing some carbon and hydrogen atoms by other atoms or groups form aromatic 5-cycles and 6-cycles as basic building bricks of DNA. I have proposed that aromatic cycles are superconducting and define fundamental and kind of basic units of molecular consciousness and in case of DNA combine to a larger linear structure.

Organic high T_c superconductivity is one of the basic predictions of quantum TGD. The mechanism of super-conductivity would be based on Cooper pairs of dark electrons with non-standard value of Planck constant $h_{eff} = n \times h$ implying quantum coherence is length scales scaled up by n (also bosonic ions and Cooper pairs of fermionic ions can be considered).

The members of dark Cooper pair would reside at parallel magnetic flux tubes carrying magnetic fields with same or opposite direction: for opposite directions one would have $S = 0$ and for the same direction $S = 1$. The cyclotron energy of electrons proportional to h_{eff} would be scaled up and this would scale up the binding energy of the Cooper pair and make super-conductivity possible at temperatures even higher than room temperature [K78].

This mechanism would explain the basic qualitative features of high T_c superconductivity in terms of quantum criticality. Between gap temperature and T_c one one would have superconductivity in short scales and below T_c superconductivity in long length scales. These temperatures would correspond to quantum criticality at which large h_{eff} phases would emerge.

What could be the role of graphite? The 2-D hexagonal structure of graphite is expected to be important as it is also in the ordinary super-conductivity: perhaps graphite provides long flux tubes and n-alkanes provide the Cooper pairs at them. Either graphite, n-alkane as organic compound, or both together could induce quantum criticality. In living matter quantum criticality would be induced by different mechanism. For instance, in microtubules it would be induced by AC current at critical frequencies [L26].

How the transition to superconductive state could be induced by classical radiation?

Blog and Facebook discussions have turned out to be very useful and quite often new details to the existing picture emerge from them. We had interesting exchanges with Christoffer Heck in the comment section to "Are microtubules macroscopic quantum systems?" (see `http://tinyurl.com/hwnnfcd`) and this pleasant surprise occurred also now.

Recall that Bandyopadhyay's team claims to have detected the analog of superconductivity, when microtubules are subjected to AC voltage [**?, ?**] (see `http://tinyurl.com/ze366ny`). The transition to a state resembling superconductivity would occur at certain critical frequencies. For the TGD inspired model see [L13].

The TGD proposal for bio-superconductivity - in particular that appearing in microtubules - is same as that for high T_c superconductivity [K77, K78]. Quantum criticality, large $h_{eff}/h = n$ phases of Cooper pairs of electrons, and parallel magnetic flux tube pairs carrying the members of Cooper pairs for the essential parts of the mechanism. $S = 0$ ($S = 1$) Cooper pairs appear when the magnetic fields at parallel flux tubes have opposite (same) direction.

Cooper pairs would be present already below the gap temperature but possible super-currents could flow in short loops formed by magnetic flux tubes in ferromagnetic system. AC voltage at critical frequency would somehow induce transition to superconductivity in long length scales by inducing a phase transition of microtubules without helical symmetry to those with helical symmetry and fusing the conduction pathways with length of 13 tubulins associated with microtubules of type B to much longer ones associated with microtubules of type A by the reconnection of magnetic flux tubes parallel to the conduction pathways.

The phonon mechanism responsible for the formation of Cooper pair in ordinary superconductivity cannot be involved with high T_c superconductivity nor bio-superconductivity. There is upper bound of about 30 K for the critical temperature of BCS superconductors. Few days ago I learned about high T_c superconductivity around 500 K for n-alkanes (see `http://tinyurl.com/hwac9e9`) so that the mechanism for high T_c is certainly different [K78].

The question of Christoffer was following. Could microwave radiation for which photon energies are around 10^{-5} eV for the ordinary value of Planck constant and correspond to the gap energy of BCS superconductivity induce phase transition to BCS super-conductivity and maybe to micro-tubular superconductivity (if it exists at all)?

This inspires the question about how precisely the AC voltage at critical frequencies could induce the transition to high T_c - and bio-super-conductivity. Consider first what could happen in the transition to high T_c super-conductivity.

(a) In high T_c super conductors such as copper-oxides the anti-ferromagnetism is known to be essential as also 2-D sub-lattice structures. Anti-ferromagnetism suggests that closed flux tubes form of squares with opposite directions of magnetic field at the opposite sides of square. The opposite sides of the square would carry the members of Cooper pair.

(b) At quantum criticality these squares would reconnect to very long flattened squares by reconnection. The members of Cooper pairs would reside at parallel flux tubes forming the sides of the flattened square. Gap energy would consists interaction energies with the magnetic fields and the mutual interaction energy of magnetic moments.

This mechanism does not work in standard QM since the energies involved are quite too low as compared to thermal energy. Large $h_{eff}/h = n$ would however scale up the magnetic energies by n. Note that the notion of gap energy should be perhaps replaced with collective binding energy per Cooper pair obtained from the difference of total energies for gap phase formed at higher temperature and for superconducting phase formed at T_c by dividing with the number of Cooper pairs.

Another important distinction to BCS is that Cooper pairs would be present already below gap temperature. At quantum criticality the conduction pathways would become much longer by reconnection. This would be represent an example about "topological" condensed matter physics. Now hover space-time topology would be in question.

(c) The analogs of phonons could be present as transversal oscillations of magnetic flux tubes: at quantum criticality long wave length "magneto-phonons" would be present. The transverse oscillations of flux tube squares would give rise to reconnection and formation of

If the irradiation or its generalization to high T_c works the energy of photon should be around gap energy or more precisely around energy difference per Cooper pair for the phases with long flux tubes pairs and short square like flux tubes.

(a) To induce superconductivity one should induce formation of Cooper pairs in BCS superconductivity. In high T_c super-conductivity it should induce a phase transition in which small square shaped flux tube reconnect to long flux tubes forming the conducting pathways. The system should radiate away the energy difference for these phases: the counterpart of binding energy could be defined as the radiated energy per Cooper pair.

(b) One could think the analog of stimulated emission (see http://tinyurl.com/hwac9e9). Assume that Cooper pairs have two states: the genuine Cooper pair and the non-superconducting Cooper pair. This is the case in high T_c superconductivity but not in BCS superconductivity, where the emergence of superconductivity creates the Cooper pairs. One can of course ask whether one could speak about the analog of stimulated emission also in this case.

(c) Above T_c but below gap temperature one has the analog of inverted population: all pairs are in higher energy state. The irradiation with photon beam with energy corresponding to energy difference gives rise to stimulated emission and the system goes to superconducting state with a lower energy state with a lower energy.

This mechanism could explain the finding of Bandyopadhyay's team [?, ?] that AC perturbation at certain critical frequencies gives rise to a ballistic state resembling superconductivity (no dependence of the resistance on the length of the wire so that the resistance must be located at its ends). The team used photons with frequency scales of MHz, GHz, and THz. The corresponding photon energy scales are about 10^{-8} eV, 10^{-5}, $10-2$ eV for the ordinary value of Planck constant and are below thermal energies.

In TGD classical radiation should have also large $h_{eff}/h = n$ photonic counterparts with much larger energies $E = h_{eff} \times f$ to explain the quantal effects of ELF radiation at EEG frequency range on brain [K70]. The general proposal is that h_{eff} equals to what I have called gravitational Planck constant $\hbar_{gr} = GMm/v_0$ [?, K71]. This implies that dark cyclotron photons have universal energy range having no dependence on the mass of the charged particle. Bio-photons have energies in visible and UV range much above thermal energy and

would result in the transition transforming dark photons with large $h_{eff} = h_{gr}$ to ordinary photons.

One could argue that AC field does not correspond to radiation. In TGD framework this kind of electric fields can be interpreted as analogs of standing waves generated when charged particle has contacts to parallel "massless extremals" representing classical radiation with same frequency propagating in opposite directions. The net force experienced by the particle corresponds to a standing wave.

Irradiation using classical fields would be a general mechanism for inducing bio-superconductivity. Superconductivity would be generated when it is needed. The findings of Blackman and other pioneers of bio-electromagnetism about quantal effects of ELF em fields on vertebrate brain stimulated the idea about dark matter as phases with non-standard value of Planck constant. The precise mechanism for how this happens has remained open. Also these finding could be interpreted as a generation of superconducting phase by this phase transition.

4.9.7 The implications of TGD view about magnetic fields for superconductivity

TGD predicts two kinds of magnetic fields depending on whether flux tubes carry monopole flux or not. In Maxwellian framework flux tubes cannot carry any monopole flux. In TGD based model of high Tc superconductivity [K77, K78] monopole flux tubes current carriers are dark having nonstandard value $h_{eff} = n \times h_0$ of effective Planck constant. Also in bio-superconductivity monopole flux tubes are current carriers. An open question has been whether also ordinary super-conductivity could correspond to monopole flux tubes and I have considered the possibility that this is the case.

The recent progress in understanding the relationship between two kinds of magnetic fields allows to consider more precisely the relationship between these two kinds of super-conductivities. In particular, one can try to understand Meissner effect in ordinary super-conductivity and its absence in the predicted super-conductivity based on monopole flux tubes. The conclusion is that ordinary super-conductivity corresponds to ordinary flux tubes and that Meissner effect has no counterpart in monopole superconductivity.

It is best to start from the ordinary super-conductivity by making an unpleasant question. Meissner effect (see `http://tinyurl.com/hesedf2`) relates to the possible penetration of magnetic field to super-conductor. Supra-current creates a local magnetic field. Why doesn't this magnetic field destroy super-conductivity?

The answer would be in TGD space-time following.

(a) The super-conductor consists of parallel cylindrical tubes carrying supra-currents at their boundaries. These currents create magnetic fields rotating around the cylinders but have no component in z- direction. Magnetic fields vanish at the boundaries of the cylinders.

(b) Superconductors can be classified to two types. For superconductors of type I (see `http://tinyurl.com/y4wkzcql`) one has $\lambda/\xi < 1/\sqrt{2}$ whereas for superconductors of type II (see `http://tinyurl.com/y279phzb`) one has $\lambda/\xi > 1/\sqrt{2}$. Here λ is the magnetic penetration length, which is roughly the radius of magnetic flux tube. ξ is the coherence length which is roughly the radius of cylinder carrying supra current at its boundary.

Supra-current generates vortices and in this manner serves as a source for magnetic field inside magnetic flux tube of field possibly penetrating into superconductor. Flux tube must contain at least one current carrying flux tube. This cannot the case for superconductor of type I. Therefore, when ordinary magnetic field penetrates to superconductor of type I above critical value of B, it must do so in the entire super-conductor . For superconductor of type II magnetic field can penetrate superconductor of type II in a cylinder of radius of order λ containing several current carrying cylinders. In this region the super-conductivity is destroyed since supra currents have component rotating along the cylinder giving rise to a longitudinal magnetic field inside the cylinder.

What about Meissner effect in monopole superconductors?

(a) Monopole flux does not require current as its source. Therefore Meissner effect does not prevent super-conductivity by requiring the super-current to be rotational to generate the magnetic field.

(b) Also now the presence of supra current inside monopole flux tube serves as a source for an additional rotational contribution to the magnetic field and the rotor of this additional contribution equals to the supra current. Monopole flux tube is deformed as a consequence. This does not however make supra-current rotational.

Monopole superconductor can be said to be intermediate between types I and II since both coherence length and magnetic length correspond to flux tube radius. A possible interpretation is that monopole superconductivity is at quantum criticality between superconductivities of type I and II.

(c) The most plausible option is that the penetration of ordinary magnetic field to monopole super-conductor occur along non-monopole flux tubes at different space-time sheets so that it would therefore not spoil the super-conductivity at the monopole flux tubes.

The group of Suchitra Sebastian has discovered very unconventional condensed matter system, which seems to be simultaneously both insulator and conductor of electricity but only in presence of magnetic field. Science article is entitled "Unconventional Fermi surface in an insulating state" [L22] (see `http://tinyurl.com/y79qo7lp`). There is also a popular article with title "Paradoxical Crystal Baffles Physicists" in Quanta Magazine summarizing the findings (see `http://tinyurl.com/qhwdmxj`). I learned about the finding first from the blog posting of Lubos Motl (see `http://tinyurl.com/yacm6bj7`).

Observations

The crystal studied at superlow temperatures was Samarium hexaboride - briefly SmB_6. The high resistance implies that electron cannot move more that one atom's width in any direction. Sebastian et al however observed electrons traversing over a distance of millions of atoms- a distance of orde 10^{-4} m, the size of a large neuron. So high mobility is expected only in conductors. SmB_6 is neither metal or insulator or is both of them! The finding is described by Sebastian as a "big schock" and as a "magnificent paradox" by condensed matter theorists Jan Zaanen. Theoreticians have started to make guesses about what might be involved but accorrding to Zaanen there is no even remotely credible hypothesis has appeared yet.

On basis of its electronic structure SmB_6 should be a conductor of electricity and it indeed is at room temperature: the average number conduction electrons per SmB_6 is one half. At low temperatures situation however changes. At low temperatures electrons behave collectivily. In superconductors resistance drops to zero as a consequence. In SmB_6 just the opposite happens. Each Sm nucleus has the average 5.5 electrons bound to it at tight orbits. Below 223 degrees of Celsius the conduction electrons of SmB_6 are thought to "hybridize" around samarium nuclei so that the system becomes an insulator. Various signatures demonstrate that SmB_6 indeed behaves like an insulator.

During last five years it has been learned that SmB_6 is not only an insulator but also so called topological insulator. The interior of SmB_6 is insulator but the surface acts as a conductor. In their experiments Sebastian *et al* hoped to find additional evidence for the topological insulator property and attempted to measure quantum oscillations in the electrical resistance of their crystal sample. The variation of quantum oscillations as sample is rotated can be used to map out the Fermi surface of the crystal. No quantum oscillations were seen. The next step was to add magnetic field and just see whether something interesting happens and could save the project. Suddenly the expected signal was there! It was possible to detect quantum oscillations deep in the interior of the sample and map the Fermi surface! The electrons in the interior travelled 1 million times faster than the electrical resistance would suggest. Fermi surface was like that in copper, silver or gold. A further surprise was that the growth of the amplitude of quantum oscillations as temperature was decreased, was very

different from the predictions of the universal Lifshitz-Kosevich formula for the conventional metals.

Could TGD Help To Understand The Strange Behavior Of SmB$_6$?

There are several indications that the paradoxical effect might reveal the underlying dynamics of quantum TGD. The mechanism of conduction must represent new physics and magnetic field must play a key role by making conductivity possible by somehow providing the "current wires". How? The TGD based answer is completely obvious: magnetic flux tubes - one of the basic distinctions between electrodynamics of Maxwell and its TGD variant! Also the failure of Lischitz-Kosevich formulas should be understood.

1. Single sheet of many-sheeted space-time resembles topological insulator

One should also understand topological insulator property at deeper level, that is the conduction along the boundaries of topological insulator. One should understand why the current runs along 2-D surfaces. In fact, many exotic condensed matter systems are 2-dimensional in good approximation. In the models of integer and fractional quantum Hall effect electrons form a 2-D system with braid statistics possible only in 2-D system. High temperature super-conductivity is also an effectively 2-D phenomenon. By strong form of holography these aspects are also key aspects of quantum TGD at the fundamental level of single space-time sheet when the approximation replacing many-sheeted space-time with that of GRT and standard model does not mask the simplicity of the fundamental dynamics.

(a) Many-sheeted space-time is second fundamental prediction TGD. The dynamics of single sheet of many-sheeted space-time should be very simple by the strong form of holography implyhing effective 2-dimensionality. The standard model description of this dynamics masks this simplicity since the sheets of many-sheeted space-time are replaced with single region of slightly curved Minkowski space with gauge potentials sums of induced gauge potentials for sheets and deviation of metric from Minkowski metric by the sum of corresponding deviations for space-time sheets. Could the dynamics of exotic condensed matter systems give a glimpse about the dynamics of single sheet? Could topological insulator and anyonic systems [K72] provide examples of this kind of systems?

(b) Second basic prediction of TGD is strong form of holography: string world sheets and partonic 2-surfaces serve as kind of "space-time genes" and the dynamics of fermions is 2-D at fundamental level. It must be however made clear that at QFT limit the spinor fields of embedding space replace these fundamental spinor fields localized at 2-surface. One might argue that the fundamental spinor fields do not make them directly visible in condensed matter physics. Nothing however prevents from asking whether in some circumstances the fundamental level could make itself visible.

In particular, for large h_{eff} dark matter systems (, whose existence can be deduced from the quantum criticality of quantum TGD) the partonic 2-surfaces with CP_2 size could be scaled up to nano-scopic and even longer size scales. I have proposed this kind of surfaces as carriers of electrons with non-standard value of h_{eff} in QHE and FQHE [K72].

The long range quantum fluctuations associated with large, $h_{eff} = n \times h$ phase would be quantum fluctuations rather than thermal ones. In the case of ordinary conductivity thermal energy makes it possible for electrons to jump between atoms and conductivity becomes very small at low temperatures. In the case of large scale quantum coherence just the opposite happens as observed. One therefore expects that Lifshitz-Kosevich formula for the temperature dependence of the amplitude does not hold true.

The generalization of Lifschitz-Kosevich formula to quantum critical case deduced from quantum holographic correspondence by Hartnoll and Hofman [D49] (`http://tinyurl.com/ybednd85` is expected to hold true qualitatively also for quantum criticality in TGD sense. The first guess is that by underlying super-conformal invariance scaling laws typical for critical systems hold true. In the proposed formula the dependence on

temperature is via a power of dimensionless parameter $x = T/mu$;, where μ is chemical potential for electron system. As a matter fact, exponent of power of x appears and reduces to first for Lifshitz-Konsevich formula. Since magnetic field is important, one also expects that the ratio of cyclotron energy scale $E_c \propto \hbar_{eff} eB/m_e$ to Fermi energy appears in the formula. One can even make an order of magnitude guess for the value of $h_{eff}/h \sim 10^6$ from the facts that the scale of conduction and conduction velocity were millions times higher than expected.

Strings are 1-D systems and strong form of holography implies that fermionic strings connecting partonic 2-surfaces and accompanied by magnetic flux tubes are fundamental. At light-like 3-surfaces fermion lines can give rise to braids. In TGD framework AdS/CFT correspondence generalizes since the conformal symmetries are extended. This is possible only in 4-D space-time and for the embedding space $H = M^4 \times CP_2$ making possible to generalize twistor approach [K109].

(c) Topological insulator property means from the perspective of modelling that the action reduces to a non-abelian Chern-Simons term. The quantum dynamics of TGD at space-time level is dictated by Kähler action. Space-time surfaces are preferred extremals of Kähler action and for them Kähler action reduces to Chern-Simons terms associated with the ends of space-time surface opposite boundaries of causal diamond and possibly to the 3-D light-like orbits of partonic 2-surfaces. Now the Chern-Simons term is Abelian but the induced gauge fields are non-Abelian. One might say that single sheeted physics resembles that of topological insulator.

(d) The effect appears only in magnetic field. I have been talking a lot about magnetic flux tubes carrying dark matter identified as large h_{eff} phases: topological quantization distinguishes TGD from Maxwell's theory: any system can be said to possess "magnetic body", whose flux tubes can serve as current wires. I have predicted the possibility of high temperature super-conductivity based on pairs of parallel magnetic flux tubes with the members of Cooper pairs at the neighboring flux tubes forming spin singlet or triplet depending on whether the fluxes are have same or opposite direction.

Also spin and electric currents assignable to the analogs of spontaneously magnetized states at single flux tube are possible. The obvious guess is that the conductivity in question is along the flux tubes of the external magnetic field. Could this kind of conductivity explains the strange behavior of SmB_6. The critical temperature would be that in which the parallel flux tubes are stable. The interaction energy of spin with the magnetic field serves as a possible criterion for the stability if the presence of dark electrons stabilizes the flux tubes.

2. Magnetic flux tubes as dark current carriers in quantum criticality

The following represents an extremely childish attempt of a non-specialist to understand how the conductivity might be understood. The current carrying electrons at flux tubes near the top of Fermi surface are current carriers. $h_{eff} = n \times h$ and magnetic flux tubes as current wires bring in the new elements. Also in the standard situation one considers cylinder symmetric solutions of Schrödinger equation in external magnetic field and introduces maximal radius for the orbits so that formally the two situations seem to be rather near to each other. Physically the large h_{eff} and associated many-sheeted covering of space-time surface providing the current wire makes the situation different since the collisions of electrons could be absent in good approximation so that the velocity of charge carriers could be much higher than expected as experiments indeed demonstrate.

Quantum criticality is the crucial aspect and corresponds to the situation in which the magnetic field attains a value for which a new orbit emerges/disappears at the surface of the flux tube: in this situation dark electron phase with non-standard value of h_{eff} can be generated. This mechanism is expected to apply also in bio-superconductivity and to provide a general control tool for magnetic body.

(a) Let us assume that flux tubes cover the whole transversal area of the crystal and there is no overlap. Assume also that the total number of conduction electrons is fixed, and

depending on the value of h_{eff} is shared differently between transversal and longitudinal degrees of freedom. Large value of h_{eff} squeezes the electrons from transversal to longitudinal flux tube degrees of freedom and gives rise to conductivity.

(b) Consider first Schrödinger equation. In radial direction one has harmonic oscillator and the orbits are Landau orbits. The cross sectional area behaves like $\pi R^2 = n_T h_{eff}/2m\omega_c$ giving $n_T \propto 1/h_{eff}$. Increase of the Planck constant scales up the radii of the orbits so that the number of states in cylinder of given radius is reduced. Angular momentum degeneracy implies that the number of transversal states is $N_T = n_T^2 \propto 1/h_{eff}^2$. In longitudinal direction one has free motion in a box of length L with states labelled by integer n_L. The number of states is given by the maximum value N_L of n_L.

(c) If the total number of states is fixed to $N = N_L N_T$ is fixed and thus does not depend on h_{eff}, one has $N_L \propto h_{eff}^2$. Quanta from transversal degrees of freedom are squeezed to longitudinal degrees of freedom, which makes possible conductivity.

(d) The conducting electrons are at the surface of the 1-D "Fermi-sphere", and the number of conduction electrons is $N_{cond} \simeq dN/d\epsilon \times \delta\epsilon \simeq dN/d\epsilon T = NT/2\epsilon_F \propto 1/h_{eff}^4$. The dependence on h_{eff} does not favor too large values of h_{eff}. On the other hand, if scattering of electrons at flux tubes could be absent. The assumption $L \propto h_{eff}$ increases the range over which current can flow.

(e) To get a non-vanishing net current one must assume that only the electrons at the second end of the 1-D Fermi sphere are current carriers. The situation would resemble that in semiconductor. The direction of electric field would induce symmetry breaking at the level of quantum states. The situation would be like that for a mass in Earth's gravitational field treated quantally and electrons would accelerate freely. Schrödinger equation would give rise to Airy functions as its solution.

3. Quantum critical quantum oscillations

What about quantum oscillations in TGD framework?

(a) Quantum oscillation refers to de Haas-van Alphen effect (`http://tinyurl.com/yaaljv9j`) - an oscillation of the induced magnetic moment as a function of $1/B$ with period $\tau = 2\pi e/\hbar A$, where A is the area of the extremal orbit of the Fermi surface, in the direction of the applied field. The effect is explained to be due to the Landau quantization of the electron energy. I failed to really understand the explanation of this source and in my humble opinion the following arguments provide a clearer view about what happens.

(b) If external magnetic field corresponds to flux tubes, Fermi surface decomposes into cylinders parallel to the magnetic field since the motion in transversal degrees of freedom is along circles. In the above thought experiment also a quantization in the longitudinal direction occurs if the flux tube has finite length so that Fermi surface in longitudinal direction has finite length. One expects on basis of Uncertainty Principle that the area S of the cross section of Fermi cylinder in momentum space is given by $S \propto h_{eff}^2/\pi R^2$. This follows also from the equation of motion of electron in magnetic field. As the external magnetic field B is increased, the radii of the orbits decrease inside the flux tube, and in momentum space the radii increase.

(c) Why does the induced magnetic moment (magnetization) and other observables oscillate?

    i. The simplest manner to understand this is to look at the situation at space-time level. Classical orbits are harmonic oscillator orbits in radial degree of freedom. Suppose that the area of flux tube is fixed and B is increased. The orbits have radius $r_n^2 = (n+1/2) \times \hbar/eB$ and shrink. For certain field values the flux $eBA = n\hbar$ corresponds to an integer multiple of the elementary flux quantum . of a new orbit at the boundary of the flux tube emerges if the new orbit is near the boundary of Fermi sphere providing the electrons. This is clearly a critical situation.

    ii. In de Haas- van Alphen effect the orbit $n+1$ for B has same radius as the orbit n for $1/B+\Delta(1/B)$: $r_{n+1}(1/B) = r_n(1/B+\Delta(1/B))$. This gives approximate differential equation with respect to n and one obtains $(1/B)(n) = (n+1/2)\times\Delta(1/B)$. $\Delta(1/B)$ is fixed from the condition the flux quantization. When largest orbit is at the surface of the flux, tube the orbits are same for $B(n)$ and $B(n + 1)$, and this gives rise to the de Haas - van Alphen effect.

    iii. It is not necessary to assume finite radius for the flux tube, and the exact value of the radius of the flux tube does not play and important role. The value of flux tube radius can be estimated from the ratio of the Fermi energy of electron to the cyclotron energy. Fermi energy about .1 eV depending only on the density of electrons in the lowest approximation and only very weakly on temperature. For a magnetic field of 1 Tesla cyclotron energy is .1 meV. The number of cylinders defined by orbits is about $n = 10^4$.

(d) What happens in TGD Universe in which the areas of flux tubes identifiable as space-time quanta are finite? Could quantum criticality of the transition in which a new orbit emerges at the boundary of flux tube lead to a large h_{eff} dark electron phase at flux tubes giving rise to conduction?

    i. The above argument makes sense also in TGD Universe for the ordinary value of Planck constant. What about non-standard values of Planck constant? For $h_{eff}/h = n$ the value of flux quantum is n-fold so that the period of the oscillation in de Haas - van Alphen effect becomes n times shorter. The values of the magnetic field for which the orbit is at the surface of the flux tube are however critical since new orbit emerges assuming that the cyclotron energy corresponds is near Fermi energy. This quantum criticality could give rise to a phase transition generating non-standard value of Planck constant.
What about the period $\Delta(1/B)$ For $h_{eff}/h = n$? Modified flux quantization for extremal orbits implies that the area of flux quantum is scaled up by n. The flux changes by n units for the same increment of $\Delta(1/B)$ as for ordinary Planck constant so that de Haas -van Alphen effect does not detect the phase transition.

    ii. If the size scale of the orbits is scaled up by $\sqrt{n}$ as the semiclassical formula suggests the number of classical orbits is reduced by a factor $1/n$ if the radius of the flux tube is not changed in the transition $h \rightarrow h_{eff}$ to dark phase. n-sheetedness of the covering however compensates this reduction.

    iii. What about possible values of h_{eff}/h? The total value of flux seems to give the upper bound of $h_{eff}/h = n_{max}$, where n_{max} is the value of magnetic flux for ordinary value of Planck constant. For electron and magnetic field for $B = 10$ Tesla and has $n \leq 10^5$. This value is of the same order as the rough estimate from the length scale for which anomalous conduction occurs.

Clearly, the mechanism leading to anomalously high conductivity might be the transformation of the flux tubes to dark ones so that they carry dark electrons currents. The observed effect would be dark, quantum critical variant of de Haas-van Alphen effect!

Also bio-superconductivity is quantum critical phenomenon and this observation would suggests sharpening of the existing TGD based model of bio-super-conductivity. Superconductivity would occur for critical magnetic fields for which largest cyclotron orbit is at the surface of the flux tube so that the system is quantum critical. Quantization of magnetic fluxes would quantify the quantum criticality. The variation of magnetic field strength would serve as control tool generating or eliminating supra currents. This conforms with the general vision about the role of dark magnetic fields in living matter.

To sum up, a breakthrough of TGD is continuing. I have written about thirty articles during this year - more than one article per week. There is huge garden there and trees contain fruits hanging low! It is very easy to pick them: just shatter and let them drop to the basket! New experimental anomalies having a nice explanation using TGD based concepts appear on weekly basis and the mathematical and physical understanding of TGD is taking place with great leaps. It is a pity that I must do all alone. I would like to share. I can only hope that colleagues could take the difficult step: admit what has happened and make a fresh start.

4.10 A New Control Mechanism Of TGD Inspired Quantum Biology

The idea that TGD Universe is quantum critical, is the corner stone of quantum TGD and fixes the theory more or less uniquely since the only coupling constant parameter of the theory - Kähler coupling strength - is analogous to critical temperature. Also more than one basic parameters are in principle possible - maximal quantum criticality fixes the values of all of them - but it seems that only Kähler coupling strength is needed. TGD Universe is a quantum critical fractal: like a ball at the top of hill at the top of hill at.... Quantum criticality allows to avoid the fine tuning problems plaguing as a rule various unified theories.

4.10.1 Quantum Criticality

The meaning of quantum criticality 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 quantum criticality is behind all of them. Behind quantum criticality are in turn number theoretic vision and strong forms of general coordinate invariance and holography.

(a) The hierarchy of Planck constants defining hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of super-symplectic algebra for which conformal weights are n-ples of those for the entire algebra, n corresponds to the value of effective Planck constant $h_{eff}/h = n$. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question.

(b) Quantum criticality in turn reduces to the number theoretic vision about strong form of holography. 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.

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 the strong form of holography possible.

(c) 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. 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 giving huge flexibility. If this is not possible in the real sector, figment 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.

4.10.2 Quantum Criticality And TGD Inspired Quantum Biology

In TGD inspired quantum biology quantum criticality is in crucial role. First some background.

(a) Quantum measurement theory as a theory of consciousness is formulated in zero energy ontology (ZEO) and defines an important aspect of quantum criticality. Strong form of NMP states that the negentropy gain in the state function reduction at either boundary

of causal diamond (CD) is maximal. Weak form of NMP allows also quantum jumps for which negentropic entanglement is not generated: this makes possible ethics (good and evil) and morally responsible free will: good means basically increase of negentropy resources.

(b) Self corresponds to a sequence state function reductions to the same boundary of CD and h_{eff} does not change during that period. The increase of h_{eff} (and thus evolution!) tends to occur spontaneously, and can be assigned to the state function reduction to the opposite boundary of CD in zero energy ontology (ZEO). The reduction to the opposite boundary means death of self and living matter is fighting in order to avoid this even. To me the only manner to make sense about basic myth of Christianity is that death of self generates negentropy.

(c) Metabolism provides negentropy resources for self and hopefully prevents NMP to force the fatal reduction to the opposite boundary of CD. Also homeostasis does the same. In this process self makes possible evolution of sub-selves (mental images dying and re-incarnating) state function by state function reduction so that the negentropic resources of the Universe increase.

4.10.3   A New Mechanism Of Quantum Criticality

Consider now the mechanisms of quantum criticality. The TGD based model [L22] [**?**] (http://tinyurl.com/y8oblpl9) for the recent paradoxical looking finding [L22] (http://tinyurl.com/y79qo7lp) that topological insulators can behave like conductors in external magnetic field led to a discovery of a highly interesting mechanism of criticality, which could play a key role in living matter.

(a) The key observation is that magnetic field is present. In TGD framework the obvious guess is that its flux tubes carry dark electrons giving rise to anomalous currents running in about million times longer time scales and with velocity, which is about million times higher than expected. Also supra-currents can be considered.

   The currents can be formed of the cyclotron energies of electrons are such that they correspond to energies near the surface of the Fermi sphere: recall that Fermi energy for electrons is determined by the density of conduction electrons and is about 1 eV. Interestingly, this energy is at the lower end of bio-photon energy spectrum. In the field of 10 Tesla the cyclotron energy of electron is .1 mV so that the integer characterizing cyclotron orbit must be $n \simeq 10^5$ if conduction electron is to be transferred to the cyclotron orbit.

(b) The assumption is that external magnetic field is realized as flux tubes of fixed radius, which correspond to space-time quanta in TGD framework. As the intensity of magnetic field is varied, one observes so called de Haas-van Alphen effect (http://tinyurl.com/hoywcnq) used to deduce the shape of the Fermi sphere: magnetization and some other observables vary periodically as function of $1/B$ (for a model for the quantum critical variant of the effect see [D49]).

   This can be understood in the following manner. As B increases, cyclotron orbits contract. For certain increments of $1/B$ $n + 1$:th orbit is contracted to n:th orbit so that the sets of the orbits are identical for the values of $1/B$, which appear periodically. This causes the periodic oscillation of say magnetization.

(c) For some critical values of the magnetic field strength a new orbit emerges at the boundary of the flux tube. If the energy of this orbit is in the vicinity of Fermi surface, an electron can be transferred to the new orbit. This situation is clearly quantum critical.

   If the quantum criticality hypothesis holds true, $h_{eff}/h = n$ dark electron phase can be generated for the critical values of magnetic fields. This would give rise to the anomalous conductivity perhaps involving spin current due to the spontaneous magnetization of the dark electrons at the flux tube. Even super-conductivity based on the formation of parallel flux tube pairs with either opposite or parallel directions of the magnetic flux such that the members of the pair are at parallel flux tubes, can be considered

and I have proposed this a mechanism of bio-superconductivity and also high Tc super-conductivity.

4.10.4 A New Mechanism Of Quantum Bio-Control

The quantum criticality of the process in which new electron orbit emerges near Fermi surface suggests a new mechanism of quantum bio-control by generation of super currents or its reversal.

(a) In TGD inspired quantum biology magnetic body uses biological body as motor instrument and sensory receptor and EEG and its fractal variants with dark photons with frequencies in EEG range but energy $E = h_{eff}f$ in the range of bio-photon energies make the necessary signalling possible.

(b) Flux tubes can become braided and this makes possible quantum computation like processes [K2]. Also so called 2-braids - defined by knotted 2-surfaces imbedded in 4-D space-time surface - are possible for the string world sheets defined by flux tubes identified to be infinitely thin, are possible. As a matter fact, also genuine string world sheets accompany the flux tubes. 2-braids and knots are purely TGD based phenomenon and not possible in superstring theory or M-theory.

(c) It is natural to speak about motor actions of the magnetic body. It is assumed that the flux tubes of the magnetic body connect biomolecules to form a kind of Indra's web explaining the gel like character of living matter. h_{eff} reducing phase transitions contract flux tubes connecting biomolecules so that they can find each other by this process and bio-catalysis becomes possible. This explains the mysterious looking ability of bio-molecules to find each other in the dense molecular soup. In fact the dark matter part is far from being soup! The hierarchy of Planck constants and $h_{eff} = h_{gr}$ hypothesis imply that dark variants of various particles with magnetic moment are neatly at their own flux tubes like books in shelf.

Reconnection of the U-shaped flux tubes emanating from two subsystems generates a flux tube pair between them and gives rise to supracurrents flowing between them. Also cyclotron radiation propagating along flux tubes and inducing resonant transitions is present. This would be the fundamental mechanism of attention.

(d) I have proposed that the variation of the thickness of the flux tubes could serve as a control mechanism since it induces a variation of cyclotron frequencies allowing to get in resonance or out of it. For instance, two molecules could get in flux tube contact when the cyclotron frequencies are identical and this can be achieved if they are able to vary their flux tube thickness. The molecules of immune system are masters in identifying alien molecules and the underlying mechanism could be based on cyclotron frequency spectrum and molecular attention. This would be also the mechanism behind water memory and homeopathy (`http://tinyurl.com/yda3d6se` [K42] which still is regarded as a taboo by mainstreamers.

(e) Finally comes the promised new mechanism of bio-control. The variation of the magnetic field induced by that of flux tube thickness allows also to control whether there is quantum criticality for the generation of dark electron supra currents of electrons. The Fermi energy of the conduction electrons at the top of Fermi sphere is the key quantity and dictated by the density of these electrons. This allows to estimate the order of magnitude of the integers N characterizing cyclotron energy for ordinary Planck constant and the maximal value of $h_{eff}/h = n$ cannot be larger than N.

4.11 TGD based model for graphene superconductivity

A highly interesting new effect associated with graphene is discussed in Phys.Org article (see `http://tinyurl.com/ydyqgk56`). The original research articles by Cao *et al* are published in Nature [D23, D24]. There is also a popular article In Nature (see `http://tinyurl.`

com/ya5jzadc). What is found that a bilayer formed by parallel graphene sheets becomes superconducting for critical values of twist angle θ. The largest critical value of θ is $\theta = 1.1$ degrees.

The finding of Cao *et al* is believed to be highly significant concerning the understanding of high T_c super-conductivity and motivates the development of a model of Mott insulators based on TGD based views about valence bond inspired by the identification of dark matter as $h_{eff}/h = n$ phases of ordinary matter emerging naturally in adelic physics [L52] [L51]. Also a more detailed version about the model of high T_c superconductivity in TGD Universe developed in [K17, K18, K77, K78] emerges.

4.11.1 Basic observations

Consider first the basic facts. The surprising discovery was that graphene becomes unconventional superconductor at temperature 1.7 K. It was already earlier discovered that the coupling of graphene to a superconductor can make also graphene superconducting.

(a) The system studied consists of two graphene (see http://tinyurl.com/8os5eas) layers twisted by angle θ with respect to each other (rotation of the second sheet by angle θ around the axis normal to sheets). For a generic value of θ the graphene layers behave as separate conductors. For certain critical twist angles below 1.1 degrees the two-layered system however behaves like single unit and Mott insulator (see http://tinyurl.com/ybqblvc7): this is due to the increase of the conduction band gap. In an applied electric field the system becomes a super conductor. The electric field provides the energy needed to kick the current carries to the conduction band, which for Mott insulators has higher energy than for the corresponding conductor: at the top of the band Cooper pairs are formed as in the case of ordinary superconductors.

(b) A kind of Moire effect (see http://tinyurl.com/qchunes) is involved. The twist creates a superlattice with larger unit cell and the electrons associated with periodically occurring C-atom pairs above each other give rise to a narrow band where the superconducting electrons are. Electric field would kick the electrons to this band.

(c) There are intriguing analogies with high T_c superconductivity. Electron density as function of temperature has a pattern similar to that for cuprates. Superconductivity occurs at electron density, which is 10^{-4} times that for conventional superconductors at the same temperature. The pairing of electrons cannot be due to phonon exchange since the density is so low. Unidentified strong interaction between electrons is believed to be the reason.

4.11.2 Mott insulators, transition metals, antiferromagnets, and high T_c superconductors in TGD framework

In 1937 Jan Hendrik de Boer and Evert Johannes Willem Verwey pointed out that a variety of transition metal oxides are insulators although they should be conductors since they have odd number of electrons per lattice cells. Nevill Mott and Rudolf Peierls predicted that the effect can be explained by taking into account the interaction between electrons neglected in the band theory of solids. These materials became known as Mott insulators (see http://tinyurl.com/ybqblvc7).

(a) 1949 Mott proposed a model for NiO as insulator (Ni is transition metal). The conduction was based on the process $(Ni^{2+}O^{2-})^2 \to Ni^{3+}O^{2-} + Ni^{1+}O^{2-}$. In this process electron is transferred between the neighboring sites. For critical values of parameters NiO however becomes insulator.

The formation of energy gap preventing conduction can be understood as competition between Coulomb potential U between 3d electrons at the same site and the transfer integral t of 3d electrons between neighboring sites characterizing the transfer of electron between neighboring sites. The total energy bap is $U - 2zt$, where z is the total number

of nearest-neighbor atoms. As U is increased by varying parameters a transition to insulator takes place when the energy gap becomes too large.

t is essentially the matrix element of atomic potential ΔU due to the neighboring atoms taken between two electronic orbitals associated with neighboring atoms. Usually this matrix element is small.

(b) It is believed that ordinary quantum mechanics can explain the needed large magnitude of t. The calculations are however not first principle calculations and involve experimental input from chemical bond energy data. Therefore one can ask whether some new physics possible related to the notion of valence bond might be needed.

In TGD framework one indeed ends up to a model of valence bonds involving nonstandard value of $h_{eff}/n = n$ for valence bonds. This could lead to a delocalization of electron wave functions and generate strong interaction between valence electrons of neighboring atoms. This mechanism might apply to all strongly interacting many-electron systems (such as that appearing in QHE and FQHE [K72]) so that the physics of dark matter would make itself visible in condensed matter physics thought to be thoroughly understood at the level of basic principles.

Remark: The original motivation for the hierarchy of Planck constants was the idea that Nature loves theoreticians [K37, **?**]. The phase transition increasing the value of Planck constant reduces the large value of gauge coupling constant $\alpha = g^2/4\pi\hbar$ making perturbation theory impoessible by factor $1/n$ and makes perturbation theory possible.

The TGD based picture about Mott insulators relies on $h_{eff}/h = n$ hierarchy giving rise to dark matter as phases of ordinary matter. In particular, one ends up with a model for valence bonds with valence electrons having value of n larger than for atoms. This in turn leads to a model of high T_c superconductivity generalizing to a model of Mott insulators. Also graphene superconductivity would rely on these mechanisms.

Dark matter as $h_{eff}/h = n$ phases

It is good to explain first the development of the ideas related to $h_{eff}/h = n$ hierarchy.

(a) I ended up to the discovery of dark matter hierarchy and eventually to adelic physics [L51], where $h_{eff}/h = n$ has number theoretic interpretation along several roads starting from anomalous findings.

One of these roads began from the claim about the existence of strange form of matter by David Hudson [H4]. Hudson associated with these strange materials several names: White Gold, monoatomic elements, and ORMEs (orbitally re-arranged metallic elements). Any colleague without suicidical tendencies would of course refuse to touch anything like White Gold even with a 10 meter long pole but I had nothing to lose anymore. The basic feature is that these elements would form metal like strongly correlates structure although the atoms are separate so that their is no lattice in the usual sense.

My question was how to explain these elements if they are actually real [K17, K36]. If all valence electrons of this kind of element are dark these element have effectively full electron shells as far as ordinary electrons are considered and behave like noble gases with charge in short scales and do not form molecules. Therefore "monoatomic element" is justified. Of course, only the electrons in the outermost shell could be dark and in this case the element would behave chemically and also look like an atom with smaller atomic number Z. So called Rydberg atoms for which valence electrons are believed to reside at very large orbitals could be actually dark atoms in the proposed sense.

Obviously also ORME is an appropriate term since some valence electrons have re-arranged orbitally. White Gold would be Gold but with dark valence electron. The electron configuration of Gold is $[Xe]4f^{14}5d^{10}6s^1$. There is single unpaired electron with principal quantum number $m = 6$ and this would be dark for White Gold and chemically like Platinum (Pt), which indeed has white color.

Remark:: The precious metals involved are also transition metals near the end point of the group along the row of the periodic table as are also Mott insulators.

The ability of ORMES consisting of single isolated atoms to behave like condensed matter system would be due to the presence of long magnetic flux tubes assignable to valence electrons with large n and connecting the atoms of ORMUS together. For ordinary valence bonds the flux tubes are short and one obtains ordinary metal lattice.

(b) Developments at quantitative level began with the TGD based explanation [L50] (see `http://tinyurl.com/y8pqcc8s`) for the finding that in heating of a system involving transition metal unpaired valence electrons mysteriously disappear. The increase of $h_{eff} = n \times h$ for valence electrons in transition metals from their normal value would explain how they become dark matter in TGD sense. Since the binding energy associated with the bond increases with n, energy is required to kick electrons to the dark valence band and heating provides it. In TGD inspired quantum biology, metabolic energy increases the value of n for valence bonds and makes possible quantum coherence in unusually long length scales.

(c) This model led soon to a TGD inspired model for valence bonds [L47] (see `http://tinyurl.com/ycg94xpl`). The value of n for valence bond depends on the valence of the atom having larger electronegativity (more towards right along the row of the Periodic Table) and increases as one moves along the row: this guarantees that the bond energies vary only weakly along the row of the periodic table. The simple expectation form ordinary quantum theory is that the dependence of bond energy should be rather strong.

The outcome is a vision about biochemistry and the roles of various valence bonds in metabolism. The valence bonds associated with atoms with high electronegativity carry especially larger metabolic energy identified as the difference of the bond energies for the actual value n_{bond} of n and its value n_{atom} for free atom. Catabolism would liberate this energy by reducing the values of n_{bond}.

Many-sheeted description of conductors

The first question is what electrons and elementary particles are at space-time level in TGD Universe.

(a) In many-sheeted space-time elementary particles are two-sheeted structures consisting of two wormhole contacts, whose throats are connected by flux tubes at both sheets. The flux tubes at other sheet defining the magnetic body of the particle could have large value of $h_{eff}/h = n$ and be rather long. For instance, in atomic nucleus the flux tubes connecting nuclei to a nuclear string would be short with length L of order nucleon size but the flux tubes at the sheet defining magnetic body would be considerably longer - naturally given by nuclear length scale [L4, K21]. The length would be even longer for dark nuclei [L41].

(b) Many-sheeted space-time predicts a hierarchy of space-time sheets and magnetic fields in various scales would correspond to these sheets and be represented as flux tubes. Flux tubes within flux tubes is what comes naturally in mind. Valence bonds would correspond to flux tubes defining only one level in this length scale hierarchy. Certainly this level is higher than elementary particle level, which corresponds to the Compton size of elementary particle.

(c) Valence flux tubes could correspond to the magnetic body of the particle and have large valued of n. In accordance with the TGD view about valence bonds [L47] (see `http://tinyurl.com/ycg94xpl`) the value of n for valence bonds making possible also conductivity is larger than for free atoms.

Remark: TGD Universe is fractal and this picture about elementary particles and their magnetic body is very similar to the view about galaxies as knots in long flux tube and having protuberances analogous to the flux loops and containing stars as sub-knots [L63] (see `http://tinyurl.com/ybbs9zhp`).

What makes the system a conductor?

(a) Suppose that valence bonds indeed correspond to flexible loop like structures, which can be rather long for large values of n. Could the hopping of electrons between neighboring molecules (or atoms) be basically a topological process?

Could the valence flux loops of neighboring molecules (say NiO) temporarily reconnect to form a pair of flux tubes connecting the molecules so that electrons can propagate along the these flux tubes between molecules?

There would be no resistance during the flow along flux tube but the stopping at the end of the flux tubes would contribute to the resistance. In absence of electric field the currents are in random direction but the presence of electric field would make possible a net current.

(b) One can try to relate this picture also to the standard description of conductivity obtained replacing many-sheeted space-time with that of special relativity so that all information about space-time topology is lost. What remains are the parameters U and t defined as matrix element of ΔU and the gap energy for the conduction band defined as $U - 2zt$.

A de-localization of electrons occurs in conductivity due to temporary reconnections inducing hopping of electrons between neighboring sites. The increase of n increases various quantum scales. In particular, the length of valence bond increases and the wave functions for valence electrons are de-localized in a larger volume.

Therefore the matrix elements of ΔU receive contributions from a volume, where ΔU is large. For flux tubes connecting neighboring unit cells it could be even larger than this.

Also the value of U as expectation value of Coulombic energy for single site is affected. When the value of the competing parameter U becomes large enough, band gap becomes so large that conductivity is lost and one has Mott insulator.

4.11.3 Mott insulators in TGD framework

In TGD framework the new view about valence bonds and anti-ferromagnetism provides new insights about Mott insulators.

(a) The valence bonds for oxides such as NiO should have high values of n and for certain critical parameter values (quantum criticality) n might become even higher than for ordinary valence bonds. This would increase the quantum coherence length measured by the flux tubes connecting neighboring molecules: the naïvest guess is that it is proportional to n (for the atomic orbitals it is proportional to n^2). This makes makes possible quantum coherence in longer scales than usually possibly leading to a formation of Cooper pairs implying super-conductivity at least in short scales at low enough temperatures.

(b) Transition metal property is essential for being a Mott insulator. The table of Wikipedia article gives an overall view about transition metals (see `http://tinyurl.com/ydyqunm4`). There are 4 groups corresponding to the values $r = 4, 5, 6, 7$ labelling the rows of the Periodic Table.

Ni atoms appearing in Mott insulator NiO and Cu atoms appearing in copper oxide high T_c superconductors belong to the group 4 of transition metals, which means that they belong to the fourth row of the Periodic Table (principal quantum number of highest valence electrons equals to 4). Ni and Cu are at the right end of the portion of 4th row containing transition metals. The value of n for copper oxides is predicted by TGD based model of valence bond to be highest in group 4 and second highest for Ni [L47] (see `http://tinyurl.com/ycg94xpl`). Copper oxides are therefore ideal candidates for high T_c superconductors in TGD Universe!

For the groups 5, 6, and 7 the oxides of the elements towards the ends of these rows, in particular those of the rightmost elements in the group are Ag, Au, and Hs are good candidates for high T_c superconductors if the TGD based interpretation makes sense. One can also ask whether T_c could be higher for the transition metals of higher groups.

Remark: ORMEs are precious metals belonging to 5th and 6th groups of transition metals and claimed to be superconducting at room temperatures. Their claimed healthy effects could be due to the large metabolic energy content of the valence bonds involved liberated when utilized.

(c) Anti-ferromagnetism is also essential for Mott insulator property besides the property called "mottism" summarized above. Also copper oxides are anti-ferromagnetic (AFM) and the TGD based model relies on the existence of parallel flux tubes carrying magnetic fluxes with same magnitudes but opposite directions [K77, K78]. The members of Cooper pairs are at different flux tubes and form spin singlets.

(d) An intriguing property of Mott insulators is the existence of bosonic excitations with charge 2e. They must consist of 2 electrons (see `http://tinyurl.com/ydyqunm4`) and are therefore natural candidates for the precursors of Cooper pairs in unconventional superconductivity.

Transition to non-conventional superconductivity

What could happen in the transition to non-conventional superconductivity?

(a) Anti-ferromagnetism is a necessary ingredient. It requires the presence of flattened square shaped flux tube loops with opposite directions of magnetic flux for the opposite sides of the flattened square. Also the flux tubes defining the valence bonds and assignable to the magnetic bodies of electrons are present. The temporary reconnection of the valence flux loops would give rise to ohmic conductivity.

Could the valence flux tubes temporarily reconnect with AFM flux tubes inducing the transfer of electrons to them so that supra current would flow along the resulting flux tube pairs and one would have high T_c superconductivity.

There is however an objection against this idea. Valence electrons are responsible for ferromagnetism: can one really distinguish between the AFM flux loops and valence flux loops. Many-sheeted space-time suggests that this is spossible. AFM loops would correspond to a higher level in the hierarchy of space-time sheets than valence loops do. Cooper pairs reside at these flux tubes whereas Ohmic current carriers reside at the valence loops.

(b) How exactly are the Cooper pairs formed? Are they formed as Cooper pairs with members assignable to neighboring lattice sites and are these pairs transferred to AFM flux tube pairs by temporary reconnections? If so, the basic mechanism giving rise to supra current would be purely topological.

As already mentioned, Mott insulators are characterized by the existence of bosonic excitations with charge 2e, which must consist of 2 electrons (see `http://tinyurl.com/ydyqunm4`). This would suggest that they are precursors for the Cooper pairs of high T_c super-conductors appearing below the upper critical temperature T_{c1} but not yet giving rise to superconductivity in long length scales? The transition to superconductivity for Mott insulators would be analogous to the transition to super-conductivity for high T_c superconductors.

(c) According to TGD based model of high T_c superconductors [K17, K18, K77, K78] the transition to superconductivity would take place at two steps. At higher critical temperature T_{c1} a phase transition to a state containing Cooper pairs takes place but there is no super-conductivity in long scales yet. Supra currents would be associated with AFM flux loops having the shape of a flattened rectangle such that magnetic fluxes have opposite directions at the opposites sides of the rectangle. At lower temperature T_c a phase transition to a genuine super-conductivity takes place: sequences of the flux loops would reconnect to much longer flux loops making possible macroscopic supra currents.

4.11.4   TGD description for the super-conductivity of graphene

The above general model for high T_c super-conductivity and Mott insulators can be applied also to graphene bi-layer.

(a) Graphene sheets are hexagonal lattices formed from aromatic rings of 6 C-atoms. Delocalization occurs for valence electrons inside 6-rings and a further delocalization occurs as the hexagonal lattice is formed and gives rise to conductivity. The current flow would be along routes associated with the flux tube network formed from the hexagons. As already explained, in the TGD based model for valence bonds the value of $h_{eff}/h = n$ is higher for valence bonds than for atoms.

(b) For the generic twist angle θ the graphene sheets behave like independent conductors with a weak interaction. For critical twist angles the system behaves as a single coherent unit and becomes Mott insulator. The increase of h_{eff} increases the energy of the valence bond increasing band gap so that it becomes difficult to kick electrons to valence band by thermal energy. Conductivity is lost. The increase of quantum coherence length can however lead to a formation of Cooper pairs (as in Mott insulators quite generally) and an applied electric field can kick the electrons to a new conduction band allowing super-conductivity.

(c) The critical twist angle can be understood in terms of a generation of lattice like structure with an increased size of the lattice cell. At the nodes of this super-lattice the carbon atoms of two sheets would be directly above each other. The formation of this super-lattice is known as Moire effect (see `http://tinyurl.com/qchunes`).

Cooper pairs would have periodic wave functions in the superlattice. Wave length would be equal to the lattice constant of the superlattice in the simplest situation. $h_{e}ff/h = n$ view about dark matter would suggest that the members of Cooper pair are dark ($n = n_s$) and that the ratio of the lattice cells sizes for super-lattice (l_s) and the original lattice (l) equals to the ratio of corresponding values of n: $l_s/l_1 = n_s/n$.

(d) Precursors of the Cooper pairs should be associated with the combination of flux tube networks defined by the two graphene lattices and would be transferred to AFM flux loops having longer length and reconnecting to long flux flux tube pairs.

Since superconductivity occurs only for a critical twist angle, a pairing of flux tubes connecting the nodes of the super-lattice should take place. The members of Cooper pair should be associated with members of these flux tube pairs. The distance between Cooper pairs would have upper bound give by l_s.

4.12   Rydberg polarons as a support for TGD view about space-time

I learned about very weird looking phenomenon (see popular article at `http://tinyurl.com/y96p48u5`) involving Bose-Einstein condensate (BEC) of strontium atoms at ultralow temperature corresponding to $T = 1.5 \times 10^{-7}$ K and thus thermal energy of order 10^{-11} eV. Experimenters create Rydberg atoms by applying a laser beam to BEC of strontium atoms: second valence electron of Sr is kicked to at an orbital with very large classical radius characterized by the principal quantum number n. This leads to a formation of "molecules" of BEC atoms inside the orbit of Rydberg electron - Rydberg polarons as they are called. The term polaron comes from charge separation in the scale of polaron.

It seems strange that a tiny electron would be able to confine BEC molecules inside its orbit. The Rydberg polaron has several counter intuitive properties distinguishing it from ordinary polarons. Skeptic can also ask whether the formation of Rydberg atoms only makes the detection of BEC molecules possible when the atom to become Rydberg atom belongs to an already existing BEC molecule.

4.12.1   Experimental findings

From the research article [D22] (see `http://tinyurl.com/ybqb7bmv`) one learns that the experimenters use in a very clever manner the information about low energy scattering of Rydberg atoms in s and p partial waves to deduce so called Born-Oppenheimer potential (BOP). BOP is analogous to that used in molecular physics to deduce electronic states assuming molecular positions fixed. Now however Rydberg state for electron is fixed and one solves the states of BEC in this potential! The idea is that BEC behaves as a single particle. The objection to this is is that the states are reported to be more like molecules of some BEC molecules containing also the Rydberg atom.

BOP is a combination of $|\Psi_R|^2$ and $|\nabla\Psi_R|^2$ with coefficients proportional to s- and p-wave scattering lengths A_s and A_p (which is momentum dependent) deduced from the low energy scattering of Rydberg atoms from BEC. The explicit expression for the BOP is given as

$$V(r) \quad = \quad \frac{2\pi\hbar^2}{m_e}\left[A_s|\Psi_R|^2 + 3A_p|\nabla\Psi_R|^2\right] \quad . \tag{4.12.1}$$

Here $\Psi(r)$ is the wave function of Rydberg electron. By using rather advanced methods (functional determinant approach (FDA) and mean field theory) the experimenters estimate the bound state energies of BEC atoms in BOP numerically. The bound states would be localized states associated with the minima of the BOP having oscillatory behavior.

The claim is that the experimental findings provide support the existence of these bound states. Usually polarons involve positive energy excitations of the surrounding medium - "cloud" - but now it would be negative energy excitations - bound states - that would be excited. The excitation means that energy is drawn from BEC by dropping some particle to negative energy state: this would be an analog of metabolism.

One can test this proposal experimentally by using two laser beams with frequencies 689 nm and 319 nm. The first beam generates intermediate excitations $5s^2 \to 5s5p^3P_1$ and latter beam the Rydberg excitations $5s5p^3P_1 \to 5snp^3S_1$. The frequency of 319 nm beam must be varied to cover the excitations corresponding to various values of n. Since the dependence of the bound states energy is of form $1/n^2$, a rather slight variation is enough to cover a wide range of values of n. One obtains peaks corresponding to various values of n.

The peaks labelled by n have however sub-structure. One can vary the beam frequency slightly downwards from the frequency $\nu_R(n)$, which generates free Rydberg atom. For given n one finds spectral peaks at lower frequencies $\nu = \nu_R(n) - \Delta\nu$. The data is expressed in terms of function $A(\nu)$ telling the intensity of the absorption of laser photons at given frequency ν, and one can estimate binding energies from the values of $\Delta E = h\Delta\nu$. For $n = 38$ $\Delta\nu$ is in the range $[1, 40]$ MHz so that the binding energies ΔE are in the range $[1, 40] \times .4 \times 10^{-8}$ eV. The peak gets narrower for larger values n scaling like $1/n^3$ suggesting that the values of $\Delta\nu$ scales like $1/n^3$.

Remark: This is true for the ordinary value of Planck constant. For non-standard value $h_{eff}/h = n$ of Planck constant the estimate for the binding energies $\Delta E = h_{eff}\Delta\nu$ would be scaled up. This would mean that also the beam energy is scaled up and this looks unrealistic. Since the temperature is extremely low, large $h_{eff}/h = n$ is not needed for macroscopic quantum coherence. Indeed, the thermal wavelength $\sqrt{1/2m_eT}$ of electron giving an idea about the scale of spatial quantum coherence is at the temperature considered of order 100 μm.

Fig. 2 of the article (see `http://tinyurl.com/ybqb7bmv`) shows for $n = 38$ clearly the peaks at multiples of -5 MHz corresponding to $\Delta E = -2.1 \times 10^{-8}$ eV for the corresponding energy interpreted as binding energy rather than positive excitation energy in the initial state. The appearance of integer multiples suggests that harmonic oscillator excitations involving one or several oscillators are in question. What looks strange that the spectrum of excitations has negative rather than positive energies. The finding is interpreted as a direct evidence for the

existence of BEC molecules - Rydberg polarons predicted by the model based on scattering length data. For a small number of BEC atoms one can even study the molecules.

Remark: The analogy with harmonic oscillator spectrum leads to ask whether a genuine harmonic oscillator spectrum with positive excitation energies could be in question - say cyclotron energy spectrum for electrons in an external magnetic field B_R assignable to the pair of s-wave electrons of Rydberg atom and having therefore positive excitation energies. The interpretation would be in terms of the analog of metabolism analogy also now. The excited Rydberg atom would drop some BEC atoms to lower energy state and in this manner extract energy from BEC.

Authors report several features distinguishing the Rydberg polaron from ordinary polaron. Ordinary polaron corresponds to a ground state of a many-particle system but now one has multiple excitations from the ground state. Also the importance of bound states would distinguish Rydberg polaron from ordinary polarons. A universal behavior of the spectral line shape decreasing like $1/n^3$ as a function of principal quantum number characterizing the Rydberg electron suggests that quantum criticality. Also the narrowing of the spectral features with n is reported.

In the model of experimenters the binding energy spectrum depends on the value of the principal quantum number n since the positions of zeros of $V(r)$ depend on n. Since $V(r)$ is product of exponent function and polynomial of order $2n$, $dV(r)/dr$ has at most $2n - 1$ real zeros and at most n minima. One expects that harmonic oscillator strength has different values for these zeros, which also depends on n. One obtains in harmonic oscillator approximation integer multiples of the basic energy depending on the minimum of $V(r)$.

On basis of the article, I am not able to tell whether the authors have any concrete model for what the assumed (effectively contact -) interaction between the Rydberg atoms and BEC atom is. What this interaction is and how it leads to a generation of bound states (not necessarily!) in the case of BEC atoms but not in the case of ordinary atoms, remains a mystery to me. The question whether TGD might provide some ideas about in this respect, served as the basic motivation for the following considerations. This led to a considerably more detailed understanding about how TGD differs from Maxwellian electrodynamics.

4.12.2 Could TGD say something interesting about Rydberg polarons?

The obvious question in TGD framework is whether this mysterious interaction giving rise to the BEC molecules (or whatever they are) could be understood using the notions of many-sheeted space-time, magnetic flux quanta, and possibly also the identification of dark matter as phases of ordinary matter with non-standard value of $h_{eff}/h = n$.

Some applications of TGD view about space-time

I have applied this general rule in various scales with inspiration coming from the fractality of TGD Universe.

(a) Elementary particles correspond in TGD pairs of wormhole contacts connected by flux tubes at both space-time sheets involved. Hadrons involve color flux tube structures carrying most of the energy of the hadron [K55, K60, K61].

(b) Atomic nuclei and their dark variants explaining "cold fusion" are nuclear strings [L20, L41]. Dark nuclear strings are also in central role in TGD inspired quantum biology [L56] and their states are in correspondence with DNA, RNA, tRNA, and amino-acids [L29].

(c) In TGD based view about chemistry valence bonds correspond to flux tubes with non-standard value of $h_{eff}/h = n$ [L47]. In biology valence bonds are carriers of metabolic energy with n measuring the amount of metabolic energy and increasing along the row of the Periodic Table. The model conforms with empirical facts and explains why the molecules towards the right end of the rows of the Periodic Table are carriers of metabolic energy.

(d) Superconductivity and superfluidity are natural applications [**?**, K71]. Flux tubes would serve as correlates for the correlation of the members of Cooper pair. In high T_c superconductivity supra currents flow along the flux tubes [K77, K78].

(e) In neuroscience and biology the quantum entangled networks of neurons and cells define the correlates of mental images at the level of brain and body and also the part of magnetic body outside biological body is in central role [L40, L61]. Gravitational and other interactions are mediated along flux tubes and here the notion of gravitational (electromagnetic, etc) Planck constant is very useful [K93, K69, K71]. The notion of gravitational Planck constant $h_{eff} = h_{gr}$ is assignable to the flux tubes mediating gravitational interaction and having very large value is involved also with TGD inspired quantum biology and neuroscience [K12, K22].

(f) At the second end of the scale hierarchy there is a model for the formation of galaxies as knots of long flux tubes carrying dark energy and dark matter and having stars as sub-knots of these knots. Second example is nuclear physics and its dark variants.

What guidelines to follow?

The listed successful applications encourage to ask whether the TGD could provide a model for Rydberg polaron. There are several guidelines to follow.

(a) The key question concerns the role of Rydberg atom. Does its formation lead to the generation of Rydberg molecules or are they already present in BEC. The mechanism for the formation of the Rydberg molecules depends crucially on the answer to this question. If Rydberg atom is necessary, the magnetic field induced by the formation of Rydberg atom could be crucial for understanding what happens. This would also force the intepretation about the role of bound states unless the arrow of geometric time changes temporarily in the process. If Rydberg atom is not necessary, then alternative options can be considered.

(b) The notion of cyclotron BEC as a condensate of cyclotron states of charged bosons or Cooper pairs playing important role in TGD inspired biology is of special interest since it could explain the appearance of excitation energies as basic energy identifiable as cyclotron energy. The BECs of electron Cooper pairs and of biologically important ions or their Cooper pairs are central in TGD based of quantum biology and neuroscience. What is encouraging that the energies identified as bound state energies have scale assignable to cyclotron states in magnetic field which is roughly $3.3 \times B_E$, where $B_E \simeq .5$ Gauss is the nominal value of the magnetic field B_E of Earth.

Remark: The strength of B_E varies in the range $[.25, .65]$ Gauss and one cannot exclude the possibility that $B_{end} = .2$ Gauss corresponds to minimum value of B_E achieved at equator. In dipole approximation the strength at poles is two times higher.

(c) One can of course argue that the introduction of an external magnetic field is unrealistic. I do not know whether this is the case: dark magnetic fields would not be observable using the detection methods of standard physics. On the other hand, the origin of B_{end} has remained a mystery. Could its flux tubes connect charged particles of opposite spin so that B_R and B_{end} would accompany essentially same physical phenomenon?

(d) The analogy with metabolism suggests the possible relevance of zero energy ontology (ZEO) leading to the proposal of what I call remote metabolism involving temporary reversal of the arrow of time at some level of the hierarchy of space-time sheets labelled by preferred p-adic primes and values of n and making possible for the system to extract energy from environment in apparent contradiction with the second law.

In the recent case the problem is that one would expect that the energy of laser photon is shared between the Rydberg atom and other BEC atoms. Just the opposite happens. One might argue that this is not a problem since temperature is so low but I am not certain about this. There is also a second problem: if B_R is responsible for the cyclotron states, then the only sensible interpretation is that the arrow of geometric

time is temporarily changed since before its cyclotron BEC providing the "metabolic energy" is not present.

In ZEO "big" state function reduction behind TGD inspired theory of consciousness means temporary reversal of arrow of time for the entire system [L54]. Conscious entity as a generalized Zeno effect in turn would correspond to a sequence of ZEO analogs of weak measurements and dying when the big reduction takes place.

What looks for the observed with standard arrow of time like extraction of metabolic energy from BEC would correspond to sharing it with BEC if the arrow of time changes temporarily. This might relate to the finding that the entanglement between electrons of Sr^+ ions lasts surprisingly long time - 15 seconds. Could this time correspond to the duration of the time reversed state.

(e) A further possible guideline comes from the general vision replacing many-particle states with tensor networks [L34] having particles as nodes connected by magnetic flux tubes carrying magnetic flux (possibly monopole flux). The general rule is that if there is quantum correlation/entanglement, it has flux tube as a space-time correlate. The model for valence bond based on $h_{eff}/h = n$ hierarchy could help here although the fact that valence bonds are between atoms with opposite electro-negativities suggests that this is not a correct guide line to follow.One can however ask whether Cooper pair as spin singlet bonded by flux tube might replace the valence bond.

One can imagine several options.

(a) The energy scale of the excitations is very low suggesting that magnetic interaction energies are in question. Since Sr atoms have vanishing nuclear magnetic moment, the magnetic field generated by the two s-wave electrons of the Rydberg atom could serve as candidate for this external magnetic field. In Maxwellian framework this option fails but in flux tube picture for the magnetic field created by the electrons the situation changes as already briefly described in the interoduction.

(b) Could the formation of Rydberg molecules (or whatever they might be) be due to a formation of flux tube contacts between BEC atoms serving as analogs of valence bonds. An immediate objection is that in chemistry valence bond is between states of opposite electronegativity. Pairing might however occur by spin-spin interaction.

Now Maxwellian expression for the magnetic spin-spin interaction energy varies in a range involving 9 orders of magnitude and for the average distance of order .1 μm it is several orders of magnitude too low. This means a loss of predictivity. One could imagine for instance a molecule of 3 BEC atoms ABC in which the distances between A and B and A and C would be different: this would give a non-trivial binding energy. Again Fermi statistics is a problem: it seem very difficult to avoid p-wave excitations of electrons.

Flux tubes distinguish TGD microscopically from Maxwell's theory. Could flux tubes be generated between the s-wave electrons of different BEC atoms. Also now the net interaction energy tends to cancel by statistics constraints in Maxwellian approach. TGD based model of superconductivity suggests a solution of the problem: the two s-electrons are condensed at different flux tubes and the spin-spin interaction between them gives rise to binding energy or at least binds them to Cooper pair (strontium-titanate is super-conductor!).

(c) TGD inspired quantum biology suggests the most promising approach found hitherto. An external magnetic field would be present: either the Earth's magnetic field B_E with nominal value of .5 Gauss (experimental arrangement might eliminate B_E) or its "endogenous" dark variant with a nominal valued $B_{end} = 2/5B_E = .2$ Gauss possibly characterized by $h_{eff}/h = n > 1$. Actually B_{end} has spectrum of strengths in TGD inspired quantum biology and explains bio-photons as ordinary photons resulting from dark photons in the transition $n > 1$.

The model of authors could be perhaps understood in terms of negative magnetic dipole interaction energy of electrons with this magnetic field. The two electrons in s^2 state would topologically condense at flux tubes with opposite magnetic fluxes and could have

negative spin-spin interaction energy binding them to a Cooper pair. There is however a problem: the shape of the spectral peak depends on the principal quantum number n suggesting that the value of the magnetic field involved behaves like $B \propto 1/n^3$.

Skeptic of course argues that the introduction of external magnetic field is a desperate last attempt before giving up. The origin of B_{end} has however remained a mystery. Could it be that B_R and B_{end} are aspects of the same phenomenon? If so then also the $B \propto 1/n^3$ dependence could be understood.

(d) An alternative model gives up the assumption that bound states are in question but allows temporarily time reversal. cyclotron excitations of the BEC condensate containing electrons of the BEC atoms still experiencing the Coulomb force would be in question. Magnetic field with strength $3.3 \times B_E \simeq 8B_{end}$ could explain the frequency spectrum quantitatively as cyclotron energy spectrum so that instead of bound states one would have positive energy states but the metabolic analogy would still apply.

Brief summary of TGD based model

TGD inspired model is based on a more detailed model for flux tubes.

(a) The strength of the constant valued flux tube magnetic field B_R associated with the flux tube model of electron plays the role of the physical dipole as a region of constant magnetization associated with a real world dipole field. The flux tube carries a monopole flux made possible by CP_2 topology so that the Maxwellian counterpart does not exists for it. This view about dipole magnetic field is a signature of many-sheeted space-time.

(b) One can model the quadrupole field B_R associated with two-sheeted closed flux tube connecting 5s and ns electrons of Rydberg atom. In Maxwellian theory B_R would vanish along the line between the dipoles but in TGD it has opposite directions at parallel (essentially same M^4 projection) space-time sheets so that it vanishes only at QFT limit. The members of BEC s^2 electron pairs topologically condense at separate flux tube sheets to minimize the magnetic interaction energy associated with their spins. This mechanism could also give rise to Cooper pairs. Negative energy spectrum could correspond to a generation of several electron pairs in energy minimum.

(c) B_R gives rise to the analog harmonic oscillator potential with ground state energy defined by the interaction energy of spins with B_R. If B_R depends on the distance L between the s-wave electrons of the Rydberg atom in a universal manner $B_R \propto 1/L^{3/2}$, one can understand the universal $1/n^3$ dependence of the width of the observed peak. The distances associated with the maxima of $|\Psi|^2$ give sub-peaks defining preferred Larmor frequencies so that the structure of the peak gives a map of $|\Psi(r)|^2$. If Rydberg atom moves with respect to BEC, one must add the p-wave contribution just like one does in the model of authors and find maxima for this. The basic difference with respect to the BOP approach of experimenters is that one has maxima rather than minima.

(d) ZEO allows also to consider the possibility that the arrow of time is temporily changed in the state function reduction creating the Rydberg atom: this interpretation would allow the excitation of cyclotron states with reversed arrow of time. For an observer living in standard direction of time the process would look like dropping cyclotron electrons to lower energy states to get surplus energy so that the laser photon energy need be so high. This would give harmonic oscillator spectrum for each electron pair behaving like Cooper pair. It should be easy to experimentally test for the correctness of the two proposals.

4.12.3 Maxwellian and TGD pictures for the magnetic interaction energy

TGD suggests that the proper way to model the spin-spin interaction is to use the flux tube picture. Maxwellian approach provides a second approach and one might hope that it could give a reasonable approximation.

Maxwellian approach

QFT limit of TGD with flux tubes replaced with Maxwellian magnetic fields is expected to give a good approximation of electromagnetic interactions. Therefore it is realistic to start from a Maxwellian picture for the electromagnetic fields. If Maxwellian picture gives reasonable order of magnitude estimates one can hope that also the TGD view based on the notion of magnetic body (MB) does so.

(a) The obvious idea is that the magnetic field in atom is created by the total electron current of electrons. In particular, valence electrons give to this kind of current via Maxwell's equations: $\nabla \times B = j_e/4\pi$. This would give connection between electron current and B analogous to that appearing in BOP where modulus squared for electron's Schrödinger amplitude and its gradient appear.

This picture applies also Coulomb interaction: now the charge density of electrons would serve as the source of electric field via $\nabla \cdot E = \rho$.

(b) The two electrons of Sr Rydberg atom create a magnetic field, call it B_R. Same applies to the valence electrons of s^2 state of BEC atom. In the first approximation the magnetic moment of the unexcited electron determines the magnetic field at large distances. Since the electron's wave functions depend on the radial coordinate only in s-wave, the current $\bar{j}_e$ due to the gradient of Ψ is radial for both electrons. One can reduce the equation $\nabla \times \overline{B} = \bar{j}_e/4\pi$ to a Laplace equation by using $\overline{B} = \nabla \times \overline{A}$ and Coulomb gauge $\nabla \cdot \overline{A} = 0$. This gives $\nabla^2 \overline{A} = \bar{j}_e \equiv j\bar{r}/4\pi$.

Besides this there is a contribution due to the spin of the electron and in the direction of spin projection for spin eigenstates. In the lowest order approximation the $n = 5$ electron looks like point-like magnetic dipole and generates dipole field. Same in principle applies also in the case of s^2 state of two electrons and also in case of electrons inside [Kr] shell (the electronic configuration of Sr is [Kr]s^2).

I do not know whether the above approach has been proposed earlier. In any case, it could be motivated by the following argument.

(a) Also the electrons of BEC atom have spin-spin interaction and the first thing that comes into mind is to estimate its contribution to the energy by taking expectation value in the two fermion state defined by s-wave valence electrons. If the pair of s^2 electrons transforms a Cooper pair, one must be able to estimate the change in energy, in particular spin-spin interaction energy.

(b) If found no mention about spin-spin interaction in web but found a popular article telling that the measurement of the spin-spin interaction energy is extremely difficult but was carried for a pair of Sr^+ ions (!) at distance of order 2 μm (see `http://tinyurl.com/yasjvufz`): this would partially explain why it has not been calculated. It was also found that the coherence time for entangled electron pair was unexpectedly long: 15 seconds.

In the popular article the calculation of the effect was mentioned to be very difficult. The repulsive interaction between fermions gives a competing contribution which - being expectation of $1/|r_1 - r_2|$ - is finite. As a matter of fact, I realized that the integral defining the expectation value of $1/|r_1 - r_2|^3$ appearing in the expectation value of spin-spin interaction energy in s-wave state in two fermion state diverges logarithmically!

The pragmatic way out of the difficulty would be straightforward: do not try to calculate anything giving an ill-defined answer! To gain more respectability for this view one could formulate the state of affairs as a general rule. One is allowed to estimate only the effects of external fields - say that of nucleus when calculating spin-orbit interaction energy or interactions between atoms - by using this approach. The external field depends in this case on the electron configuration involved so that one cannot regard spin-spin interaction as being due to an external magnetic field.

Atomistic skeptic can however argue that in Born-Oppenheimer approach assumes the configuration of atoms to be given and calculates electron states associated with this and then

solves Schrödinger equation for the atoms. Also in the calculation of color-magnetic spin-spin splitting of mesons and baryons this approach is used. Therefore the problem is real and one must solve it.

The proposed approach could however allow to get rid of the divergence associated with spin-spin interaction since the magnetic field determined by the total current defined by electrons gives smoothed out magnetic field free of singularity associated with point-like magnetic dipole.

How flux tubes as mediators of magnetic spin-spin interaction would relate to the Maxwellian picture?

In TGD based approach flux tubes would mediate the magnetic interaction. For two different atoms electrons would be connected by flux tubes and the electrons at its end or possibly moving freely in the interior would interact with essentially 1-D magnetic flux. This picture could apply also to electrons inside single atom. Also Coulomb interaction energy could be estimated in the same manner between electrons of single atom. In the case of separate atoms one can argue that repulsive Coulomb interaction can be neglected in excellent approximation.

Remark: Strong form of holography (SH) implies that at least in the sense of information theory electrons at space-time level can be thought of as being localized at 2-D string world sheets - that is electron states are fixed by 2-D data. In this picture flux tubes are accompanied by fermionic strings with fermions at their ends assignable to the light-like orbits of partonic 2-surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian. At the level of embedding space $M^4 \times CP_2$ the spinors characterizing ground states of super-conformal representations are however 8-D and it is these spinors that correspond to those of standard model.

One must have rules for how to replace Maxwellian field with flux tubes.

(a) Flux tubes carry a conserved magnetic flux. Therefore the magnetic field is essentially constant inside flux tube and the situation is effectively 1-dimensional. One can consider also the possibility that the magnetic flux is quantized. In TGD framework it is also possible to have closed flux tubes carrying monopole flux looking locally like pair of flux tubes with opposite fluxes: they could appear in super-conductors and in cosmology. No currents are needed to create these magnetic fields made possible by the topology of CP_2. The cross section of this kind of flux tube is closed 2-surface rather than a disk with holes. For these flux tube pairs Maxwellian limit does not exist.

(b) Flux conservation implies that the spin-spin magnetic interaction energy for given flux tube does not depend on distance.

(c) There is a distribution of magnetic flux tubes, which should correspond to the Maxwellian field. The intuitive picture is that the density dn/dS of flux tubes normal to given 2-surface having normal direction $\overline{n}$ multiplied by possibly quantized magnetic flux corresponds to the value of Maxwellian magnetic field:

$$\overline{B} \leftrightarrow \frac{dn}{dS} \Phi \overline{n} \ . \tag{4.12.2}$$

dn/dS would be determined by the wave function for 3-surfaces in the "world of classical worlds" (WCW). This picture would hold true at larger distances from the source - say dipole.

(d) Flux tubes field could mimic Maxwellian field with a better accuracy if the flux tubes can branch at larger distances. This would look natural for dipole fields. The outcome be a kind of fractal tree like structure growing in the radial direction. This would involve reduction of the field strength and possible also the net flux which could be large in the vicinity of dipole but reduce later.

This picture generalizes to electric flux tubes/quanta carrying constant electric flux. By effective one-dimensionality the electric potential is proportional to distance along flux tube.

Interesting questions relate to the possibility of space-time sheets parallel in $M^4 \times CP_2$ and having same M^4 projection: at QFT limit they are replaced region of M^4 with deformed metric.

(a) One can imagine that both valence electrons with opposite spins are accompanied magnetic flux tubes such that they correspond 4-surfaces on top of each other and extremely near to each other in $M^4 \times CP_2$ such that the magnetic fluxes are in opposite directions but of the same magnitude. At QFT limit the total magnetic field would vanish on test particle if it touches all parallel sheets and experiences the fields from all of them.

(b) Consider a situation involving two magnetic flux tubes as different sheets associated with spins in opposite directions so that magnetic fluxes are opposite at them. One can imagine a deformation implying that space-time sheets at not at top of each other. Now the magnetic spin-spin interaction would be non-trivial in these regions and favor the formation of bound state spin singlet identifiable as Cooper pairs. Could energy minimization favor the formation of pairs of this kind of single-sheeted regions? For instance, the formation of groups of BEC atoms connected by flux tubes could involve this mechanism. In the situation when the flux tubes project to same region of M^4, bound states would not be possible.

What could happen when the Maxwellian approach fails?

To understand the flux tube picture and connect with with the Rydberg polaron, it helps to ponder what happens when the Maxwellian approach fails. For the magnetic dipole field the region near the locus of the dipole represents a situation, where Maxwellian description might indeed fail. One can take the TGD inspired model of electron itself as a starting point.

(a) Electron (actually any elementary particle) would be a pair of wormhole contacts (I and II with throats I1,I2 and II1,II2) connecting two space-time sheets with electron at the throat I1 of contact I and left-handed neutrino ν_L at throat II1 and right-handed neutrino $\overline{\nu}_R$ at throat II2 of contact II. The flux tubes would carry monopole magnetic flux flowing also through the contacts and stabilizing it: otherwise the space-time sheets would only touch for some time.

In scales shorter than the length L of the flux tubes electron would have also weak isospin. At longer scales electron would effectively have only em charge just as standard model predicts.

(b) The flux tubes at given space-time sheet would be a correlate for the dipole assigned with dipole magnetic field and carry a constant flux. This corresponds to constant magnetization for a non-ideal dipole created by an inductance in circuit theory.

Now no current is needed to create the constant magnetic field since monopole flux is in question and the cross section of flux tube is a closed 2-surface. The absence of the current corresponds to the fact that electron's magnetic moment is due to spin and is not created by a current. Monopole flux tube would however give a space-time correlate for the dipole created by spin.

The strength of the magnetic field would be proportional to $1/S$, S the area of the flux tube projection in M^4. Magnetic dipole would be effectively a pair of magnetic charges (TGD does not however allow isolated magnetic charges) made possible by the topology of CP_2. For non-standard values of h_{eff} these dipoles could have even macroscopic sizes. Monopole fluxes could explain even the mysterious existence of long length scale magnetic fields in cosmological scales.

4.12.4   A model for Rydberg polaron

The proposd picture for spin dipoples allows to imagine a concrete model for the quadrupole type magnetic field created by a pair of s-wave electrons taken far apart as in the formation

of Rydberg atom. This model applies also to Cooper pairs and perhaps even to s^2 pairs of electrons in atom.

(a) What happens when one has two electrons identifiable as dipoles with opposite spins as in the case of Rydberg atom? Suppose that the spins are oriented along the connecting line. In the region between electrons the magnetic field vanishes in the Maxwellian world. In many-sheeted space-time it is enough that the magnetic fields have opposite direction but exist as induced magnetic fields at parallel space-time sheets. At QFT limit the field vanishes as sum of these fields.

One could imagine the following model for the resulting magnetic field. The monopole flux tube pairs associated with electrons would reconnect to a single flux tube pair so that the wormhole throats carrying ν_L and $\overline{\nu}_R$ disappear and $\nu_L\overline{\nu}_R$ pairs at throats opposite to electron carrying throats to take care about the vanishing of weak isospin at longer length scales correlating with the massivation causing the short range of weak forces. The magnetic fields at the opposite throats of both wormhole contacts would have opposite values and at QFT limit the total magnetic field would vanish. This effect is not possible in Maxwellian electrodynamics.

(b) The magnetic field would be constant at the flux tubes and equal to $eB = \Phi/S$, $\Phi = BS = n$. One can imagine a topological condensation of the BEC atoms at this flux tube pair. The s^2 electrons of BEC atom would condense at different flux tubes to minimize their magnetic interaction energies $E = -\mu_e \times B$, $\mu_e = e\hbar/2m_e$. Maybe this kind of process could produce the Rydberg polaron.

(c) What would be the dependence of the surface area S of the flux tube on the distance L between the electrons? The naïve guess that B has dependence $B \propto 1/L^3$ classically would give $S \propto L^3$. This does not make sense as detailed checks demonstrated.

If I have interpreted correctly the findings about Rydberg atom, the spectral width as the width of absorption spectrum as function of frequency becomes narrower and scales down as $1/n^3$: the experimenters talk about universality. The $B \propto 1/n^3$ scaling of the magnetic interaction energies would explain this. If the magnetic interaction energies are responsible for the observed spectrum then the proportionality of the size scale of Rydberg atom to n^2 would require $S \propto L^{3/2} \propto n^3$. For $n = 38$ one has $\Delta f = -5$ MHz. This gives the rough estimate

$$\frac{\mu_B \Phi}{S(n=38)} == \frac{\mu_B \Phi}{\pi R^2(n=5)}\left(\frac{5}{38}\right)^3 = 2.1 \times 10^{-8} \ eV \ .$$

This condition fixes the radius $R(n=5)$ of the flux tube at distance $L(n=5) \sim 6.3$ Angstrom to be $R \simeq 10^4 a_0 \simeq .5$ μm. More generally, the basic length scales of biology might be hidden to many-sheeted atomic physics.

(d) One could hope that this dependence of S on the distance L between electrons of opposite spin with the line connecting the electrons serving as quantization axis is universal. Could this idea have some explanatory power?

In TGD inspired quantum biology one encounters the notion of endogenous magnetic field $B_{end} = 2/5 B_E$, which is roughly by factor $x = 1/7.5 \sim 2^{-3}$ weaker than $B(n=38)$. As a matter of fact, B_{end} must have spectrum reflected directly in the spectrum of bio-photons in visible and UV [K12, K22] and in the spectrum of audible frequencies [K79]. The origin of this magnetic field has remained a mystery. Could it correspond to a magnetic field associated with a flux tube connecting electron dipoles with opposite directions at distance L_{end}?

The proposed model would give the factor

$$x = \frac{S(38)}{S} = \left(\frac{L(38)}{L_{end}}\right)^{3/2}$$

allowing to estimate corresponding distance L_{end} between electrons as

$$L_{end} = x^{-2/3}L(38) = 4 \times L(38) = \left(\frac{38}{5}\right)^2 L(5) \simeq 231 L(5) \ .$$

Assuming that Sr atom behaves for $n = 5$ state like hydrogen atom with effective nuclear charge $Z_{eff} = 2$ (screening would be due to [Kr] shell), one obtains a rough estimate for $L(5)$ would be $5^2 a_0/2 \simeq 6.3$ Angstrom. This would give $L_{end} \sim 1.5 \ \mu m$. It is encouraging that this corresponds to the p-adic length scale $L(169) \simeq 1.5 \ \mu m$ assignable to cell nucleus size. Note that the p-adic length scale $L(167) = 2.5 \ \mu m$ corresponds to Gaussian Mersenne $M_{G,n=167} = (1 + i)^n - 1$.

The factor 2 would suggest that the B_{end} corresponds to Rydberg atom with $n = 2 \times 38 = 76$. This is only a rough estimate: the estimate for $L(5)$ assumes hydrogen-like atom and this assumes is only approximate since the s^2 electrons spend considerable time inside [Kr] shell which tends to reduce the radius $L(5)$. An interesting question concerns the identification of Rydberg atom(s) possibly responsible for the generation of B_{end}. The spectrum for $B_{end}(n)$ would be of form $1/n^3$. For given n there would br a spectrum along the n:th row of Periodic Table.

Spin-spin interaction energy at temperature of 1.5×10^{-11} eV would correspond to an energy which is by a factor 10^{-3} lower than that associated with $L(n = 38)$. This corresponds to the scaling $n \to 10n$ and $L(38) \to 100L(38)$.

(e) In the realistic situation the Rydberg electron has wave function Ψ. $|\Psi|^2$ has several maxima and minima which correspond to zeros for a polynomial closely related to the square of Laguerre polynomial and having degree $2n$ so that the number of real maxima would be at most $n - 1$. One would have a quantum superposition of also flux tube pairs with different lengths L.

The flux tube lengths L associated with the maxima would be visible as peaks in the absorption spectrum. One would have peaks at the corresponding Larmor frequencies (and possibly also cyclotron frequencies if temporary time reversal takes place). This picture includes only s wave scattering length and the reason would be that one indeed has pure s-wave electrons.

The BOP of authors includes also a term proportional to p-wave scattering length: one must adds to Ψ a term proportional to the gradient of Ψ representing the change of the wave function due to the motion. When the Rydberg atom moves with respect to BEC, the wave function has also p-wave component and the scattering length A_p is indeed momentum dependent going to zero at the limit of vanishing momentum. If one can neglect the cross terms proportional to $p \cdot (\overline{\Psi} \nabla \Psi + c.c)$ one obtains the BOP. It therefore seems that TGD might be able to explain the basic properties of the Rydberg polaron.

To sum up, Rydberg polaron could provide a clearcut evidence for the notions of many-sheeted space-time, flux tube, and ZEO and also allow to assign "endogenous" magnetic fields to Rydberg atoms.

Acknowledgements

Chapter 5

TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology

5.1 Introduction

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.

(a) Superposition and interference of the classical fields is very natural in Maxwell electro-dynamics 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 simply impossible.

How can one cope with this situation? The answer is based on simple observation: only the *effects* caused by 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. Charged particles have topological sum contacts to several space-time sheets and experience the sum of the effects caused by the classical fields at all space-time sheets involved.

Tis picture allows also to understand how the many-sheeted space-time gives rise to effective space-time of GRT when sheets are collapsed to single sheet and metric replaced with sum of Minkowski metric and deviations of induced metrics of sheets from Minkowski metric. Gauge potentials are defined in an analogous way. Equivalence Principle in Einstein's form follows from Poincare invariance.

(b) 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 but for field lines and do not play so important role. Braiding and reconnection are however in a central role in TGD Universe and especially so in in TGD inspired theory of consciousness and quantum biology [K2]. Also 2-braiding in 4-D space-time is possible generalizes the quantum computation paradigm. The challenge is to build a coherent overall phenomenological view about the role of topologically quantized classical fields in biology and neuroscience.

For instance, the notion of conscious hologram [K15] is key concept in TGD inspired theory of consciousness, and the challenge is to formulate this notion more precisely. One can can ask whether the presence of magnetic flux tubes connecting two systems could serve as a correlate of entanglement - or at least negentropic entanglement suggested by the number theoretic vision to be a basic signature of living matter.

(c) Topological quantization and the notion of magnetic body are especially important in TGD inspired model of EEG [K95]. The attempt to understand the findings of Persinger from the study of God helmet (see `http://tinyurl.com/3cpoyq`) [J1, **?**, **?**] leads to a considerable progress in the understanding the possible role of topologically quantized classical fields in biology and neuro-science. In neurotheology the goal is to understand neurological aspects of spiritual experiences and near death experiences (see `http://tinyurl.com/yj523z`) [**?**] (NDEs) and out-of-body experiences (see `http://tinyurl.com/2j342h`) [J2] [K101] are challenges for this approach. A good candidate for "God" as it appears in these experiences is magnetic body, perhaps a new leayer added to the personal magnetic body during the experience. This explains also the paradoxical Brahman=Atman experience. TGD indeed predicts infinite hierarchy of selves with entire Universe at the top so that TGD view is not in conflict with the basic ideas of religion.

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` [L11].

5.2   Comparison Of Maxwellian And TGD Views About Classical Gauge Fields

In TGD Universe gauge fields are replaced with topological field quanta. Examples are topological light rays, magnetic flux tubes and sheets, and electric flux quanta carrying both magnetic and electric fields. Flux quanta form a fractal hierarchy in the sense that there are flux quanta inside flux quanta. It is natural to assume quantization of Kähler magnetic flux. Braiding and reconnection are basic topological operations for flux quanta.

One important example is the description of non-perturbative aspects of strong interactions in terms of reconnection of color magnetic flux quanta carrying magnetic monopole fluxes [K38, K60]. These objects are string like structures and one can indeed assign to them string world sheets. The transitions in which the thickness of flux tube increases so that flux conservation implies that part of magnetic energy is liberated unless the length of the flux quantum increases, are central in TGD inspired cosmology and astrophysics. The magnetic energy of flux quantum is interpreted as dark energy and magnetic tension as negative "pressure" causing accelerated expansion.

This picture is beautiful and extremely general but raises challenges. How to describe interference and linear superposition for classical gauge fields in terms of topologically quantized classical fields? How the interference and superposition of Maxwellian magnetic fields is realized in the situation when magnetic fields decompose to flux quanta? How to describe simple systems such as solenoidal current generating constant magnetic field using the language of flux quanta?

5.2.1 Superposition Of Fields In Terms Of Flux Quanta

The basic question concerns the elegant description of superposition of classical fields in terms of topological field quanta. What it means that magnetic fields superpose.

(a) In Maxwell's linear theory the answer would be trivial but not now. Linear superposition holds true only inside topological light rays for signals propagating in fixed direction with light velocity and with same local polarization. The easy solution would be to say that one considers small perturbations of background space-time sheet and linearizes the theory. Linearization would apply also to induced gauge fields and metric and one would obtain linear superposition approximately. This does not look elegant. Rather, quantum classical correspondence requires the space-time counterpart for the expansion of quantum fields as sum of modes in terms of topological field quanta. Topological field quanta should not lose their identity in the superposition.

(b) In the spirit of topological field quantization it would be nice to have topological representation for the superposition and interference without any linearization. To make progress one must return to the roots and ask how the fields are operationally defined. One has test particle and it experiences a gauge force in the field. From the acceleration of the test particle the value of field is deduced. What one observes is the superposition of gauge forces, not of gauge fields.

  i. Let us just assume that we have two space-time sheets representing field configurations to be effectively superposed. Suppose that they are "on top" of each other with respect to CP_2 degrees of freedom so that their M^4 volumes overlap. The points of the sheets representing the field values that would sum in Maxwell's theory are typically at distance of CP_2 radius of about 10^4 Planck lengths. Wormhole contacts representing the interaction between the field configurations are formed. Hence the analog of linear superposition does not hold true exactly. For instance, amplitude modulation becomes possible. This is however not essential for the argment.

  ii. Test particle could be taken to be fermion which is simultaneously topologically condensed to both sheets. In other words, fermionic CP_2 type almost vacuum extremal touches both sheets and wormhole throats at which the signature of the induced metric changes is formed. Fermion experiences the sum of gauge forces from the two space-time sheets through its wormhole throats. From this one usually concludes that superposition holds true for the induced gauge fields. This assumption is however not true and is also un-necessary in the recent case. In case of topological light rays the representation of modes in given direction in terms of massless extremals makes possible to realize the analogy for the representation of quantum field as sum of modes. The representation does not depend on approximate linearity as in the case of quantum field theories and therefore removes a lot of fuzziness related to the quantum theory. In TGD framework the bosonic action is indeed extremely non-linear (see **Fig. http://tgdtheory.fi/appfigures/fieldsuperpose.jpg** or **Fig. ??** in the appendix of this book).

(c) This view about linear superposition has interesting implications. In effective superposition the superposed field patterns do not lose their identity which means that the information about the sources is not lost - this is true at least mathematically. This is nothing but quantum classical correspondence: it is the decomposition of radiation into quanta which allows to conclude that the radiation arrives from a particular astrophysical object. It is also possible to have superposition of fields to zero field in Maxwellian sense but in the sense of TGD both fields patterns still exist. Linear superposition in TGD sense might allow testing using time dependent magnetic fields. In the critical situation in which the magnetic field created by AC current passes through zero, flux quanta have macroscopic size and the direction of the flux quantum changes to opposite.

5.2.2   The Basic Objection Against TGD

The basic objection against TGD is that induced metrics for space-time surfaces in $M^4 \times CP_2$ form an extremely limited set in the space of all space-time metrics appearing in the path integral formulation of General Relativity. Even special metrics like the metric of a rotating black hole fail to be imbeddable as an induced metric. For instance, one can argue that TGD cannot reproduce the post-Newtonian approximation to General Relativity since it involves linear superposition of gravitational fields of massive objects. As a matter fact, Holger B. Nielsen - one of the very few colleagues who has shown interest in my work - made this objection for at least two decades ago in some conference and I remember vividly the discussion in which I tried to defend TGD with my poor English.

The objection generalizes also to induced gauge fields expressible solely in terms of CP_2 coordinates and their gradients. This argument is not so strong as one might think first since in standard model only classical electromagnetic field plays an important role.

(a) Any electromagnetic gauge potential has in principle a local embedding in some region. Preferred extremal property poses strong additional constraints and the linear superposition of massless modes possible in Maxwell's electrodynamics is not possible.

(b) There are also global constraints leading to topological quantization playing a central role in the interpretation of TGD and leads to the notions of field body and magnetic body having non-trivial application even in non-perturbative hadron physics. For a very large class of preferred extremals space-time sheets decompose into regions having interpretation as geometric counterparts for massless quanta characterized by local polarization and momentum directions. Therefore it seems that TGD space-time is very quantal. Is it possible to obtain from TGD what we have used to call classical physics at all?

The imbeddability constraint has actually highly desirable implications in cosmology. The enormously tight constraints from imbeddability imply that imbeddable Robertson-Walker cosmologies with infinite duration are sub-critical so that the most pressing problem of General Relativity disappears. Critical and over-critical cosmologies are unique apart from a parameter characterizing their duration and critical cosmology replaces both inflationary cosmology and cosmology characterized by accelerating expansion. In inflationary theories the situation is just the opposite of this: one ends up with fine tuning of inflaton potential in order to obtain recent day cosmology.

Despite these and many other nice implications of the induced field concept and of sub-manifold gravity the basic question remains. Is the imbeddability condition too strong physically? What about linear superposition of fields which is exact for Maxwell's electrodynamics in vacuum and a good approximation central also in gauge theories. Can one obtain linear superposition in some sense?

(a) Linear superposition for small deformations of gauge fields makes sense also in TGD but for space-time sheets the field variables would be the deformations of CP_2 coordinates which are scalar fields. One could use preferred complex coordinates determined about SU(3) rotation to do perturbation theory but the idea about perturbations of metric and gauge fields would be lost. This does not look promising. Could linear superposition for fields be replaced with something more general but physically equivalent?

(b) This is indeed possible. The basic observation is utterly simple: what we know is that the *effects* of gauge fields superpose. The assumption that fields superpose is un-necessary! This is a highly non-trivial lesson in what operationalism means for theoreticians tending to take these kind of considerations as mere "philosophy".

(c) The hypothesis is that the superposition of the effects of gauge fields occurs when the M^4 projections of space-time sheets carrying gauge and gravitational fields intersect so that the sheets are extremely near to each other and can touch each other (CP_2 size is the relevant scale). Particles having topological sum contacts to these space-time sheets experience the sum of the gauge and gravitational fields associated with the space-time sheets.

A more detailed formulation goes as follows.

(a) One can introduce common M^4 coordinates for the space-time sheets. A test particle (or real particle) is identifiable as a wormhole contact and is therefore point-like in excellent approximation. In the intersection region for M^4 projections of space-time sheets the particle forms topological sum contacts with all the space-time sheets for which M^4 projections intersect.

(b) The test particle experiences the sum of various gauge potentials of space-time sheets involved. For Maxwellian gauge fields linear superposition is obtained. For non-Abelian gauge fields gauge fields contain interaction terms between gauge potentials associated with different space-time sheets. Also the quantum generalization is obvious. The sum of the fields induces quantum transitions for states of individual space time sheets in some sense stationary in their internal gauge potentials.

(c) The linear superposition applies also in the case of gravitation. The induced metric for each space-time sheet can be expressed as a sum of Minkowski metric and CP_2 part having interpretation as gravitational field. The natural hypothesis that in the above kind of situation the effective metric is sum of Minkowski metric with the sum of the CP_2 contributions from various sheets. The effective metric for the system is well-defined and one can calculate a curvature tensor for it among other things and it contains naturally the interaction terms between different space-time sheets. At the Newtonian limit one obtains linear superposition of gravitational potentials. One can also postulate that test particles move along geodesics in the effective metric. These geodesics are not geodesics in the induced metrics of the individual space-time sheets.

(d) This picture makes it possible to interpret classical physics as the physics based on effective gauge and gravitational fields and applying in the regions where there are very many space-time sheets for which M^4 projections intersect. The loss of quantum coherence would be due to the effective superposition of very many modes having random phases.

The effective superposition of the CP_2 parts of the induced metrics gives rise to an effective space-time metric, which is not in general imbeddable to $M^4 \times CP_2$. Therefore many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) makes possible a rather wide repertoire of 4-metrics realized as effective metrics as one might have expected and the basic objection can be circumvented. In asymptotic regions where one can expect single sheetedness, only a rather narrow repertoire of "archetypal" field patterns of gauge fields and gravitational fields defined by topological field quanta is possible. This gives connection with quantum physics and state function reduction.

The skeptic can argue that this still need not make possible the embedding of a rotating black hole metric as induced metric in any physically natural manner. This might be the case but need of course not be a catastrophe. We do not really know whether rotating blackhole metric is realized in Nature. I have indeed proposed that TGD predicts new physics

new physics in rotating systems (see `http://tinyurl.com/yantmeot`) [K113]. Unfortunately, gravity probe B could not check whether this new physics is there since it was located at equator where the new effects vanish.

5.2.3   Induction coils in many-sheeted space-time

I have been trying to concretize many-sheeted space-time by thinking what simple systems involving electric and magnetic fields would look like in many-sheeted space-time. The challenge is highly non-trivial since the basic difference between Maxwell's theory and TGD is that allows extremely limited repertoire of preferred extremals and there is no linear superposition.

(a) By general coordinate invariance only 4 field like variables (say CP_2 coordinates) are possible meaning that all classical fields identified as induced fields are expressible in terms of only four field like variables at at given sheet. This has several implications.

The classical field equations determining the space-time surface theory is extremely non-linear although they have simple interpretation as expression for local conservation laws of Poincare charges and color charges. Linear superposition of Maxwell's equations is lost.

Only for so called topological light rays ("massless extremals"), MEs) the linear super-position holds true but in extremely limited sense: for the analogous of plane waves travelling in either direction along ME. One has pulses of arbitrary shape preserving their shape and propagating in single direction only with maximal signal velocity.

(b) Strong form of holography (SH) implies that 2-dimensional data at string world sheets and partonic 2-surfaces fix the space-time surfaces. 2-D data include also the tangent spaces of partonic 2-surfaces so that the situation is only effectively 2-D and TGD does not reduce to any kind of string model.

It is possible that the light-like 3-surfaces defining parton orbits as the boundaries of Minkowskian and Euclidian space-time regions possess dynamical degrees of freedom as conformal equivalence classes. Kac-Moody type transformations trivial at the ends of partonic orbit at boundaries of causal diamond (CD) would generate physically equiv-alent partonic orbits. There would be n conformal equivalence classes, where n would correspond to the value of Planck constant $h_{eff} = n \times h$. At the ends of orbit all these n sheets of the singular covering would co-incide. Possible additional degrees of freedom making partonic 2-surfaces somewhat 3-D would be therefore discrete and make possible dark matter in TGD sense.

What is clear that single space-time sheet is very simple entity, and one can assign to it only extremely limited set of say solutions of Maxwell's equations. More complex solutions must correspond to many-sheeted space-time surfaces approximated as slightly curved pieces of Minkowski space at the GRT-QFT limit of TGD.

This limit is discovered by noticing that a test particle touches all sheets of the space-time surface in a given region of Minkowski space - they are extremely near to each other. Test particle experiences sums for the induced gauge potentials and gravitational fields defined is deviations of the induced metric from flat Minkowski metric. These sums corresponds naturally to the gauge potentials and gravitational fields assignable to the GRT-QFT limit. One obtains GRT plus standard model.

The challenge is to look whether one can indeed construct typical Maxwellian field configu-rations as sums of electromagnetic gauge potentials represented as induced gauge potentials at various sheets. The simplest configurations would be realizable using only two sheets.

I have already considered the realization of standing waves not possible as single sheeted structures as $\geq$ 2-sheeted structures carrying the analogs of sinusoidal waves [L37] (see `http://tinyurl.com/q4jyoc5`).

(a) The proposal is that magnetic bodies (MBs) use this kind of standing wave patterns to generate biological structures: charged biomolecules would end up the nodal surfaces of the standing wave and become stationary structures. Of course, also time varying nodes are possible.

(b) MB could use the MEs parallel to flux tubes connected to a given node of tensor network to generate biological structures at the node. Note that the interference patter would be completely analogous to that of a hologram but allowing more than two waves. As a matter of fact, I considered a vision about living systems as conscious holograms for decades ago [K15] but was not able to invent a concrete model at that time. This Chladni mechanism - as one might call it - could be a general mechanism of morphogenesis and morphostasis.

Second challenge is provided by the field patterns of an inductance coil with AC current flowing around the boundary of cylinder.

(a) The current is typically AC current. Oscillating magnetic field has direction parallel or opposite to the cylinder and electric field field lines rotate around the cylinder. That the geometry of field pattern is this is easy to understand by looking just the general form of the solutions of the Maxwell's equations in question.

(b) What is essential is that one has standing wave type field pattern meaning that the fields at all points of the cylinder oscillates in the same phase. The temporal and spatial dependences of the magnetic field separate into product of sinusoidal function and spatial function, which in the simplest situation is constant. One might even regard the standing wave property as a signal of quantum coherence.

Could one use MEs as building bricks to construct the field pattern associated with the coil?

(a) MEs define an extremely general set of (hopefully preferred) extremals of Kähler action. Basic type of ME corresponds to cylindrical regions inside which pulses propagate in the same direction along the cylinder and have transversal polarization. The simplest of them are form $f_{\omega,k}(t,z,u) = sin(\omega t - kz)\epsilon(u)$, where one has $\omega = kc$ and u is an arbitrary function depending on some coordinate of the plane orthogonal to the plane characterized by t and z. For instance, u could be chosen to be the radial coordinate ρ in cylindrical coordinates. The sum of the MEs with fields $f_{\omega,k}$ and $f_{\omega,-k}$ gives rise to an effective standing wave in the axial direction representing just right kind of magnetic and electric fields. The nodal surfaces correspond to the planes $sin(kz) = 0$ and to cylinders $\epsilon(\rho) = 0$ in this case.

(b) What is amusing that the field experienced by the test particle would be expressible as sum of the two modes of TGD counterpart of radiation field. If the AC frequency is 50 Hz, the period of radial cylindrical wave characterized by wave vector $k = \omega$ ($c = 1$) is of order wave length $\lambda = 2\pi/k$, which is of order 10^7 meters, order of magnitude of Earth radius! Hence the longitudinal magnetic field is essentially constant for the coils encountered in practical situation. Radial field depends on ρ or some more general transversal coordinate in very general manner.

(c) The boundary of the cylinder carries the AC current. The description of this current is a further challenge to TGD and will not be considered here.

One can of course have more general currents generating much more general waves, not necessary standing waves.

(a) The general recipe would be simple. These fields can be expressed as a Fourier decomposition of simple sinusoidal field patterns. Assign to each sinusoidal field pattern a space-time sheet in the proposed manner so that superposition for modes is replaced with union of space-time surfaces.

(b) The more terms in the Fourier expansion, the larger the number of sheets for the many-sheeted space-time is. The number of space-time sheets gives a measure for the complexity of the system. For instance, a current with form of square pulse is an interesting challenge. Should one approximate the square pulse as a superposition of space-time sheets of its Fourier components?

5.2.4 The Notion Of Conscious Hologram

In TGD inspired theory of consciousness the idea about living system as a conscious hologram (see http://tinyurl.com/ydx4fuk5) [K15] is central. It is of course far from clear what this notion means. The notions of interference and superposition of fields are crucial for the description of the ordinary hologram. Therefore the proposed general description for the TGD counterpart for the superposition of fields is a natural starting point for the more precise formulation of the notion of conscious hologram.

(a) Consider ordinary hologram first. Reference wave and reflected wave interfere and produce an interference pattern to which the substrate of the hologram reacts so that its

absorption coefficient is affected. When the substrate is illuminated with the conjugate of the reference wave, the original reflected wave is generated. The modification of the absorption coefficient is assumed to be proportional to the modulus squared fro the sum of the reflected and reference waves. This implies that the wave reflected from the hologram is in good approximation identical with the original reflected wave.

(b) Conscious hologram would be dynamical rather than static. It would be also quantal: the quantum transitions of particles in the fields defined by the hologram would be responsible for the realization of the interference pattern as a conscious experience. The previous considerations actually leave only this option since the interference of classical fields does not happen. Reference wave and reflected wave correspond now to any field configurations. The charged particles having wormhole contacts to the space-time sheets representing the field configurations experience the sum of the fields involved, and this induces quantum jumps between the quantum states associated with the situation in which only the reference wave is present.

This would induce a conscious experience representing an interference pattern. The reference wave can also correspond to a flux tube of magnetic body carrying a static magnetic field and defining cyclotron states as stationary state. External time dependent magnetic field can replace reflected wave and induces cyclotron transitions. Also radiation fields represented by MEs can represent the reference wave and reflected wave. If there is need for the "reading" of the hologram it would correspond to the addition of a space-time sheet carrying fields which in good approximation have opposite sign and same magnitude as those in the sheet representing reference wave so that the effect on the charged particles reduces to that of the "reflected wave".

This step might be un-necessary since already the formation of hologram would give rise to a conscious experience. On the other hand, the conscious holograms created when the hologram is created and when the conjugate of the reference wave is added give rise to two different conscious representations. This might have something to do with holistic and reductionistic views about the same situation.

(c) One can imagine several realizations for the conscious hologram. It seems that the realization at the macroscopic level is essentially four-dimensional. By quantum holography it would reduce at microscopic level to a hologram realized at the 3-D light-like surfaces defining the surfaces at which the signature of induce metric changes (generalized Feynman diagrams having also macroscopic size - anyons (see `http://tinyurl.com/y89xp4bu`) [K72]) or space-like 3-surfaces at the ends of space-time sheets at the two light-like boundaries of CD. Strong form of holography implied by the strong form of general coordinate invariance requires that holograms correspond to collections of partonic 2-surfaces in given measurement resolution. This could be understood in the sense that the charged particles defining the substrate can be described mathematically in terms of the ends of the corresponding light-like 3-surfaces at the ends of CDs. The cyclotron transitions could be thought of as occurring for particles represent as partonic 2-surfaces topologically condensed at several space-time sheets.

One can imagine several applications in TGD inspired quantum biology.

(a) One can develop a model for how certain aspects of sensory experience could be understood in terms of interference patterns for signals sent from the biological body to the magnetic body. The information about the relative position of the magnetic body and biological body would be coded by the interference patterns giving rise to conscious sensory percepts. This information would represent

geometric qualia (see `http://tinyurl.com/y7vahkzg`) [K39] giving information about distances and angles basically. There would be a magnetic flux tube representing the analog of the reference wave and magnetic flux tube carrying the analog of reflected wave which could represent the effect of neural activity. When the signal changes with time, cyclotron transitions are induced and conscious percept is generated. In principle it there is no need not compensate for the reference wave although also this is possible.

(b) The natural first guess is that EEG rhythms (see `http://tinyurl.com/y9y87z84`) [K35] (and those for its fractal generalization) represent reference waves and that the frequencies in question are either harmonics of cyclotron frequencies or linear combinations of these and Josephson frequency assignable to cell membrane (and possibly its harmonics). The modulation of the membrane resting potential would induce modulations of Josephson frequency and if the modulation is large enough it would generate nerve pulses. These modulations would define the counterpart of the reflected wave. The flux tubes representing unperturbed magnetic field would represent reference waves.

(c) For instance, the motion of the biological body relative to the magnetic body changes the signal at the space-time sheets carrying the signal and this generates cyclotron transitions giving rise to a conscious experience. Perhaps the sensation of having a body is based in this mechanism. The signals could emerge directly from cells. It could of course be that this sensation corresponds to lower level selves rather than us. Second option is that nerve pulses to brain induce the signals sent to the our magnetic body.

(d) The motion of biological body relative to the biological body generates virtual sensory experience which could be responsible for the illusions like train illusion and the unpleasant sensory experience about falling down from cliff by just imagining it [K101]. OBEs (see `http://tinyurl.com/y797h78x`) could be also due to the virtual sensory experiences of the magnetic body. One interesting illusion results when one swims long time in windy sea. After the return to the shore one has rather long lasting experience of being still in sea. The explanation is that magnetic body gradually learns to compensate the motion of sea so that the perception of the wavy motion is reduced. At the shore this compensation mechanism however continues to work. This mechanism represents an example of adaptation and could be a very general mechanism. Since also magnetic body uses metabolic energy, this mechanism could have justification in terms of metabolic economy.

Also thinking as internal, silent speech might be assigned with magnetic body and would represent those aspects of the sensory experience of ordinary speech which involve quantum jumps at magnetic body. This speech would be internal speech since there would be no real sound signal or virtual sound signal from brain to cochlea.

(e) Conscious hologram would make possible to represent phase information. This information is especially important for hearing (see `http://tinyurl.com/ybwqawhn`) [K79]. The mere power spectrum is not enough since it is same for speech and its time reversal. Cochlea performs an analysis of sounds to frequencies. It it is not easy to imagine how this process could preserve the phase information associated with the Fourier components. It is believed that both right and left cochlea are needed to abstract the phase difference between the signals arriving to right and left ear allowing to deduce the direction of the source neural mechanisms for this has been proposed but these mechanism are not enough in case of speech. Could there exists a separate holistic representation in which sound wave as a whole generates a single signal interfering with the reference wave at the magnetic body and in this manner represents as a conscious experience the phase?

(f) Also the control and reference signals from the magnetic body to biological body could create time dependent interference patterns giving rise to neural response initiating motor actions and other responses. Basically the quantum interference should reduce the magnitude of membrane resting potentials so that nerve pulses would be generated and give rise to motor action. Similar mechanism would be at work at the level of sensory receptors - at least retina. The generation of nerve pulses would mean kind of emergency situation at the neuronal level. Frequency modulation of Josephson radiation would be the normal situation.

5.3 Magnetic Body And Consciousness

In the following some aspects of magnetic body as a basic notion of TGD inspired theory of consciousness is discussed. The discussion emphasizes the difference between Maxwellian and

TGD based view about gauge fields in which topological field quantization is in fundamental role. The central question concerns the TGD counterpart for the superposition of classical fields and the answer to this question distinguishes between TGD and Maxwell's electrodynamics and gauge field theories in general. These differences are essential for the vision about living systems as conscious holograms and also for the view about how the Josephson currents determined by cell membrane voltage give rise to representations of the geometry qualia at the magnetic body [K35, K80, K83]. Braiding and reconnection are basic processes changing the topology of the magnetic body and their interpretation in TGD inspired theory of consciousness is discussed briefly.

One might say that magnetic body is responsible for the third person aspects of consciousness. One could also perhaps say that magnetic body serves as an intentional agent using biological body as a motor instrument and sensory receptor. One must however remember than in TGD inspired theory of consciousness it is in principle wrong to speak about doers of deeds: only quantum jumps- deeds- are real. There is no need to postulate any permanent conscious entity, say "soul". Almost by definition self assimilates with the regions of space-time from which the contents of consciousness are about and this corresponds to the region of embedding space where the non-determinism of quantum jump is located. Causal diamonds (see `http://tinyurl.com/yblbzk6x`) analogous to Penrose diagrams are the correlates of selves in this sense [K7]. Quantum jump involves a cascade proceeding from the level of CD to the level of sub-CDs identified as correlates of sub-selves interpreted as mental images of self. Negentropy Maximization Principle (see `http://tinyurl.com/yd3mly5m`) implies that the cascade stops when it is not possible to generate negentropy by reducing entropic entanglement [K59].

5.3.1   Questions

It is perhaps best to proceed by making questions. In some other mood I would perhaps use more determined approach and replace questions with assumptions. The basic question is what does one really mean with magnetic body?

(a) Is magnetic body a separate entity and connected to biological body with magnetic flux tubes which are like "threads" ? What happens to magnetic body when biological body moves. Does magnetic body move along like a rigid part of body? Or does it remain stationary and the sensation of movement results from the relative motion of magnetic body and biological body. Is magnetic body like observer looking at biological body. Is it responsible for the third person aspect of consciousness?

(b) What part of sensory percept and its cognitive representation magnetic body is responsible for? The hypothesis is that sensory organs are seats of the primary qualia and the virtual sensory input from brain allows to build standardized mental sensory mental images. Magnetic body would be responsible for the "geometric" qualia such as distance, angles, positions of objects of perceptive field. The representation at magnetic body would provide the organization of sensory input to percepts consisting of objects. Position of sensory percept would correspond to a position at magnetic body: for instance the pattern associated with a sensation of touch (it is possible to "see" through tactile sense). The interference with connections to magnetic body and affecting signals sent to magnetic body should affect these aspects of sensory perception and cognition.

Magnetic body can be regarded as a virtual body. For instance, OBEs (see `http://tinyurl.com/y797h78x`) could be understood in terms of magnetic body. Moving train illusion is an everyday example about OBE [K101]. Personal magnetic body representing also the train starts to move with respect to biological body and in this manner creates the percept about moving train. The unpleasant sensation of falling down from a cliff could is a virtual world effect resulting from the motion of magnetic body relative to biological body. Interference patterns for radiation from biological body to magnetic body. Conscious holograms are responsible for the generation of sensory percepts at the magnetic body and also for the realization of control signals from magnetic body generating nerve pulse patterns give rise to motor actions.

(c) What does the connection between body and magnetic body mean? Flux tubes from body -, which can be moving - to the stationary part of the magnetic body? Somewhat like neural pathways from muscles to brain. Biological body is the motor instrument changing its shape and position under the control of magnetic body. Magnetic body uses biological and is relatively stationary in the first approximation. Real motion to the situation in which biological body moves. Of course, also magnetic body can have motor activity and this can be very important for living matter

"DNA as topological quantum computer" (see `http://tinyurl.com/ybyscdpt`) based on braiding of the flux tubes [K2] and the reconnection processes at the level of biological body accompanying metabolism [K48]). Imagined motion could correspond to a situation in which magnetic body moves.

5.3.2 Magnetic Body And Conscious Holograms

The idea about bio-systems as conscious holograms involves in an essential manner the TGD counterpart for the interference and superposition of classical fields.

(a) The TGD based description for interference and superposition of classical fields has been already discussed. Consider two parallel space-time sheets - now magnetic flux tubes. Assume that charged particles having wormhole contacts to both sheets are present and therefore experience effectively the sum of fields associated with the two sheets. Interference pattern is represented as the transition probability as a function of M^4 position. In stationary situation no transitions take place.

(b) When the relative position of the biological body and magnetic body change - in particular, when the distance between magnetic body and biological body is changed - the interference pattern changes so that either a motion of biological body or magnetic body is experienced as a real motion. This could explain could assign to the sensory percept what could be called geometric qualia such as the position of the sensation represented as a position at magnetic body.

(c) The motion of the magnetic body relative to stationary biological body can give rise to virtual world sensory experiences carrying only the geometric qualia. This could give rise to imagination and thinking as internal speech involving all aspects of speech except those assignable to the primary sound quale at cochlea. This would also explain the unpleasant sensation of falling down when one is near cliff.

(d) Magnetic body could also move so that the motion of the biological body is compensated so that the metabolic energy used in quantum transitions giving rise to the conscious experience is minimized. Example: swimming a long time swimming in sea creates the experience of being in sea after one has returned to the shore. Magnetic body learns to compensate the motion in sea so that the waves are hardly observed. At the shore this mechanism continues to work and create illusion of being in sea.

(e) Correlational opponent processing seems to be a more general concept inspired by this phenomenon. Ron Blue has proposed in his correlational opponent-processing theory (see `http://tinyurl.com/y76w9bz4`) that right and left hemisphere form opponents for each other creating opposite reactions. The above argument suggests that magnetic body and biological body could form this kind of pair. Magnetic body would tend to generate compensating effect cancelling the effect caused by motion of biological body with respect to magnetic body to minimize metabolism. This would in general lead to a habituation.

(f) Opponent process-theory (see `http://tinyurl.com/348fwq`) is a psychological and neurological model inspired by the observation that emotional response is often followed by its opposite. Could also this phenomenon relate somehow to the relationship between biological and magnetic body? This does not look plausible. Maybe generalized second law of thermodynamics (see `http://tinyurl.com/ybg8qypx`) [L6] - stating that although the generation of genuine negentropy is possible locally it is always compensated by a generation of entropy somewhere else - could provide more natural explanation for this.

5.3.3 Topological Effects On Magnetic Flux Quanta Affecting The Biological Body-Magnetic Body Connection

Magnetic flux tubes make possible braiding and reconnection of flux tubes. These processes are fundamental in TGD inspired quantum biology. Braiding and reconnection are also possible for magnetic field lines and therefore in Maxwellian electrodynamics.

(a) Braiding of flux tubes makes possible topological quantum computation like processes. This leads to the idea about DNA as topological quantum computer (see `http://tinyurl.com/ybyscdpt`) [K2]. p-Adic fractality implies that there are flux tubes inside flux tubes defining braids with braids. Also the connections between biological body and magnetic body could define braids and make possible quantum computation like processes. Could it be possible to affect braiding artificially and affect cognition?

(b) Reconnection of flux tubes is second topological process. Reconnection process for flux tubes changes the topology of the magnetic field. For instance, magnetic storms and auroras involve reconnection process occurring in astrophysical scale. Currents flowing along flux tubes are redistributed in the process. The proposal is that flux tubes serve as correlates of attention [K2]. In living matter at cellular level the reconnections of flux tubes connecting flux tubes would be occurring all the time. The process transforming ATP to ADP and vice versa could be seen as a reconnection at molecular level.

Could reconnection between flux tubes connecting two magnetic bodies A and B - say those assignable to brain hemispheres or two subject persons - leading to a splitting of the connection between the magnetic bodies take place. Could this give rise to a kind of split brain syndrome (see `http://tinyurl.com/s38z2`). Signals from biological body **a** would go to magnetic body B and magnetic body B could induce motor actions at **a**. Does hypnosis involve reconnection? Flux tubes from the subject person (hypnotizer) would not go to her magnetic body but the magnetic body of hypnotizer (subject person)? Hypnotizer uses the magnetic body of the subject person. Is becoming possessed something like this?

(c) Two flux tubes leading from biological body to magnetic body could reconnect. To parallel flux tubes- II - would transform to cup and cap. Also the closed flux tubes of the external magnetic field could reconnect with the flux tubes connecting left and right magnetic bodies so that the connection between magnetic bodies is via the magnet which is inanimate matter which entangles entropically. If the magnetic flux tube connections between living systems are correlates for negentropic entanglement, then their splitting or transformation to those between living and inanimate system could mean the transformation of entanglement to entropic entanglement unstable under state function reduction. Could this take place in the experiments of Persinger and lead to a split brain situation and to visitor experiencers?

5.3.4 FM Modulations Of Membrane Potential As Code Of Consciousness?

What AM/FM modulation means using the language of topologically quantized fields? The answer to this question might provide new insights also about whether AM or FM is more natural at quantum level.

(a) Does the presence of two space-time sheets whose M^4 projections overlap imply amplitude modulation? Does the modulation of distance between charged plates induce the modulation of voltages which in turn induces modulation of ohmic current which in turn induces modulation of the amplitude of radiation. Note that for Josephson junction - cell membrane is regarded as Josephson junction [K80] - it is *frequency* of Josephson radiation which is modulated.

(b) Could frequency modulation reduce to the modulation of magnetic fields or to the modulation of membrane potential inducing the modulation of Josephson frequency?

(c) The carrier frequency of speech suffers frequency modulations. Whale song involves frequency modulation. Note that artificially slowed down speech is also strongly frequency modulated.

(d) Could it be that at quantum level FM is more natural? Could FM allow to realize some kind of code. In the model of hearing FM for Josephson frequencies of cell membrane induced by amplitude modulation of the membrane potential represent sound frequencies. The representation is based on resonances at the period of sound wave when absorption occurs at cyclotron resonance at the magnetic body.

The cautious conclusion is that FM by periodic or more general temporal pattern induces a variation of membrane potential. This induces a variation of Josephson frequency affecting in turn the input to magnetic body and could generate interesting effects on consciousness and behavior. If the amplitude of the modulation of the membrane potential has too large amplitude, nerve pulse is generated and has mode drastic effect.

5.4 The Relation To Persinger's Work

Anyone - atheist or believer - wanting to learn about Persinger's work and the basic insights of neuro-theology should listen the extremely inspiring talk *God and the Brain - The Persinger "God Helmet", The Brain, and visions of God* (see `http://tinyurl.com/y83pq5vl`) by Todd Murphy [**?**]. Persinger's work (for references to the articles by Persinger and collaborators see theWikipedia article about God helmet at `http://tinyurl.com/3cpoyq`) suggests that the temporal pattern of the modulation of magnetic field strength (FM would be in question for slow variations) is important. We do not however know the "code". Also the strength of the magnetic field can be important. Note that the effects of very weak ELF em fields on vertebrate brain (see `http://tinyurl.com/y9y87z84`) take place in amplitude windows [K35].

The modulation of magnetic field would probably induce FM of cyclotron frequencies. The model for hearing (see `http://tinyurl.com/ybwqawhn`) suggests this kind of modulation as a way to represents the frequencies of the sound wave. Also phase information is very important: time reversed speech sounds very different as normal speech but has the same power spectrum. Modulations would be slow in the time scales defined by the audible frequency range..1 seconds would represent lower limit for the variation rate of modulation. Audible frequencies above 20 Hz.

5.4.1 God Helmet

God helmet (see `http://tinyurl.com/3cpoyq`) or Koren helmet named after its inventor is the device used by Persinger and collaborators to study the effects of magnetic field on consciousness. Transcranial magnetic stimulation is not in question: TCMS uses fields of order Tesla whereas Persinger uses magnetic fields with strength of order.01 Gauss. This is 2 per cent of the nominal value of Earth's magnetic field. There is a coil above both temporal lobes and the active coil rotates counterclockwise.

(a) At the first stage the coil above right temporal lobe rotates counterclockwise. A chirp sequence is used. Chirp means use of an oscillating magnetic field with maximum amplitude about 1 microTesla with oscillation frequency going gradually down. The interpretation is that right-brain self is activated and dominates conscious experiences. The experiences have negative emotional coloring and sometimes the subject person has even fearful experiences.

(b) At second stage both coils rotate counterclockwise. The signal is derived from amygdala and hippocampal EEG. Faraday cage is used to eliminate external electromagnetic perturbations and also sensory deprivation is necessary (subject person is blind-folded

and in an acoustic chamber). Earth's magnetic field is present, which might have relevance and is indeed used in experiments related to the hypothesis that the variations in Earth's magnetic field affect consciousness.

A burst of left brain activity is reported to take place during second stage. Also visitor experience is reported to occur during this period. This can mean meeting of God/light being, of angels, of deceased or of group of "beings", or just sense the presence of some conscious entity. A strong sense of meaning can accompany the experience. 80 per cent of subjec persons experience at least the sense of presence.

5.4.2 Persinger's Experiments And Cyclotron Frequencies?

A more quantitative description of the God helmet experiment assuming that cyclotron frequencies are essential goes as follows.

(a) The field strength used by Persinger is of the order .01 Gauss and very weak and different from $B_{end} = .2$ Gauss which is $.4B_E$ with $B_E = .5$ Gauss the nominal value of the Earth's magnetic field. Cyclotron frequencies are by a factor of order 1/20 smaller than for B_{end}. This gives .75 Hz for Ca^{++}.

From this it is clear that the changes of cyclotron frequencies would be small in static external field in Persinger's experiments and could be treated as a small perturbation. External magnetic field could superpose with $B_{end} = .2$ Gauss and affect cyclotron states and induce transitions between them. This would induce effects on EEG visible as frequency modulations. It seems that the period for the oscillation of B must be longer than cyclotron period for this picture to make sense.

(b) One expects a fractal hierarchy of field strengths for endogenous magnetic fields and $B \simeq .01$ Gauss could correspond to higher levels of consciousness so that cyclotron frequencies for these fields would be important. In this case the external magnetic field would not be a small perturbation. The cyclotron frequencies of DNA strand carrying charge density of 2 elementary charges per nucleotide from the phosphates depend only weakly on the length of DNA strand and are about 1 Hz in B_{end}. Could the cyclotron radiation from cyclotron states associated with the external magnetic field induce interaction with DNA cyclotron states in field $B_{end} = .2$ Gauss?

(c) Consider next the time scales. The stimulation of right brain lasts during the first stage last about half an hour. There are however many lacking bits of data.

    i. In what range are the values of the rotation frequency for the magnetic field? ELf frequencies are used [**?**]. If EEG frequencies are in question the rotation should be slower what the lowest EEG frequency involved and below 1 turn per second.

    ii. The rotated magnetic field is time dependent. Chirp sequences are used to stimulate temporal lobe. What is the duration of single chirp and the frequency range covered during chirp? A good guess is that the frequency range is that of EEG. The natural expectation is that the duration of chirp is much longer than the periods in the frequency range considered. This would mean that one scan entire frequency range and that it makes sense to say that the changes of frequency during chirp is slow as compared to the instantaneous frequency.

    iii. EEG signals from left amygdala or hippocampus are used to stimulate both temporal lobes during the second stage. This means that their natural frequency scale should be in the range 1-100 Hz. These time scales would be shorter than the time scale of order 1 second assignal to Ca^{++}. This suggests that small amplitude modulation of the cyclotron frequencies in EEG range is in question. The signals sent to the magnetic body would be determined by this modulation and at least in the second stage this modification would carry information.

5.4.3 Persinger's Explanation

Persinger's own explanation relies on what might be called neurotheology (see `http://tinyurl.com/bm76c`) [**?**].

(a) The basic claim of Persinger is that the experiences in question are produced by brain so that meeting of God would not be real. Todd Murphy emphasizes that it is actually impossible to conclude anything about the existence or non-existence of God on basis of these experiments. He however claims that evolution would have developed for brain the ability to produce visions of God which often accompany near death experiences and make it easier to accept the un-avoidablity of the biological death. The reader can decide whether these two statements are consistent or not.

(b) The general idea is that both right and left amygdala, which are the most sensitive parts of the brain because the membrane potential is nearest to the threshold for nerve pulse generation. The right hippocampus is assumed to be responsible for non-verbal, "silent" thinking and left brain hemisphere to verbal thinking. This general picture is used by Todd Murphy to understand the conscious experiences accompanying death process about which near death experiences give a information. The experiences generated by God helmet during the first stage would be akin to the fearful emotions associated with near death experiences [?, ?] (NDE). The experiences during the second stage bring in mind the spiritual experiences accompanying death process and having strong positive emotional coloring.

(c) Persinger [?] and Murphy [?] propose that left amygdala is specialized to produce positive emotions (happiness, bliss, and even experience of encountering God or almost synonymously light being). Right amygdala would be specialized to produce negative emotions (such as fear and horror) and one can assign with it also depressive mood. This is not a generally accepted theory. If one accepts it, the natural question is whether right amygdala could serve as a kind of entropic dump pit and left amygdala as as a highly negentropic structure. The empirical data does not force the poor right amygdala to be a whole-daily sufferer.

Consider now the explanation of the experiences induced by God helmet. The lecture by Todd Murphy (see `http://tinyurl.com/y83pq5vl`) [?] helps considerably in attempts to understand the gist of the explanation and also helsp to see its problematic aspects.

(a) The selves of right and left brain fuse in some sense to form single self normally. The nerve bundles connecting the brain hemispheres allowing communications between them are essential for this integration. Right brain self is assumed to be sub-ordinate for left brain self. Magnetic pulses during the first period decompose self to two pieces: one could call them right and left self.

(b) During the first stage the mental images from the right brain self become dominating and fearful experiences are due to the fact that right brain amygdala, which is specialized to produce negative emotions, is hyper-active. This phase is believed to break the connection between left and right brain hemispheres. The anecdotal evidence by Todd Murphy suggests a correlation between non-verbal mood of consciousness and negative emotions. One must be however very cautious because extreme fear and horror alone might make impossible not only verbal communication but any coherent action.

(c) During the second stage both left and right brain are stimulated and expected contribute to the mental images of self when the connection between the hemispheres is intact. If I have understood correctly, the proposal is that the splitting of self to separate selves induced during the first phase is present almost permanently during the second phase and that left brain self dominates.

(d) The temporary "intrusion" of the right hemisphere self to the consciousness of left brain self would give rise to visitor experience. Intrusions would mean occasional re-establishment of the connection between hemispheres. One can question the assumption that God experience and the sensed presence represent instances of the same basic experience due to the intrusion. One could also argue that sensed presence is a signal for the breakdown of the connection and is created by the realization that there is also another self using the same biological body.

(e) The model of Todd Murphy for near death experiences would be that right amygdala can give rise to extremely frightening experiences but that the flow of the information to left

amygdala transforms this experience to its emotional opposite. The right hippocampus suggested to be responsible for "silent" thinking would be responsible to the experiences of deep meaningfulness and of understanding. To my opinion this picture is too complex and involves too many ad hoc assumptions.

Somehow my personal feeling is that this model is not quite correct. For instance, I do not understand the meaning "intrusion" ? This could be of course be just my misunderstanding. Also the hypothesis about the specialization of left and right amygdala looks strange.

5.4.4 The TGD Based Interpretation Of The God Helmet Experiments

To my opinion also other interpretations for the findings of Persinger can be imagined.

Frequency modulation as a "code of consciousness"

Maxwell's electrodynamics would suggest that a superposition of endogenous and external magnetic fields takes place in God helmet experiments and is partially responsible for the effects. This is clear from the fact that quite specific magnetic stimulation is used (signals derived from EEG during the second stage). In TGD framework one should be able to interpret this.

(a) In TGD Universe endogenous magnetic fields could form a fractal hierarchy: flux quanta inside flux quanta. Several critical values of magnetic field expected. Flux quanta could be flux tubes or sheets (DNA strands could be traversed by flux sheets and one could have hierarchy of genomes making possible collective gene expression at various levels).

(b) There is a hierarchy of Planck constants so that one can assign to the cell membrane potential a Josephson frequency proportional to $1/\hbar$ and to cyclotron frequencies photon energy proportional to $\hbar$ [K35].

(c) The code for the communications from biological body to various levels of the magnetic body relies on the modulation of the Josephson frequencies assignable to the cell membrane. Assuming that the value of Planck constant is integer multiple of its standard value these frequencies span an enormous range. In the case of EEG the Planck constant is of order 10^{13} in order to for photons with the energy of visible photon to have frequency about 10 Hz. Since Josephson frequency is proportional to the membrane potential, the modulations of the membrane potential induce modulations of Josephson frequency so that the signal sent to the magnetic body is modulated and this frequency modulation must define the "code of consciousness".

(d) The frequencies involved with these communications are sums of harmonics of Josephson frequency and cyclotron frequency and also cyclotron frequencies can be modulated by modulating magnetic fields. The simplest possibility is that the external magnetic field induces modulation of the magnetic field. This modulation is small since the field strength is of order.01 Gauss and by a factor 1/20 smaller than the endogenous magnetic field $B_{end} = .2$ Gauss suggested by the effects of ELF em fields on vertebrate brain. Of course also other field values are expected to be present.

The basic philosophy behind the TGD based model

The basic philosophy behind the TGD based explanation of God helmet experiences differs in many respects from that behind the model of Persinger and Murphy. Therefore it is good to describe this philosophy first.

(a) In the normal social consciousness based strongly on verbal communications the left brain self dominates and social interactions actually split the left brain self from right

brain self so that right brain self remains a silent companion unable to express itself except through intuitions. This raises some questions.

Could just the need to communicate the experience verbally automatically project "me" to left brain me and cut if from "right brain self" so that only the memories of left brain self are communicated. What would happen if the subject person would communicate with external world by singing? Often persons who have lost their ability to speak and comprehend spoken language can communicate by singing. Would the the projection occur to left brain self and could the memories be different?

(b) Persinger and Murphy seem to assume that right brain is God from the perspective of the left brain. Magnetic body is responsible for the third person aspect of consciousness and also for the ability to see the dying biological body from the bird's eye perspective during OBEs accompanying also NDEs, which accordingly to Murphy could be quite real. There is indeed evidence that a subject person unable to move from bed has been able to see objects which she should not have been able to see. If magnetic body is real it could also receive extra-sensory information.

Could the magnetic body of right brain or of the entire brain be in some sense the God from the view point of the brain? The TGD based interpretation (see `http://tinyurl.com/y7qfgcbx`) for the vision of Jaynes about bicameral consviousness as a precedessor of modern consciousness [**?**] citeallbsemitrance would conform with this. The God of old testament would be the personal magnetic body which would not have yet become a highly integrated part of self and could be experienced as an outsider. Jaynes also proposes that the consciousness of schizophrenic is much like bicameral consciousness.

(c) It is not necessary to assume that the right amygdala is specialized to produce negatively colored motions and left amygdala positive emotions. Same applies also to the proposed roles of right and left hippocampi. In fact, according to Wikipedia article about lateralization of brain function (see `http://tinyurl.com/ye2os3`) depression is linked with hyperactive right hemisphere and selective involvement in "processing negative emotions, pessimistic thoughts and non-constructive thinking styles". A relatively hypoactive left hemisphere is said to be "specifically involved in processing pleasurable experiences" and "relatively more involved in decision-making processes". One can interpret this in many ways. The hyper-activity of right hemisphere could tend to cut its connection with its magnetic body and cause a depressive mood.

Intense nerve pulse activity could cause this if nerve pulse generation breaks coherence of the EEG oscillation due to the oscillating membrane potentials inducing generation of signals to the magnetic body. The reduced neural activity of left hemisphere would mean a better connection to the magnetic flux tube and positive emotional coloring.

(d) Note that this picture conforms with spiritual practices which teach that the manner to achieve piece of mind and bliss is to stop thinking, which indeed means reduce neural activity and more stable connection to the magnetic body. If one takes this conceptualization seriously, one could conclude that the modern hectic society tends to split the connections to the personal magnetic bodies. Since they represent higher levels in the hierarchy of conscious entities, this would lead to a loss of spirituality and also social regression if magnetic bodies are responsible for social structures and cultural evolution.

(e) For about 26 years ago I had also a long-lasting "enlightenment" experience - actually two of them. The general structure of these experiences fits with thde proposed general format. The first experience began with the experience of getting in contact with what I spontaneously called Great Mind. I started to make all kinds of questions which I imagined of writing to a monitor that I saw in front of me. Later I realized that the writing was not necessary. I also realized that our communication was severely estricted by the fact that my language did not yet have words for to express the messages of this Great Mind so that the messages contained a lot of "blancos". I had an experience of understanding but did not know what I understand. I also felt that everything around me has extremely deep meaning. One of the first questions I did was "How long I will

live?". From the humorous reply expressed as an endless rapid running of a counter containing a long sequence of digits I understood that there is no death. I also asked "Am I alone in this Universe?". The reply was enigmatic "You are a God!". Later it somehow became clear that this God like entity was actually in some sense me. A possible interpretation could be that a new higher layer to the hierarchy of layers of my personal magnetic body had emerged as this God like creature became a part of my personal magnetic body. Much later I realized that this paradoxical realization was the analog for Brahman=Atman identity of Eastern philosophies.

Consider now the more technical assumptions.

(a) One can assume that right and left brain selves can entangle to form a single self and that magnetic flux tubes between brain hemispheres closely associated with the connecting nerve bundles serve as a correlate for this entanglement. In TGD framework the notion of negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) makes sense and means entanglement entropy defined number theoretically is negative rather than being positive as usually. Negentropy Maximization Principle for quantum jumps guarantees the stability of negentropic entanglement. Entanglement probabilities must be rational or at most algebraic numbers or negentropic entanglement.

(b) The basic mechanism would be reconnection of magnetic flux tubes. Typically two parallel connecting flux tubes would touch each other and reconnect to form U-shaped flux tubes representing flux tubes beginning and returning to left (right magnetic body). What is the role of the external magnetic field in this process? Could the closed flux tubes of the external magnetic fields reconnect with those connecting the right hemisphere to left hemisphere. Suppose that magnetic flux tubes indeed serve as geometric correlates for attention interpreted as negentropic entanglement.

Could one say that the magnet creating chirp signal catches the attention of the right brain magnetic body directed to the right hemisphere? Could the splitting of the connection to the magnetic body create the negative emotions. It is enough that the magnet-magnetic body entanglement becomes entropic to destroy the entanglement in state function reduction if one believes in NMP and perhaps this occurs.

(c) One an ask whether this kind of mechanism could explain also the effects of strong (or order 1 Tesla) fields on brain in transcranial magnetic stimulation (see http://tinyurl.com/s4aw7) or is the standard explanation in terms of eddy currents inducing nerve pulse patterns enough to explain the effects.

The model for God helmet experiences

Consider now a the general TGD inspired model explaining God helmet experiences.

(a) The magnetic chirp during the first stage tends to decouple the right hemisphere from its magnetic body and possibly also from the magnetic body of left brain. This alone creates the negatively colored emotions- kind of feeling of being abandoned by God. This could be also general mechanism of depression and the manner to cure depression would be re-establishment of this connection.

At quantum level the cutting of the magnetic connection would mean the destruction of entanglement between parts of the two brain hemispheres or between part of right hemisphere and its magnetic body temporarily. This would lead to the splitting of self to right and left brain sub-selves or the loss of the right hemisphere magnetic body entanglement.

(b) If one is ready to take seriously the notion of number theoretic entropy [K59], the minimum condition would be that the magnetic chirp causes the entanglement probabilities become non-rational or even non-algebraic numbers so that the number theoretic entropy does not make sense. Ordinary entanglement entropy is always non-negative and state function reduction reduces the entanglement and self splits to two.

(c) During the second stage the simultaneous activation of both hemispheres by artificial neuronal signals derived from the EEG of amygdala and hippocampus would fuse both hemispheres to single coherent unit so that the mental images of the right hemisphere would contribute to the conscious experience. The coherence could increase from what it is during ordinary wake-up consciousness dominated by verbal communications. "Being nearer to God" alone could give rise to highly positively colored emotions and to a direct experience of seeing the God/light being/magnetic body and explain the experience of meaningfulness and deep understanding without being able to express what one understands. This inability could be simply to the lack of appropriate language. There is no need to assign this experience to the right hippocampus.

Part II

Quantum Model for Hearing

Chapter 6

Quantum Model for Hearing

6.1 Introduction

The quantum model of hearing has evolved through several twists and turns. For years this model seemed to be one of the stable portions of TGD inspired theory of qualia and, what was remarkable, allowed rather precise quantitative predictions. The model relied crucially on TGD based new physics: in particular, the roles of long ranged dark weak force and of neutrinos was central. Long ranged weak force predicted by TGD explains nicely the parity breaking effects in living matter but the idea that neutrinos could be central for cognition looks outlandish in the context provided by the text book myth about elusive neutrino travelling light years through condensed matter without any interactions.

The emergence of zero energy ontology, the explanation of dark matter in terms of a hierarchy of Planck constants requiring a generalization of the notion of embedding space, the view about life as something in the intersection of real and p-adic worlds, and the notion of number theoretic entanglement negentropy lead to the breakthrough in TGD inspired quantum biology and also to the recent view of qualia and sensory representations including hearing allowing a precise quantitative model at the level of cell membrane. This also modified dramatically the speculative ideas about the role of neutrinos in hearing.

Also in the recent view long range weak forces play a key role. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other wheras for standard ground state classical Z^0 fields are very weak. Neutrinos are present but it seems that they do not define cognitive representations in the time scales characterizing neural activity. Electrons and quarks for which the time scales of causal diamonds correspond to fundamental biorhythms - one of the key observations during last years- take this role.

6.1.1 General Model For Qualia And Sensory Receptor

The identification of quantum number increments in quantum jump for a subsystem representing sub-self and the capacitor model of sensory receptor are already more than decade old ideas.

The concrete realization of this vision is based on several ideas that I have developed during last five years.

(a) The vision about dark matter as a hierarchy of phases partially labeled by the value of Planck constant led to the model of DNA as topological quantum computer [K2]. In this model magnetic flux tubes connecting DNA nucleotides with the lipids of the cell membrane define strands of the braids defining topological quantum computations. The braid strand corresponds to so called wormhole flux tube and has quark and antiquark at its ends. u and d quarks and their antiquarks code for four DNA nucleotides in this model.

(b) Zero energy ontology assigns to elementary particles so called causal diamonds (CDs). For u and d quarks and electron these time scales are (6.5,.78, 100) ms respectively, and correspond to fundamental biorhythms. Electron time scale corresponds to 10 Hz fundamental biorhythm defining also the fundamental frequency of speech organs,.78 ms to kHz cortical synchrony [**?**]. and 160 Hz to cerebellar synchrony [**?**]. Elementary particles therefore seem to be directly associated with neural activity, language, and presumably also hearing. One outcome was the modification of the earlier model of memetic code involving the notion of cognitive neutrino pair by replacing the sequence of cognitive neutrino pairs with that of quark sub-CDs within electron CD. Nerve pulses could induce the magnetization direction of quark coding for bit but there are also other possibilities. The detailed implications for the model of nerve pulse [K80] remain to be disentangled.

(c) The understanding of the Negentropy Maximization Principle [K59] and the role of negentropic entanglement in living matter together with the vision about life as something in the intersection of real and p-adic worlds was a dramatic step forward. In particular, space-like and time-like negentropic entanglement become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.

(d) The most important implication concerning the model of sensory receptors however relate to the vacuum degeneracy of Kähler action. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction [K80]. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as bio-photons (energies) [I34] and EEG radiation (frequencies) emerge since the values of Planck constant can be very large. The value of the Weinberg angle in this phase is fixed to $sin^2(\theta_W) = .0295$, whereas in standard phase the value is given by $sin^2(\theta_W) = .23$. The significance of this quantitative success for TGD and TGD inspired quantum biology cannot be over-estimated.

6.1.2   Some Implications Of The Model Of Cell Membrane As Sensory Receptor

The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

(a) DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.

(b) Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.

(c) Josephson frequencies of biologically important ions are in one-one correspondence with the qualia and Josephson radiation could re-generate the qualia or map them to different

qualia in a one-one and synesthetic way in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both bio-photons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.

(d) At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action can be indeed seen as a time reversed sensory perception so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

6.1.3   Model For Hearing

The model for hearing follows as a special case from the general model for sensory receptor and representations.

(a) Concerning hearing, the basic questions relate to the precise identification of the hearing quale, to the representation of pitch of the sound at the magnetic body, and to the representation of various geometric data about sound. The electromagnetic charge of the quark pair (or equivalently electroweak isospin) looks like an excellent candidate in this respect so that charge increment would define one fundamental hearing quale.

This quale need not correspond to pitch. The vision about hearing as a frequency quale suggests that cyclotron transition frequency corresponds to the pitch. Sound frequency would be coded to an increment of cyclotron frequency and pitch would be a quale assignable to the magnetic body rather than biological body. Hearing would be in a well-defined sense represent a higher level sensory modality not understandable without the notion of magnetic body. The strength of the magnetic field would code for cyclotron frequency and therefore for the pitch. One of the mysteries related to hearing is the ability to hear frequencies much higher than the maximum rate of nerve pulses which is below kHz. The coding by Josephson frequencies and representation of them as a quale of the magnetic body resolves this mystery.

(b) Equilibrioception (perception of the position and orientation of head) is very closely related to hearing as far as sensory receptors are considered: the basic difference is that the motion of hair cells is periodic for the sound perception and constant shift for equilibrioception. In this case the most important sensory data is geometric and the challenge is to build a model for magnetic body and for how the sensory data is communicated to the magnetic body.

(c) At the quantative level the first challenge is to understand the typical hearing ranges (humans, mice, bats, sea mammals) and here the time scales of CDs associated with quarks and leptons give intriguing hints. Also their cyclotron frequencies are involved and large values of Planck constant are unavoidable. Josephson frequencies are given by the effective membrane potential (Z^0 potential must be included) divided by Planck constant and it is possible to represent arbitrarily low frequencies in terms of membrane potential by allowing Planck constant to have high enough values.

(d) The frequency 2 kHz scale represents the lower bound for the frequencies representable in terms of cyclotron frequencies assignable to the CD of d quark. The CD of u quark allows to reduce the lower cutoff to 320 Hz and the CD of electron reduces the lower scale to 20 Hz representing the lower bound for the range of audible frequencies. The coding by the rate of nerve pulses can also resolve this problem as long as the rate of pulses is so high that the pulses sequences is experienced as a sound with a well-define pitch (the lower bound is about 28 Hz and higher than 20 Hz). The ultimate representation of the pitch would be always at the magnetic body.

(e) The extreme rapidity of signalling from hair cells to brain is one of the mysteries of hearing and here Josephson radiation (bio-photons) provides a direct neuronal window with practically instantaneous communication. Microtubules could be associated with the flux tubes along which Josephson radiation propagates and also microtubular conformational waves could be involved.

(f) Hearing represent in many respects an exceptional quale: consider only music experience, language, internal speech, the understanding and production of speech, and right brain sings- left brain talks metaphor. This conforms with the assumption that magnetic body is involved in essential way with hearing. Zero energy ontology leads to a vision explaining basic aspects of music experience and the notion of memetic code plus possible realization of genetic code as temporal patterns could provide first principle understanding of language.

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` [L11].

6.2 TGD Based Model For Qualia And Sensory Receptors

The identification of quantum number increments in quantum jump for a subsystem representing sub-self and the capacitor model of sensory receptor are already more than decade old ideas.

The concrete realization of this vision is based on several ideas that I have developed during last five years.

(a) The vision about dark matter as a hierarchy of phases partially labeled by the value of Planck constant led to the model of DNA as topological quantum computer [K2]. In this model magnetic flux tubes connecting DNA nucleotides with the lipids of the cell membrane define strands of the braids defining topological quantum computations. The braid strand corresponds to so called wormhole flux tube and has quark and antiquark at its ends. u and d quarks and their antiquarks code for four DNA nucleotides in this model.

(b) Zero energy ontology assigns to elementary particles so called causal diamonds (CDs). For u and d quarks and electron these time scales are (6.5, .78, 100) ms respectively, and correspond to fundamental biorhythms. Electron time scale corresponds to 10 Hz fundamental biorhythm defining also the fundamental frequency of speech organs, .78 ms to kHz cortical synchrony [?], and 160 Hz to cerebellar synchrony [?]. Elementary particles therefore seem to be directly associated with neural activity, language, and presumably also hearing. One outcome was the modification of the earlier model of memetic code involving the notion of cognitive neutrino pair by replacing the sequence of cognitive neutrino pairs with that of quark sub-CDs within electron CD. Nerve pulses could induce the magnetization direction of quark coding for bit but there are also other possibilities. The detailed implications for the model of nerve pulse [K80] remain to be disentangled.

(c) The understanding of the Negentropy Maximization Principle [K59] and the role of negentropic entanglement in living matter together with the vision about life as something in the intersection of real and p-adic worlds was a dramatic step forward. In particular, space-like and time-like negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.

(d) One of the basic challenge has been to construct a quantitative model for cell membrane.

i. The first model was based on the assumption that long range weak forces however play a key role [K10]. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other whereas for the standard ground state classical Z^0 fields are very weak. Neutrinos are present but it seems that they do not define cognitive or Boolean representations in the time scales characterizing neural activity. Electrons and quarks for which the time scales of causal diamonds correspond to fundamental biorhythms - one of the key observations during last years- take this role. The essential element is that the energies of the Josephson photons are in visible range. This would explain bio-photons and even why the frequencies assignable to visual receptors. The problem is that Weinberg angle must be assumed to be much smaller in the near vacuum extremal phase than in standard model.

ii. Second model is based on Gerald Pollack's findings about fourth phase of water and exclusion zones [L14]. These zones inspire a model for pre-biotic cells. The outcome is a modification of the simplest model of Josephson junction. Besides resting potential also the difference between cyclotron energies between the two sides of the membrane plays a key role. This model allows to understand what happens in metabolism in terms of a quantum model replacing the thermodynamical model for cell membrane with its quantal "square root" inspired by Zero Energy Ontology. The model allows also to understand bio-photons as decay products of dark photons.

iii. The success of the latter model does not of course mean that the weak forces could not be important in cell membrane scale and the realistic model could be a hybrid of these two models. The inclusion of Z^0 contribution to the effective magnetic field could also to the fact that the endogenous magnetic field deduced from Blackman's experiments is $B_{end} = 2B_E/5$ rather than B_E (Earth's magnetic field).

6.2.1 A General Model Of Qualia And Sensory Receptor

The identification of sensory qualia in terms of quantum number increments and geometric qualia representing geometric and kinematic information in terms of moduli of CD, the assignment of sensory qualia with the membrane of sensory receptor, and capacitor model of qualia are basic ideas behind the model. The communication of sensory data to magnetic body using Josephson photons is also a key aspect of the model.

A general model of qualia

It is good to start by summarizing the general vision about sensory qualia and geometric qualia in TGD Universe.

(a) The basic assumption is that sensory qualia correspond to increments of various quantum numbers in quantum jump. Standard model quantum numbers- color quantum numbers, electromagnetic charge and weak isospin, and spin are the most obvious candidates. Also cyclotron transitions changing the integer characterizing cyclotron state could corresponds to some kind of quale- perhaps "a feeling of existence". This could make sense for the qualia of the magnetic body.

(b) Geometric qualia could correspond to the increments of zero modes characterizing the induced CP_2 Käjhler form of the partonic 2-surface and of the moduli characterizing the causal diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in CP_2 and relative position of two CP_2 points assigned to the future and past boundaries of CD. There are good motivations for proposing that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could would represent this kind of qualia. Also kinematical qualia like sensation of acceleration could correspond to geometric qualia in generalized 4-D sense.

For instance, the sensation about motion could be coded by Lorentz boots of sub-CD representing mental image about the object.

(c) One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images. The simplest starting assumption consistent with neuroscience is that sensory qualia are assigned with the cell membrane of sensory receptor and perhaps also with the neurons receiving data from it carried by Josephson radiation coding for the qualia and possibly partially regenerating them if the receiving neuron has same value of membrane potential as the sensory receptor when active. Note that during nerve pulse also this values of membrane potential is achieved for some time.

Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary a sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the "feeling of existence" type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

(a) Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. One the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the "feeling of existence" at magnetic body entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.

(b) If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about 10^{14} Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of $\hbar$ must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of bio-photons and EEG. One expects that only high level qualia can correspond to a very large values of $\hbar$ needed.

For the sake of completeness it should be noticed that one might do without large values of $\hbar$ if the carrier wave with frequency defined by the metabolic energy quantum assignable to the kicking and that the small modulation frequency corresponds to the cyclotron frequency. This would require that Josephson frequency corresponds to the frequency defined by the metabolic quantum. This is not consistent with the fact that very primitive organisms possess sensory systems.

(c) If all primary qualia are assigned to the magnetic body, Josephson radiation must include also gluons and light counterparts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification

of sensory qualia in terms of quantum numbers of quark pair restricts them to the cell membrane. The coding of qualia by Josephson frequencies is however possible and makes it possible to regenerate them in nervous system. The successful model explaining the peak frequencies of photoreceptors in terms of ionic cyclotron frequencies supports this view and provides a realization for an old idea about spectroscopy of consciousness which I had already been ready to give up.

Capacitor model of sensory qualia

In capacitor model of sensory receptor the increments of quantum numbers are amplified as particles with given quantum numbers flow between the plates of capacitor like system and the second plate defines the sub-self responsible for the mental image. The generation of complementary qualia assignable to the two plates and bringing in mind complementary colors is predicted. The capacitor is at the verge of di-electric breakdown. The interior and exterior of the receptor cell are the most plausible candidates for the capacitor plates with lipid layers defining the analog of di-electric able to changes its properties. Josephson currents generating Josephson radiation could communicate the sensory percept to the magnetic body but would not generate genuine sensory qualia there (the pitch of sound would be interpreted as a geometric quale). The coding is possible if the basic qualia correspond in one-one manner to ionic Josephson currents. There are sensory receptors which themselves do not fire (this is the case for hair cells for hearing and tactile receptor cells) and in this case the neuron next to the receptor in the sensory pathway would take the role of the quantum critical system.

The notion of sensory capacitor can be generalized. In zero energy ontology the plates could be effectively replaced with positive and negative energy parts of zero energy state or with cyclotron Bose-Einstein condensates corresponding to two different energies. Plates could also correspond to a pair of space-time sheets labeled by different p-adic primes and the generation of quale would correspond in this case to a flow of particles between the space-time sheets or magnetic flux tubes connected by contacts defining Josephson junctions.

The TGD inspired model for photoreceptors [K80] relies crucially on the assumption that sensory neurons at least and probably all cell membranes correspond to nearly vacuum extremals with the value of Weinberg angle equal to $sin^2(\theta_W) = .0295$ and weak bosons having Compton length of order cell size and ordinary value of Planck constant. This also explains the large parity breaking effects in living matter. The almost vacuum extremal property conforms with the vision about cell membrane as a quantum critical system ideal for acting as a sensory receptor.

6.2.2 Detailed Model For The Qualia

The proposed vision about qualia requires a lot of new physics provided by TGD. What leads to a highly unique proposal is the intriguing coincidence of fundamental elementary particle time scales with basic time scales of biology and neuro science and the model of DNA as topological quantum computer [K2].

(a) Zero energy ontology brings in the size scale of CD assignable to the field body of the elementary particle. Zero energy states with negentropic time-like entanglement between positive and negative energy parts of the state might provide a key piece of the puzzle. The negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) beween positive energy parts of the states associated with the sub-CD assignable to the cell membrane and sub-CD at the magnetic body is expected to be an important factor.

(b) For the standard value of $\hbar$ the basic prediction would be 1 ms second time scale of d quark, 6.5 ms time scale of u quark, and.1 second time scale of electron as basic characterizes of sensory experience if one accept the most recent estimates $m(u) = 2$ MeV and $m(d) = 5$ MeV for the quark masses [C1]. These time scales correspond to 10 Hz, 160 Hz, and 1280 Hz frequencies, which all characterize neural activity (for the

identification of 160 Hz frequency as cerebellar resonance frequency see [**?**]). Hence quarks could be the most interesting particles as far as qualia are considered and the first working hypothesis would be that the fundamental quantum number increments correspond to those for quark-anti-quark pair. The identification in terms of quantum numbers of single quark is inconsistent with the model of color qualia.

(c) The model of DNA as topological quantum computer led to the proposal that DNA nucleotides are connected to the lipids of the cell membrane by magnetic flux tubes having quark and antiquark at its ends such that the u and d quarks and their antiquarks code for the four nucleotides. The outer lipid layer was also assumed to be connected by flux tubes to the nucleotide in some other cell or in cell itself.

(d) The model for DNA as topological quantum computer did not completely specify whether the flux tubes are ordinary flux tubes or wormhole flux tubes with possibly opposite signs of energy assigned with the members of the flux tube pair. Although it is not necessary, one could assume that the quantum numbers of the two parallel flux tubes cancel each other so that wormhole flux tube would be characterized by quantum numbers of quark pairs at its ends. It is not even necessary to assume that the net quantum numbers of the flux tubes vanish. Color confinement however suggests that the color quantum at the opposite ends of the flux tube are of opposite sign.

    i. The absence of a flux tube between lipid layers was interpreted as an isolation from external world during the topological quantum computation. The emergence of the flux tube connection means halting of topological quantum computation. The flux tube connection with the external world corresponds to sensory perception at the level of DNA nucleotide in consistency with the idea that DNA plays the role of the brain of cell [K88]. The total color quantum numbers at the ends of the flux tubes were assumed to sum up to zero. This means that the fusion of the flux tubes ending to the interior and exterior cell membrane to single one creates a flux tube state not localized inside cell and that the interior of cell carries net quantum numbers. The attractive interpretation is that this process represents the generation of quale of single nucleotide.

    ii. The formation of the flux tube connection between lipid layers would involve the transformation of both quark-antiquark pairs to an intermediate state. There would be no kinematic constraints on the process nor to the mass scales of quarks. A possible mechanism for the separation of the two quark-antiquark pairs associated with the lipids from the system is double reconnection of flux tubes which leads to a situation in which the quark-antiquark pairs associated with the lipid layers are connected by short flux loops and separated to a disjoint state and there is a long wormhole flux tube connecting the nucleotides possibly belonging to different cells.

    iii. The state of two quark pairs need not have vanishing quantum numbers and one possibility is that the quantum numbers of this state code for qualia. If the total numbers of flux tubes are vanishing also the net quantum numbers of the resulting long flux tube connecting two different cells provide equivalent coding. A stronger condition is that this state has vanishing net quantum numbers and in this case the ends of the long flux tube would carry opposite quantum numbers. The end of flux tube at DNA nucleotide would characterize the quale.

(e) Two identification of primary qualia are therefore possible.

    i. If the flux tubes have vanishing net quantum numbers, the primary sensory quale can be assigned to single receptor cell and the flow of the quantum numbers corresponds to the extension of the system with vanishing net quantum numbers in two-cell system.

    ii. If the net quantum numbers of the flux tube need not vanish, the resulting two cell system carries non-vanishing quantum numbers as the pair of quark-antiquark pairs removes net quantum numbers out of the system.

(f) If the net quantum numbers for the flux tubes vanish always, the specialization of the sensory receptor membrane to produce a specific quale would correspond to an

assignment of specific quantum numbers at the DNA ends of the wormhole flux tubes attached to the lipid layers of the cell membrane. The simplest possibility that one can imagine is that the outer lipid layer is connected to the conjugate DNA nucleotide inside same cell nucleus. This option would however assign vanishing net quantum number increments to the cell as whole and is therefore unacceptable.

(g) The formation of a temporary flux tube connection with another cell is necessary during the generation of quale and the question is what kind of cell is in question. The connection of the receptor to cells along the sensory pathway are expected to be present along the entire sensory pathway from DNA nucleotide to a nucleotide in the conjugate strand of second neuron to DNA nucleotide of the third neutron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.

(h) The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same quale and at the level of neurons sensory maps assigning different qualia to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the CDs of electron and quarks.

(a) Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore have long enough confinement length scales. The first possibility is provided by almost vacuum extremals with a long confinement scale also at the flux tubes. Large $\hbar$ for the cell membrane space-time sheet seems to be unavoidable and suggests that color is free in much longer length scale than cell length scale.

(b) Since the length of the flux tubes connecting DNA and cell membrane is roughly 1 micrometer and by a factor of order 10^7 longer than the d quark Compton length, it seems that the value of Planck constant must be of this order for the flux tubes. This however scales up the time scale of d quark CD by a factor of 10^{14} to about 10^4 years! The millisecond and 160 ms time scales are much more attractive. This forces to ask what happens to the quark-anti-quark pairs at the ends of the tubes.

(c) The only possibility seems to be that the reconnection process involves a phase transition in which the closed flux tube structure containing the two quark pairs assignable to the wormhole contacts at lipid layers is formed and leaks to the page of the Big Book with pages partially labeled by the values of Planck constant. This page would correspond to the standard value of Planck constant so that the corresponding d quark CDs would have a duration of millisecond. The reconnection leading to the ordinary situation would take place after millisecond time scale. The standard physics interpretation would be as a quantum fluctuation having this duration. This sequence of quark sub-CDs could define what might be called memetic codon representation of the nerve pulse sequence.

(d) One can also consider the possibility is that near vacuum extremals give rise to a copy of hadron physics for which the quarks associated with the flux tubes are light. The

Gaussian Mersennes corresponding to $k = 151, 157, 163, 167$ define excellent p-adic time scales for quarks and light variants of weak gauge bosons. Quark mass 5 MeV would with $k = 120$ would be replaced with $k = 163$ (167) one would have mass 1.77 eV (.44 eV). Small scaling of both masses gives 2 eV and.5 eV which correspond to basic metabolic quanta in TGD framework. For quark mass of 2 MeV with $k = 123$ $k = 163$ (167) one would give masses.8 eV (.05 eV). The latter scale correspond to Josephson energy assignable with the membrane potential in the ordinary phase.

In this case a phase transition transforming almost vacuum extremal to ordinary one takes place. What this would mean that the vacuum extremal property would hold true below much shorter p-adic length scale. In zero energy ontology the scaling up of quark masses is in principle possible. This option looks however too artificial.

6.2.3   Overall View About Qualia

This picture leads to the following overall view about qualia. There are two options depending on whether single quark-antiquark pair or two of them labels the qualia. In the following only the simpler option with single quark-antiquark pair is discussed.

(a) All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into 3×15 qualia with vanishing increments of color quantum numbers and 6×16 qualia with non-vanishing increments of color quantum numbers. The qualia with vanishing increments for electroweak quantum numbers could correspond to visual colors. If electroweak quantum numbers of the quark-anti-quark pair vanish, one has 3×7 *resp.* 6×8 combinations of colorless *resp.* colored qualia.

(b) There is a huge number of various combinations of these fundamental qualia if one assumes that each nucleotide defines its own quale and fundamental qualia would be analogous to constant functions and more general qualia to general functions having values in the space with $9 \times 16 - 1$ points. Only a very small fraction of all possible qualia could be realized in living matter unless the neurons in brain provide representations of body parts or of external world in terms of qualia assignable to lipid-nucleotide pairs. The passive DNA strand would be ideal in this respect.

(c) The basic classification of qualia is as color qualia, electro-weak quale, and spin quale and products of these qualia. Also combinations of color qualiaandelectroweak and spin quale are possible and could define exotic sensory qualia perhaps not yet realized in the evolution. Synesthesia is usually explained in terms of sensory leakage between sensory pathways and this explanation makes sense also in TGD framework if there exists a feedback from the brain to the sensory organ. Synesthesia cannot however correspond to the product qualia: for "quantum synesthesia" cross association works in both directions and this distinguishes it from the ordinary synesthesia.

(d) The idea about brain and genome as holograms encourages to ask whether neurons or equivalently DNA could correspond to sensory maps with individual lipids representing qualia combinations assignable to the points of the perceptive field. In this framework quantum synesthesia would correspond to the binding of qualia of single nucleotide (or lipid) of neuron cell membrane as a sensory representation of the external world. DNA is indeed a holographic representation of the body (gene expression of course restricts the representation to a part of organism). Perhaps it is this kind of representation also at the level of sensory experience so that all neurons could be little sensory copies of body parts as holographic quantum homunculi. In particular, in the associative areas of the cortex neurons would be quantum synesthetes experiencing the world in terms of composite qualia.

(e) The number of flux tube connections generated by sensory input would code for the intensity of the quale. Josephson radiation would do the same at the level of communications to the magnetic body. Also the temporal pattern of the sequence of quale

mental images matters. In the case of hearing this would code for the rhythmic aspects and pitch of the sound.

6.2.4 About Detailed Identification Of The Qualia

One can make also guesses about detailed correspondence between qualia and quantum number increments.

(a) Visual colors would correspond to the increments of only color quantum numbers. Each biologically important ion would correspond to its own color increment in one-one correspondence with the three pairs of color-charged gluons and these would correspond to blue-yellow, red-green, and black white [K80]. Black-white vision would mean a restriction to the $SU(2)$ subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide an manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.

(b) Also tastes and odours define qualia with "colors". Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give c 3×4 basic combinations are possible and can certainly explain the 5 or 6 basic tastes (counted as the number of different receptors). Whether there is a finite number of odours or not has been a subject of a continual debate and it might be that odours already correspond to a distribution of primary qualia for the receptor cell. That odours are coded by nerve pulse patterns for a group of neurons [?] would conform with this picture.

(c) Hearing seems to represent a rather colorless quale so that electroweak isospin suggests again itself. If we had a need to hear transversely polarized sound also spin would be involved. Cilia are involved also with hair cells acting as sensory receptors in the auditory system and vestibular system. In the case of hearing the receptor itself does not fire but induces a firing of the higher level neuron. The temporal pattern of qualia mental images could define the pitch of the sound whereas the intensity would correspond to the number of flux tube connections generated.

The modulation of Josephson frequencies -rather than Josephson frequencies as such- would code for the pitch and the total intensity of the Josephson radiation for the intensity of the sound and in fact any quale. Pitch represents non-local information and the qualia sub-selves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggests that right and left brain have different kind of specializations already at the level of sensory receptors.

(d) Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nocireceptors, mechanoreceptors, thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

6.2.5   Recent TGD based view about qualia

The TGD inspired theory of qualia [K39] has evolved gradually and the recent view differs from the above described picture in some aspects.

(a) 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.

(b) 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.

(c) 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 [K59] 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.

6.3   The Roles Of Josephson Radiation, Cyclotron Radiation, And Of Magnetic Body

Before representing any detailed model for hearing, it is good to summarize the vision about the roles of Josephson radiation, cyclotron radiation, and of magnetic body on basis of the proposed general view about qualia and sensory receptors. The representation below is somewhat out of date and the updated and considerably more detailed view can be found in [K6].

6.3.1   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.

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 6.1: 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.

Josephson photons could be used to communicate the qualia to the magnetic body.

(a) 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.

(b) 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.

(c) 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 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 by **Table 6.1** 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 $d$quark with kHz CD the upper bound for cyclotron frequencies would be 20 kHz which corresponds to the upper limit of audible frequencies.

(d) 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.

6.3.2   What Is The Role Of The Magnetic Body?

The basic vision is that magnetic body receives sensory data from the biological body- basically from cell membranes and possibly via genome - and controls biological body via genome. This leaves a huge amount of details open and the almost impossible challenge of theoretician

is to guess the correct realization practically without any experimental input. The following considerations try to clarify what is involved.

Is magnetic body really needed?

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.

Is motor action time reversal of sensory perception in zero energy ontology?

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 [?]. 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.

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 however 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?

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(a) 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.

(b) 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.

(c) 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.

(d) Flux quantization for large value of $\hbar$ poses an additional constraint on the model.

    i. 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

$$\int BdA = n\hbar$$

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.

ii. The quantization of magnetic flux could be replaced by a more general condition

$$\oint (p - ZeA)dl = n\hbar \ ,$$
(6.3.1)

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.

iii. 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

$$N \quad = \quad \frac{2m}{RZ^2e^2}$$
(6.3.2)

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

$$N_i \quad = \quad \frac{2m_iv_i}{RZ_i \sum_k Z_kv_ke^2} \ .$$
(6.3.3)

It seems that this condition is the most realistic one for the large $\hbar$ flux sheets at which Josephson radiation induces cyclotron transitions.

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.

(a) 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.

(b) 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.

(c) 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.

(d) 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 characterizing 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.

(a) 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.

(b) 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.

(c) 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.

(d) 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.

6.3.3 Magnetic Homeostasis And Magnetic Circulation?

The possible importance of the precise value of the local magnetic field for say memetic code [K41] suggests that living matter has learned to control local magnetic field inside magnetic flux tubes just as it controls salt level of biological water.

Variation of the local strength of B_{end}

B_{end} -which is assigned to the magnetic body of particular body part- should scale as $1/\hbar$ to maintain the constant ratio of Josephson and cyclotron frequencies. This predicts hierarchy of cyclotron frequency scales coming in octaves if one accepts that the preferred levels of dark matter hierarchy come as $r = \hbar/\hbar_0 = 2^{k_d}$ with values of k_d fixed by Mersenne hypothesis introduced in introduction and discussed in detail in [K35]. Cell differentiation could lead to the differentiation of the local value of k_d and the value could vary even inside single cell nucleus.

Also a slight variation of the strength of B_{end} for a given value of r is possible. The condition that the ratios of Josephson frequencies and cyclotron frequencies remain constant means that the scalings of B_{end} and membrane resting potential are identical. Also the relative variation of EEG frequency scale would be same as that of the resting potential. The variation of resting potential is 10 per cent as is also that of EEG frequency scale so that this prediction is correct. Since the resting potential is characteristic of cell type [K35], also the value of B_{end} for corresponding part of magnetic body would be such. In the model of hearing the variation of both k_d decomposing the frequencies into octaves and smaller variations of B_{end} allowing to decompose octaves into smaller intervals would make possible to sense the pitch of the sound [K79]. This sense would be essentially a sensory quale assignable to magnetic body.

Magnetic circulation

There is a rather precise analogy with blood flow since both incompressible velocity field of blood and magnetic field are divergenceless: one can imagine magnetic flux to flow along "B-veins" (magnetic flux tubes) along organism or at least CNS. Variation of the magnetic field strength would be forced by the variation of the thickness of the flux tube since magnetic flux is conserved just as the variation of the thickness of blood veins affects blood flow. Artificial small alteration of local magnetic from outside would only interfere with this control.

For instance, alpha peak drifts in Hz range and this could be due the variation of the value of local magnetic field varies as much as 10 per cent. If this variation is due to the homeostatic variation of the local magnetic field, absolute variation should increase for higher frequencies: at the upper end of gamma band it would be 9 Hz. An alternative explanation for drifting is in terms of amplitude modulation: amplitude modulation of frequency f_1 by frequency f implies that original frequency is split to frequencies $f_1 \pm f$. In this case the amplitude of drifting does not depend on frequency.

The analogy with blood flow suggests that one could speak about B-circulation completely analogous to blood circulation: B-circulation could be crucial for bio-system to act as macroscopic quantum system. B-circulation would naturally accompany neural circuitry. It could be also accompany ordinary blood circulation physically or could form an independent system. The association with blood circulation would provide prerequisites for quantum control of also blood circulation and metabolism. The control could be based on MW frequency Josephson currents associated with ELF em fields inducing conformational changes of proteins coherently in large regions in turn giving rise to needed synchronous biochemical self-organization processes.

Temperature dependence of the local magnetic field strength

EEG frequencies are known to change with [I65] [?] in the sense that the increase of the temperature raises the peak frequency of the power spectrum. This need not mean that the individual EEG frequencies are affected since the distribution of these frequencies could be affected due to the effects on the ionic conductances.

On the other hand, the equilibrium potentials for various ions are proportional to the temperature. In TGD framework this would predict that also EEG frequency scale is proportional to T so that the effect of temperature could be understood at least partially. Of course, very large drop of temperature known to induce sleep EEG involves dropping of higher EEG bands from the spectrum. The maximal reduction of body temperature have been to about 1 degree C and correspond to 10 per cent reduction of absolute temperature. 10 per cent variation is also characteristic variation of EEG band positions.

As far as nerve pulse generation is considered small reduction of temperature should lead to reduced membrane potential and if the value of the potential inducing nerve pulse does not follow, this would lead to a level of arousal. Maybe this could explain the stimulating effect of cold.

The question is whether cyclotron frequency scale follows the scale of the resting potential. If this is not the case, the communications to the magnetic body suffer from temperature changes since resonance conditions are lost. This could partially explain why a serious hibernation leads to a lower level of arousal. Cyclotron frequency scale can follow the change of the temperature as long as the transversal size scale of the magnetic flux quanta can react on the changes of the temperature and by flux conservation induce a change of the magnetic field strength. It is however highly questionable whether this is possible at distant parts of the magnetic body if it indeed can have the size scale of Earth.

The results of Blackman [?] suggesting that ELF effects with given frequency disappear when body temperature is not in the range $36 - 37$ C inspires the hypothesis that quantum critical high T_c superconductivity and almost vacuum extremal property of the cell membrane space-time sheet are possible only in the range 36-37 C. This obviously provides a more plausible explanation for the effect of hibernation. In this picture the extreme importance

of temperature regulation for the functioning of organism could be seen as a prerequisite for continual quantum control by magnetic transition frequencies.

Circadial temperature variation can be something like 20 Kelvins, which means relative variation about 10 per cent for poikilotherms, which is of same order as alpha frequency drifting. The relative width of the cyclotron resonance would be from this about 7 per cent ($\Delta f/f = \Delta B/B \propto \Delta T/T$). The relative variation of the membrane resting potential as a function of temperature is predicted to be sam.

Why the increase of the local magnetic field strength by factor of ten does not raise alpha band to heaven?

The increase of the local magnetic field strength by a factor $10 - 20$ is known to induce stress [**?**] and confuse biological timekeeper mechanisms but it certainly cannot raise alpha band above 100 Hz as as a very naïve standard physics based application of the cyclotron frequency hypothesis would suggest.

In standard physics picture one could indeed argue that the increase of the strength of the local magnetic field interferes directly with bio-control and has catastrophic consequences. This is not the case of B_{end} corresponds to so large value of Planck constant that cyclotron energy corresponds to the energy of visible or UV photon and if the local magnetic field corresponds to the ordinary (or just different) value of Planck constant. That the variation local magnetic field has effect can be understood if the flux tubes of the dark magnetic field B_{end} are in contact with the those of the local magnetic field presumably having standard value of Planck constant. This would be classical interaction between visible and dark sectors of "world of classical worlds". One can of course imagine also other interaction mechanisms.

6.3.4   Some Remarks And Questions

Synchronizing effect of Earth's magnetic field

Earth's magnetic field could act as grand synchronizer of biorhythms of even separate organisms. Magnetic homeostasis does not prevent the effects due to the variation of Earth's magnetic field on human consciousness.

The close correlation of various cycles of biological and brain activity, in particular sleep-wake cycle, with periodic circadial variations of the geomagnetic field [**?**], is consistent with this. Magnetic storms change temporarily the value of the local magnetic field and also this should have effects on consciousness. The statistics about mental hospitals supports this view [**?**]. Also Persinger has proposed that the modulations of Earth's magnetic field caused by geomagnetic perturbations have effect on human consciousness [**?, ?**]. Michael Persinger has studied extensively the effects of Schumann resonances on brain and has even explained religious and UFO experiences as correlates of this interaction [**?**].

Also the diurnal changes of magnetic field caused by Moon having period of 25 hours are known and this variation seems to provide fundamental biological clock which sets on in absence of the normal 24 rhythm regulated by sunlight. The diurnal variations of the geomagnetic field are also responsible for sleep-awake rhythm: the increased melatonin secretion during dark hours correlate with the variation of Earth's magnetic field.

It is also known that the exposure to magnetic fields 10-20 times geomagnetic field induces stress in rabbits and slowed reaction time in humans; that the absence of geomagnetic field leads to a complete de-synchronization of biorhythms and that the synchronization of ELF biorhythms is coupled to ELF geomagnetic pulsations [**?**]. In particular, pineal gland serves as biological timekeeper with cyclotron frequency of Co^{2+} ion defining the basic time unit of .1 seconds.

Dr. Phil Callahan [I1] claims on basis of intensive experimental work that there is a tendency of political strifes and wars to concentrate on regions where Schumann resonances are weak.

This would not be surprising since Schumann resonances act as collective bio-rhythms if vertebrate brains are connected to the magnetic body of Earth.

3. What happens to astronaut's magnetic body

There is an old objection against the notion of magnetic body. If the local value of Earth's magnetic field is crucial for the brain functioning, astronauts should experience grave difficulties or at least dramatic changes in the character of consciousness. A possible estimate for the weakening of the local magnetic field is based on the scaling law $B \propto 1/r^3$ for dipole field. In this case a rough estimate for the relative change of the EEG frequency scale is $\Delta f/f = 3\Delta R/R \sim 6$ per cent for satellites moving below the ionosphere. This should affect the state of consciousness.

As a matter fact, there is reported evidence [**?**, **?**] that cosmonauts spending months in MIR had strange altered states of consciousness involving among other things precognition of the difficulties to be countered by MIR and receiving advices and identification experiences with other people and life forms, even dinosaurs of ancient Earth!

In the many-sheeted space-time the situation looks like following.

(a) Only the levels k_d for which the size scale is between the size scale of personal magnetic body and the distance travelled could have been affected.

(b) Astronauts could have drawn the magnetic flux sheets connecting them to the magnetic body of Earth and higher level magnetic bodies with them but long period could have led to a loss of the connections to the magnetic body of Earth.

(c) At the level of cell nuclei nothing dramatic need happen. Energetically the stretching magnetic flux sheets associated with DNA is not a problem since the energy densities involved are rather tiny. Furthermore, if the flux sheets carry homological monopole flux, they could highly stable against increase of length since they would have magnetic monopole wormhole contacts at their ends.

(d) A long period in space without contact with magnetic Mother Gaia might relate to the strange experiences reported by astronauts. One might imagine that the magnetic body of say solar system or even galactic magnetic body replaces Earth's magnetic body as a kind of fundamental reference frame. For instance, the third person perspective could rely on the inner magnetosphere which is at rest with respect to rotating Earth and the outer magnetosphere which does not rotate with Earth would provide even higher level reference system which begins to dominate in this kind of situation.

(e) The experiences are consistent with TGD based view about geometric time and possibility of geometric memories extending beyond the duration of individual life cycle. There is also a consistency with Mersenne hypothesis summarized in the introduction and with the vision about long term memory inspired by this hypothesis [K35]. If one takes seriously the report about dinosaurs, which lived for $\sim 10^8$ years ago, the level $k_{eff} = 163 + k_d = 257$, which corresponds to Josephson period of about 10^8 years could have contributed to the conscious experience of astronauts. Therefore $k_d = 94$ characterizes the value of Planck constant as $r = \hbar/\hbar_0 = 2^{k_d}$. $k_{eff} = 257$ is consistent with Mersenne hypothesis. One has $257 = 239 + 18$, where $k_{eff} = 239$ is member of the twin pair $(239, 241)$ of Gaussian Mersennes suggested to be responsible for long term memory. $257 - 239 = 18$ in turn equals to the difference $107 - 89 = 18$ corresponds to the ratio of hadronic p-adic length scale $k = 107$ and intermediate boson length scale $k = 89$ defined by Mersenne primes. One cannot of course take the individual numbers deadly seriously: what is important the general view about memory based on hierarchy of weak physics assigned to Mersennes and their Gaussian counterparts suggests an explanation for the reported transpersonal memories.

5. What the reduction of Earth's magnetic field means?

The strength of Earth's magnetic field has reduced 50 per cent during last 1.000 years. The fact that an exponential evolution of civilization has occurred during this period, is perhaps

not an accident. Surprisingly many magnetic transition frequencies happen to be near to Schumann resonance frequencies which do not depend on the strength of the magnetic field. If the scale of dark magnetic field B_{end} has followed the scale of B_E the the weakening of B_E furing this period has reduced cyclotron frequency spectrum of heavy ions from $3-8$ Hz range to the range $1.5-4$ Hz but leaving the spectrum of Schuman resonances unchanged. Rather remarkably, delta frequencies near 3 Hz correspond to a peak in the frequency spectrum of so called sferics associated with lightning activity [**?**].

These observations suggest the emergence of strong interaction between brain and higher levels of the self hierarchy based on spherics and Schumann resonances. Assuming temporal linearity, the reduction of Earth's magnetic field has been 25 per cent after Newton and 5 per cent during last 100 years. Perhaps an exponential development of mathematical consciousness made possible by the activation of cyclotron frequencies of heavy ions with high nuclear and electronic angular momenta and allowing large number of conscious-to-us magnetic transitions, and possibly also involving some kind of fine tuning is taking place.

The weakening of Earth's magnetic field probably relates to a forthcoming change in the polarity of Earth's magnetic field. One might guess that the personal magnetic bodies are not affected appreciably during this period but that the violent change of Earth's magnetic field induces dramatic effects on collective aspects of consciousness at $k_d = 44$ level as the findings of Callahan suggest.

What about spin flips?

The natural question is whether also spin flips to which Larmor frequencies are associated could be important. If anomalous magnetic moment vanishes Larmor frequency differs by a factor $1/2$ from cyclotron frequency: $f_L = f_c/2$ so that spin flip frequency is same as cyclotron frequency. For atomic nuclei the Larmor frequency tends to be larger than cyclotron frequency as the table of Appendix demonstrates. The effects of em fields in living matter at Larmor frequencies have not been however reported.

The natural expectation is that Larmor frequency behaves in the same manner as cyclotron frequency in the scaling of Planck constant and this is indeed the case since spin scales as $\hbar_{eff}$. This allows to consider the possibility that also spin flip transitions are of interest and perhaps define correlates for sensory qualia.

Spin flip frequencies are in general of order few hundred Hz for $B = .2$ Gauss. The eight ions listed in **Table 6.2** have however exceptionally low Larmor frequencies and, very importantly, the singly ionized states have vanishing electronic spin for all ions except Rh and IR for which electronic configuration corresponds to $J - e = 2/2$ (non-vanishing electronic spin implies that the Larmor frequency of ion is of order $f_L = f_c(e)/2 \simeq 3 \times 10^5$ Hz). This suggests that electromagnetic spin flip transitions for these ions at least could be related to our consciousness. Note that K, Ag and Au have spin flip frequencies near to the harmonics of the fundamental frequencies of exotic super-symplectic representations important in EEG frequency range. Note that the spin flip frequency of K is 39.1 Hz which is in 40 Hz thalamocortical resonance band. The spin flip frequency 82.2 Hz for Cl might relate to the resonance frequency 80 Hz associated with retina.

6.4 Quantum Model For Hearing

It is very difficult to understand how neural processing could cope with the fast temporal gradients of the auditory input: the rate of nerve pulse transmission is simply too slow for this. The basic difficulty is that the time scale of nerve pulses is below millisecond whereas the highest audible sounds correspond to frequencies of about 200 kHz for some sea mammals [J5]. Also bats hear very high frequencies. The frequencies below kHz seem to be coded to spike interval distributions [**?**] but for higher frequencies this is not possible. The mystery is how brain -or whatever is the ultimate perceiver- receives the information about

Ion	(Z, A, S)	f_1/Hz	f_{flip}/Hz	J
Cl	(17, 35, F)	8.5	82.2	3/2
K	(19, 39, F)	7.5	39.1	3/2
Rb	(37, 85, F)	3.5	81.0	5/2
Y	(39, 89, F)	3.4	41.2	1/2
Rh	(45, 103, F)	2.9	26.6	1/2
Ag	(47, 107, F)	2.8	34.2 (39.2)	1/2
Ir	(77, 193, F)	1.6	17.0	3/2
Au	(79, 197, F)	1.5	14.0	3/2

Table 6.2: The ions for which electronic spin vanishes in ground state and minimum spin flip frequency f_{flip} is below 90 Hz. f_{flip} is defined as $f_{min} = 2f_L/Jm$, where J is nuclear spin. Ag allows two stable isotopes with almost same abundances and the values of f_{flip} are given for both.

higher frequencies. There is also the mystery of missing fundamenta [**?**], which suggests a feedback from brain to ear, which is indeed known to exist and can sometimes be even heard directly as oto-acoustic sounds.

6.4.1 Basic Facts About Hearing And Their Interpretation In TGD Framework

It is good to start by a summary of the basic facts about hearing before applying the already summarized general model.

Inner and outer hair cells

Cochlea [J9] is the basic structure responsible for the transformation of sound to nerve pulse patterns and conscious experience. It is located in the inner ear together with the vestibular system [**?**] responsible for equilibrioception- sense of balance requiring coding of information about the position and orientation of head. Both these systems utilize hair cells [**?**] to detect the motion of the fluid and the only basic difference is that in the case of hair cells related to hearing the motion is oscillatory inducing oscillation of membrane potential whereas for vestibular system the motion is non-periodic inducing a shift of the membrane potential.

The ear of mammals involves outer and inner hair cells [J5, **?**]. Outer hair cells have no axons to brain but there are efferents from cortex to them. The interpretation is that outer hair cells act as pre-amplifiers. They also make possible feedback from cortex allowing to build sensory percepts already at the level of ear. This makes reasonable the idea that sensory representations are indeed constructed at the level of sensory organs.

Hair cells act as filters selecting only one particular frequency. For cochlea piano keyboard is a good but not complete metaphor. The input at a given frequency presses various keys with a maximum activation at a key characterized by this frequency. Stereo cilia are nanotubes emerging from the surface of hair cell and participate the motion of the oscillation cochlear fluid. In inner cells this mechanism induces evoked potential varying in the rhythm of the filtered frequency. In outer cells the hair cell feeds actively energy to the sound wave and amplifies it. Outer hair cells as a dancer is a good metaphor.

The coupling of hair cells with neurons

The coupling of hair cells with neurons mediating neuronal signals to brain is poorly understood [J5, **?**].

(a) The transmission of neurotransmitters to postsynaptic neuron from the hair cell should be uncannily fast. The existence of unidentified very fast neurotransmitter is postulated.

  (b) Hair cell contains near presynaptic cleft a mysterious structure with ring like shape known as presynaptic dense body. The function of this structure is not known but is believed to be crucial for the transfer of the neural transmitter.

  (c) There is chronical Ca^{2+} leakage to the hair cell. This is also believed to be crucial for the transmission of the mystery transmitter.

Hearing range

The hearing ranges [**?**] are the basic quantitative facts that the model of hearing should be able to explain.

  (a) For humans the hearing range is between 20 Hz and 20 kHz. For dogs the hearing range is from 40 Hz to 60 kHz. For bats the hearing range is between 20 Hz and 120 kHz. This suggests the existence of two different mechanisms of hearing. For mice the hearing range is from 1 kHz to 70 kHz, which suggests that the ranges $20 - 10^3$ Hz and the range above it are fundamentally different as far hearing is considered. One explanation is that rate coding is lacking.

     Sea mammals have also wide hearing ranges. Harbour porpoise emits sounds at two bands: one at 2 kHz and one above 110 kHz and the cochlear of these dolphins are specialized to accommodate extremely high frequencies. Bottlenose dolphin produces sound in a range varying from 250 Hz to 150 kHz. Marine mammals are also known to possess language and whales are known to sing.

  (b) Outer hair cells -possessed only by mammals- are known to be crucial for the expansion of the hearing range besides pre-amplification increasing the sensitivity and it might be that the two hearing ranges relate to the presence of two kinds of hair cells. Mechanoreception is based on vibrations of stereocialia in the cochlear fluid mediating the sound vibrations.

Hearing range involves several poorly understood aspects. Frequencies above kHz do not allow rate coding by nerve pulses and one mystery of neuroscience is how these sounds give rise to a conscious experience. One should also understand why 20 Hz defines the lower bound of audible frequencies and why the fundamental frequency of speech organs is 10 Hz, which by the way suggests that harmonics of 10 Hz could provide a fundamental representation of frequencies. One should identify the mechanism giving rise to the two audible ranges suggested by the hearing of bats and sea mammals.

Pitch

Pitch corresponds to the subjective sensation created by the sound and is determined by the fundamental frequency and its harmonics which are its integer multiples. If the distribution of frequencies is even (non-harmonicy) there is no distinguishable pitch. The sounds produced by music instruments to represent melodies have well-defined pitch.

The phenomenon of missing fundamental means that fundamental is experienced although it is not present. This can be understood in terms of the feedback from brain artificially generating the missing harmonic in outer hair cells. The higher harmonics of the fundamental determine the character of the pitch and define the recognizable character of music instrument and human voice (timbre).

The relative resolution of pitch is $\Delta f / f = 4.3$ per cent so that octave could be divided to 86 notes distinguishable from each other to be compared with 12 notes in the well-tempered scale. If the two frequencies are heard simultaneously the resolution increases since beat frequencies can be perceived. According to [**?**] even subjects with absolute pitch require a context in order to recognize the pitch of the sound. There are several acoustic illusions related to pitch. For instance, a continues or discrete sequence of specially formed tones can be made to sound as if the sequence would continue to ascend or descend indefinitely.

Other aspects of hearing

Hearing involves also many other aspects discussed in [**?**] and is clearly an exceptional sensory modality.

(a) One key aspect of hearing relates to the determination of the direction of the sound source. This is known to involve the comparison of timing of the signals coming to ears and involves neuronal activity.

(b) Hearing can be selective and auditory system is able to recognize the voice of a familiar person from the crowd. This suggests that the feedback generating artificial percept is especially important for hearing. I have a personal experience about conference held in Finland, where I listened english for a week. As I returned from the conference I heard to my surprise the finnish language as english for some time. Obviously, my brain manipulated the auditory input very actively.

(c) Music experience involves several poorly understood phenomena serving as guidelines for anyone trying to understand sensory experience at deeper level. Mention only octave phenomenon and harmony and rhythm and pitch are dual aspects of the music.

(d) Speech and language relate also to hearing. Why just hearing? Does this reflect that fact that pitch is a quale of magnetic body? And how internal speech relates to speech and hearing? The interpretation of internal speech as imagined speech would look natural but the challenge is to understand what imagination is. Could internal speech be based to a cortical projection to outer hair cells generating a weak auditory stimulus? Or could neurons generate internal speech in terms of neuronal quale distributions analogous to hearing quale but without the signalling to the magnetic body? Also sign languages are possible but sign language might express internal speech. Right brain sings-left brain talks metaphor has also something in it and the theory should provide insights about this specialization.

Cochlea and its magnetic body could give rise not only to auditory qualia but also define low level cognitive and emotional representations of auditory input realized already at the magnetic body of cochlea and realized in terms of cyclotron phase transitions. The right brain signs-left brain talks metaphor suggests an identification of cognitive *resp.* emotional representations as sequences of "phonemes"*resp.* "notes". The construction of the sensory representations involves in an essential manner back projection from brain to outer hair cells. Astrocytes regarded earlier as mere metabolic energy reservoirs are in this model carriers of higher level cognitive and emotional representations: this applies to all qualia. Microtubuli are responsible for mediating auditory input to brain as acoustic/electric signals (also propagating conformational patterns could be involved) and this resolves the mystery of how frequencies above kHz frequency are heard.

6.4.2   How Pitch Is Represented?

The proposed vision about sensory perception would suggests that pitch is directly experienced at the magnetic body of the cochlea or some higher level magnetic body. This would solve the problem posed by high pitches for the model based on rate coding. The frequency modulated Josephson radiation generated by the hair cells would define the experienced pitch. Given hair cell would correspond to a specific position of the magnetic body and Josephson radiation from the hair cell could induce cyclotron transition at it.

The frequencies assignable to CDs seem to be involved

The frequency coding by cyclotron frequencies or by harmonics assignable to various kinds of CDs is highly suggestive.

(a) This coding need not be same as the coding by cyclotron frequencies. Indeed, since the time scale of CD scales as $\hbar$, the CDs in question must correspond to the standard

value of Planck constant. This would require that Josephson photons leak to these CDs and are transformed to bunches of ordinary photons. The proposed model for the generation of quale involves a leakage of two quark-antiquark pairs to a space-time sheet with ordinary value of $\hbar$ for a time interval defined by the corresponding CD scale. This CD could be interpreted as the embedding space region in which attention is directed when mental image is created. For low frequencies electron CD would be involved also.

(b) Quark sub-CD correspond to time span of 1 ms (d quark) or 6.5 ms (u quark) and electronic sub-CD to the time scale .1 s. The restriction to harmonics of the fundamental frequency would mean frequency cutoff $f_{low} = (2 \times 10^3, 320, 20)$ Hz for (d, u, e) respectively. For frequencies below the 320 Hz electronic sub-CD should be used and this gives IR cutoff frequency of 20 Hz, which is indeed the cutoff for audible frequencies.

(c) The Josephson radiation with frequencies above $f_{low} = (2 \times 10^3, 320, 20)$ Hz could be generated during the nerve pulse and induce (d, u, e) cyclotron transition at the flux tube assignable to the sensory pathway corresponding to a given frequency. Rate coding by nerve pulse patterns could apply below frequencies sufficiently below kHz. These frequencies would correspond most naturally to harmonics of the fundamental frequency (10, 160, 1280) Hz, which suggests that this coding relates to music experience.

(d) The frequencies could be coded by the local value of the magnetic field at magnetic body and the pitch of the sound could be represented in this manner as a quale of the magnetic body. Similar coding is possible for other qualia. One can of course ask whether cyclotron frequencies are involved with this coding at all. The idea about resonance at the level of CD is suggestive but a proper formulation for this idea is lacking.

Codings based on cyclotron frequencies

The cyclotron frequencies of electron and quarks would define three different frequency ranges. For the standard vacuum (classical Z^0 field is very small) electron, u, and d quarks would define for $B_{end} = .2$ Gauss the basic cyclotron frequencies as $f_{up} = (564, 94, 19)$ kHz. The lower bound for the cyclotron frequency would be above $f_{low} = (2 \times 10^3, 320, 20)$ Hz for B_{end}. For electron this would give $B_{end,min} = 2$ nT, which represents an alarmingly weak magnetic field but could make sense if the value of Planck constant is large.

One can imagine several kinds of codings even if one assumes that the ultimate representation of the pitch is based a cyclotron transitions and that Josephson frequencies or their modulation codes for qualia. It is not completely clear what the correct option could be. Two basic classes of codings can be considered depending on whether the magnetic flux quanta correspond to the ordinary value of $\hbar$ or not.

(a) If one assumes generalized flux quantization posing no conditions on the thickness of the flux quanta, the frequency can be coded by $B_{end} \propto 1/\hbar$, and one can assume that they correspond to flux tubes assignable to cell membranes. It seems that this option is the only reasonable one if flux tubes correspond to large $\hbar$. This in turn is supported by the dual interpretation of Josephson radiation in terms of bio-photons and EEG.

(b) If one assumes that flux tube correspond to the ordinary value of $\hbar$ and that the geometric data about percept -say the direction of the sound source- are coded by Josephson radiation, one must assume that the quanta of Josephson radiation are transformed to bundles of ordinary photons with cyclotron frequency in a phase transition changing the value of $\hbar$.

Two mechanisms for the coding of the pitch using cyclotron frequencies

The basic idea is that magnetic body responds by cyclotron transitions to the incoming radiation representing the frequencies of sound. The Josephson frequency of the cell membrane proportional to $1/\hbar$ is a natural first guess for the representative of the sound frequency. Also its frequency modulation with sound frequency could be a natural manner to represent the

sound frequency: this would require amplitude modulation of the membrane potential by sound frequency.

One can imagine several mechanisms for the coding of the pitch.

(a) The sound is directly converted to electromagnetic oscillations so that Josephson frequencies would not be involved at all. This requires piezoelectricity. Biomolecules are typically electrets and often also piezeoelectrics. The interaction of the electric field most naturally represented as MEs with the magnetic field body would induce cyclotron transitions.

(b) Second mechanism relies on the coding of sound frequency by Josephson frequency. Large values of $\hbar$ are unavoidable since for ordinary value of $\hbar$ Josephson frequency would be of order 10^{14} Hz. In this case place coding is possible in the sense that different sound frequencies would stimulate different positions at the magnetic body with flux tubes of varying thickness but same magnetic flux.

(c) Third mechanism relies on the modulation of Josephson frequency by sound frequency. In this case the carrier frequency could be rather high. Piezo-electric effect would code sound waves to amplitude modulations of the membrane voltage. The resonance mechanism implies that the pitch is represented by the time interval between absorption peaks. Note that sound is analyzed already in the cochlea to frequencies and resonance mechanism allows response only in a limited region of magnetic body if the magnetic field at magnetic body varies (say flux tubes do not have constant thickness). Therefore place coding is natural also now. Quite generally, FM is very natural for place coding for coding of all kinds of geometric information such as positions of objects of perceptive field.

The latter option allows several alternatives.

(a) If the modulation frequency is much lower than Josephson frequency (proportional to $1/\hbar$), the periodic variation of the Josephson frequency defining cyclotron frequency f_c for the receiving end induces a sequence of peaks as the Josephson frequency passes through f_c and this sequence would generate the sensation of pitch.

For frequencies below kHz the same mechanism could realize rate coding. A sequence of nerve pulses would generate sequence of pulses of Josephson radiation generating the cyclotron transition. Since the Josephson frequency of cell membrane can be quite high -varying up to about 10^{14} Hz, also high frequencies can be coded using FM.

(b) In principle the cyclotron frequency need not depend on the frequency detected by the hair cell. It can be also a piecewise constant functions of it. If sound wave generates a perturbation of membrane potential, linear coding in the entire range communicating different frequencies to different positions of the magnetic body is natural. Josephson radiation with given frequency should be guided by magnetic flux tubes -most naturally the flux tubes assignable to cell membranes or microtuli- to a larger area of the magnetic body. Only the spots of the magnetic body for which the cyclotron frequency corresponds to Josephson frequency would respond to the Josephson radiation.

(c) Josephson frequency cannot be too large since the cyclotron frequencies at the magnetic body are bounded by the value of magnetic field. For high audible frequencies electron's cyclotron frequency is natural at the receiving end: for $B_{end} = .2$ Gauss it equals to 6×10^5 Hz and poses upper bound for audible frequencies unless one allows stronger magnetic fields. Certainly a rather large value of $\hbar$ is needed for Josephson radiation and also for the flux tubes unless Josephson radiation is transformed to a energy radiation radiation with ordinary value of Planck constant before the interaction with the cyclotron condensate. The amplitude of the modulation of the membrane potential would define the maximum deviation from the cyclotron resonance.

(d) Cyclotron frequency could be proportional to the audible frequency so that the modulation frequency would be a constant proportion of modulated frequency- most naturally identical with it. In this case, place coding by position at magnetic body would result

even when only massless extremals propagating in arbitrary directions are used (mass communication and tuning at the receiving end). This would require that the field strength at the magnetic body varies. The magnetic body of the entire cochlea would experience the sounds as spatial patterns of cyclotron transitions.

(e) Each hair cell could represent its special frequency at the magnetic body of the group of hair cells coding for the same frequency. If Josephson frequency equals to the modulating frequency, one cannot speak about frequency modulation anymore. The resulting Josephson radiation would be at the harmonics of the audible frequency. If the cyclotron frequencies are identical to Josephson frequencies, one would have a coding of audible frequencies by magnetic field strength. $B_{end} = .2$ Gauss is a good guess for the order of magnitude. This option is attractive since the modulation can be said to be in resonance.

This option is problematic if one assumes flux quantization in the form $\int BdA = n\hbar$. As explained, there are two ways to avoid the problems. The first one relies on currents at the boundaries flux tubes generating the magnetic flux. Second one assumes ordinary value of Planck constant and that Josephson photons are first transformed to bunches of ordinary cyclotron photons. For both options magnetic field strength is proportional to $1/\hbar$ which therefore codes for the frequency. For the first option the transversal scale of the flux tube can be independent of $\hbar$ constant and most naturally corresponds to that for the axonal membrane.

The cyclotron frequencies of electron and quarks define three different frequency ranges and all these might be involved with frequency coding.

(a) For the standard vacuum (classical Z^0 field is very small) and for $B_{end} = .2$ Gauss the cyclotron frequencies would be $(f_e, f_u, f_d) = (564, 94, 19)$ kHz. For $f = 20$ Hz frequency the ratio $f/f_d \sim 10^{-3}$ would be obtained for d quark. These choices would allow to understand all hearing ranges. 150 kHz is the highest upper bound for the hearing range and should corresponds to electron's cyclotron frequency. The coding of 20 Hz frequency for d quark would require $B_{end,min}/B_{end,max} = 10^{-3}$ in the case of human auditory range containing 10 octaves. The same ratio would predict hearing range 94 Hz-94 kHz for u quark and hearing range 564 Hz-564 kHz for electron. For $B_{end,max} = .2$ Gauss one would have $B_{end,min} = .2$ μT. Magnetic fields of strength of order .05 μT have effects on living matter [**?**] so that the proposal is consistent with experimental findings.

(b) The flux tubes could also correspond to almost vacuum extremals. In this case the values of cyclotron frequencies would be considerable higher. This option does not seem to bring anything essentially new to the picture but cannot be excluded. It might even forced by the fact that cell membrane space-time sheet corresponds to almost vacuum extremal. In this case the frequencies corresponding to $B_{end} = .2$ Gauss are $(f_e, f_u, f_d) = (8.996, 2.275, .947)$ MHz. This option would give $B_{end,min}/B_{end,max} \simeq 10^{-5}$ and $B_{end,min} \sim .4$ nT if d quark is required to code for 20 Hz.

(c) Fractality encourages to consider a fractal consisting of flux tubes inside flux tubes with flux tubes associated with the low frequencies containing those assigned to high frequencies. The quantization of magnetic flux is consistent with this mechanism. For B_{end} the flux tube thickness from the quantization of the magnetic flux would be about cell size, which looks natural. For larger values of $\hbar$ the natural quantization condition at the axonal level involves the currents at the boundaries of the flux tube generating the magnetic field. The flux tubes assignable to axons and other structures could fuse outside the body to larger flux tubes satisfying the standard quantization condition of magnetic flux and form flux tubes inside flux tubes.

(d) If the magnetic field of Earth is used for place coding the distance to the flux tube would code for the frequency. This would however induce frequency dependent phase shift and distortion of spectrum. This suggests that endogenous magnetic field -that is magnetic field assignable to personal magnetic body must be used. The most natural quanta are the flux tubes assignable to teh cell membranes.

6.4.3   The Mystery Of The Fast Transmitter

The extreme rapidity of the transfer of the postulated unidentified nerve transmitter from the hair cells to the nerve axons is a mystery.

(a) The transmitter is not needed at all if Josephson radiation mediates the signal along the auditory pathways and possibly also re-generates the quale at neuronal level. This is certainly the most elegant solution of the mystery since Josephson radiation has also interpretation in terms of EEG and EEG correlates strongly with the contents of conscious experience. The chronic leakage of Ca^{++} wave would relate to the Josephson current and the related Josephson radiation would provides EEG representation of the quale.

(b) Also microtubuli could mediate the information about evoked potentials at hair cell membrane to brain as microtubular conformal patterns and/or acoustic/electric waves. Acoustic and electric waves would be both present since microtubuli are electrets.

   i. The transfer of auditory information from hair cells to postsynaptic neuron could occur also via acoustic transmission meaning that the time lag spent in this step would be of order $\sim .1$ ns only. The reported extreme sensitivity of of the axonal signal to the evoked potential (the resolution is about $\Delta V \sim .1$ mV) [J5] conforms with the view that evoked potential provides a representation of the sensory input.

   ii. The representation and communication of acoustic signals at microtubular level could induce the coding of frequencies sufficiently below 1 kHz to spike interval distributions [?]. The obvious critical question is how badly nerve pulse disturbs microtubular communications. One might argue that these perturbations do not affect conformational waves. As proposed earlier, the microtubular conformational wave patterns could be responsible for long term memories for instance. Acoustic waves could fulfill the same function.

   iii. For this option the presynaptic dense body would be involved with the transformation of the temporal pattern represented by the time pattern of Ca^{2+} leakage to a signal propagating along the microtubule. Coupling to the microtubular conformational waves/acoustic signals could be also mechanical and the dense body could generate acoustic oscillations representing the temporal pattern of Ca^{2+} waves.

6.5   Music And Consciousness

Music experience provides an interesting testing ground for several assumptions of quantum TGD and TGD inspired theory of consciousness. The notion of self is especially interesting in this respect.

6.5.1   Some Aspects Of Music Experience

It is good to list first some elementary characteristics of music experience that the model should be able to explain. Both rhythmic aspects and pitch of the sound are important. Rhythmic aspects correspond to time domain representation for the intentsity of sound carrying local information about sound wave whereas pitch carries global information. The relationship between these two elements of music is like that of function and its Fourier transform. Harmony enters the game when several frequencies are present.

Rhythm

There are two basic types of views about rhythm, additive and divisive, and they correspond to the multiplication and sum as basic arithmetic operations.

(a) In western music rhythm corresponds to a division of longer periods of time divived into smaller rhythmic units. Rhythm is basically a clock and rhythm is essentially a decomposition of integer to a product of integers defining the rhythmic unit and their number. Classical western music is relatively simple rhythmically (consider only the music of Bach). In the music of Chopin tempo rubato makes the duration of the basic rhythmic unit and of its basic structural elements dynamical but rhythms are still relatively simple although simultaneous 3/4 and 3/8+3/8 appears often. In jazz and various forms of popular music rhythms tend to be highly clocklike but are very complex.

(b) In Indian music for instance, rhythms are additive and larger periods of time are constructed from smaller rhythmic unis added to the end of the previous unit. This division corresponds to addition rather than multiplication algebraically. Also intermediate forms can appear and do so often in folk music (say folk music of Greece, Balkan, and Spain). For instance, one can have the sum of 3/4+3/8+3/8 as a repeating rhythmic unit. In flamenco form known as Bulerias [J8] the basic rhythmic unit consists of 12 beats and the collective performance creates a very complex and emotionally catching rhythm, which is almost impossible to analyze to pieces. It is easy to believe the claim that artists often fall in trance during the flamenco sessions.

Pitch

Pitch can be identified as the fundamental frequency of note. Pure sine wave is aesthetically unpleasing and harmonics are always present and characterize the music instrument. Not only frequencies but also phase relationships between them are important. For instance, they distinguish between the phonemes of spoken language and in the case of singing this brings in an important additional element not so important for non-electronic instrumental music. Furthermore, melody is never a mere sequence of precisely defined frequencies. For instance, slow modulations of the pitch reducing mathematically to a superposition of closely separated frequencies and glissandos have emotional affect.

The model of music experience should explain also the following aspects related to pitch understand as fundamental frequency.

(a) Octaves of the fundamental are experienced as equivalent. The presence of higher harmonics is needed to make pure sinus wave a musical note. Higher harmonics determine the character of the pitch chracterizing the music instrument.

(b) There exists a large number of different scales to which one assigns attributes like diatonic, minor, chromatic, whole tone, pentatonic, diminished... All these scales have quite specific emotional coloring and they characterize different music styles. The minimum frequency interval corresponds to a minimal scaling of the frequency and depends on music style. Western classical music uses semitone as the basic unit corresponding to the scaling $2^{1/12}$ in equally tempered scale but also microintervals are used and the only limitation comes the from ability to discriminate between different frequencies. The scales have special notes such as tonic, supertonic, mediant, subdominant, dominant, submediant, subtonic with special roles in harmony. For instance, listener is often able to remember the basic scales even if the tonic of the scale has suffered several modulations during the music piece. Deviations from basic scale have important emotional effects (say in the case of minor scale).

(c) Ancient mathematicians believed that the presence of rational multiples of fundamental frequencies are essential for harmony. It is possible to construct the basic scales involving only rational multiples of the fundamental in terms of selected harmonics. For instance, Pythagorean construction uses only powers of 3/2 and octaves to construct the basic scale (C, G, D, A, E, H, ...). Although the pitch is distinguished only within a finite resolution and equally tempered 12-note scale uses only powers of $2^{1/12}$ of the fundamental, rational multiples of the fundamental might relate deeply to the basic physics of cognition and to the frequencies generated in brain as opposed to those used to produce the music.

(d) The expectation of an engineer is that the transposition of the scale should not effect on the music experience and one could think that it could be done in a continuous manner. Many composers, for instances Sibelius, experienced different modes differently and as synesthetes assigned to them different visual associations. Many people are able to recognize the ratios of notes but there is also the much rare phenomenon of absolute ear meaning that subject person is able to tell the pitch of the note directly. A synesthesia like phenomenon is probably in question.

(e) An interesting question the notion of absolute scale could make sense to some degree? The fundamental frequency of sound producing organs is 10 Hz and the region of audible frequencies begins at 20 Hz and consists of approximately 10 octaves. kHz frequency is the resonance frequency of head sized object and at this frequency the mechanism allowing to deduce the direction of sound source changes. The biological basis for this would be that 10 Hz and 1 kHz define fundamental biorhythms. The quantum physical basis for this could relate to the p-adic length scale hypothesis predicting that 10 Hz and 1280 Hz could correspond CDs of electron and quarks. To get a contact with concretia note that soprano C corresponds to 1046.50 Hz. Also the cyclotron frequencies assignable to various biologically important ions in endogenic magnetic fields could defined preferred scales. The A above middle C corresponds by convention to 440 Hz, which is integer multiple of 10 Hz but by pure convention and fifth octave of 8.175 Hz which is not too far from the lowest Schumann resonance. An interesting question is whether the transposition to a scale for which the fundamental is simple rational multiple of 10 Hz or lowest Schumann resonance might have some specific emotional effect.

Harmony and other collective aspects of music

Harmony relates closely to the interaction of different frequencies and is therefore one particular collective aspect of music experience.

In the terminology of physicists, harmony is a phenomenon of many particle physics with particles replaced notes of the scale and many-particle states with chords. Depending on the ratios of the frequencies certain chords are aesthetically pleasing and emotionally significant and there are also principles governing aesthetically pleasing chord progressions. Harmony might be seen as the vertical aspect of the music whereas melody would correspond to horizontal one. Dissonance is the opposite of harmony and tritonus was forbidden in the early western music but is nowadays used to create tension. Polyphony -say in Bach's music- and simple chords used to accompany singing represent two opposite views about harmony. Chopin's music has especially rich harmonies and emotional expressive power.

While listening music one typically selects some instrument as figure and the rest as a background. In romantic piano concertos the competition between the solist and orchestra about the attention of the listener creates the basic tension. In polyphonic music one must also select the tone progression to which attention is directed and it is difficult -perhaps even impossible- to simultaneously grasp the separate tone progressions. Same applies to other elements of music.

6.5.2 Zero Energy Ontology, Hierarchy Of Planck Constants, And Number Theoretic Physics

The number theoretic vision brings interesting new physics elements which might help to understand music experience.

(a) The hierarchy of selves has as an embedding space correlate the hierarchy of CD is basic prediction. p-Adic length scale hypothesis suggests that quantization of size scales of CDs as octaves and the question is whether this relates directly to the preferred role of octaves in music experience. The time scales of CDs define preferred fundamental frequencies coming as octaves and the hierarchy of Planck constants defines scaled variants

of these as rational or integer multiples (depending on generalization of the embedding space).

(b) The question is whether these fundamental frequencies also define fundamental keys so that music experience would depend on absolute frequency scale. Even if CDs define fundamental keys, the frequency scale associated with sub-CD as experienced in the rest system of CD can be scaled continuously by performing a Lorentz boost for CD. Even glissando could be achieved for CD by performing to the sub-CD a Lorentz boost continuously and leaving the other tip of CD invariant. The boost would be the hyperbolic analog of an ordinary rotation and act like acceleration from rest to constant velocity inside sub-CD. If one takes this picture seriously also Lorentz boosts would be important part of the representation of music at the level of magnetic body (presumably using MEs). Quantum TGD proper suggests the quantization of these boosts.

(c) Number theoretic vision predicts an infinite number of algebraic extensions of p-adic numbers -in particular those corresponding to roots of unity. In the p-adic context the proper representation of sine waves requires the introduction of these algebraic extensions and the prediction is that rational multiples of the fundamental frequencies assignable to p-adic length scales should have a special role from the point of view of cognition.

This might justify the belief that the notes of the scale should be expressible in the optimal situation as rational multiples of the fundamental note. The cognitive representation of the music in the intersection of real and p-adic worlds should map the physical frequencies or rather the sine waves at a discrete set of time values to their p-adic counterparts. One has to deal with phase factors defined by plane waves $exp(ift_n)$ at discrete set of points t_n such that the exponent equals to $exp(i2\pi m/N)$ and belongs to the algebraic extension. The harmonics of f obviously satisfy the same condition. The representation of pitch in terms of algebraic extensions of rationals requires that the corresponding partonic 2-surfaces correspond to complex enough algebraic extensions of rationals containing high enough roots of unity. The modulation of the pitch as superposition of two nearby rational frequencies could is possible without leaving this framework.

(d) One can consider also different but not exclusive explanation for why scales define preferred collections of frequencies. Pythagorean scale involves rational multiples of fundamental obtained as powers of 3/2 and 2 so that the frequencies involved correspond to rationals of form $3^m 2^n$ for which only 3-adic and 2-adic norms differ from one. Small-p p-adicity associated with $p = 2$ and $p = 3$ could select the preferred frequencies.

6.5.3 Why Octaves Are Experienced Similarly?

The model should explain the basic features of music experience. There are many interesting questions related to this. One of the most important is why frequencies which are 2^k-multiples of the fundamental frequency, notes differing by octaves, are experienced as identical notes.

1. p-Adic length scale hypothesis, zero energy ontology, and octaves

Thus the phenomenon of octaves could relate to the p-adic length scale hypothesis, which implies that physically preferred p-adic primes correspond to primes near prime power powers of two. For instance, this implies that the massless extremals (MEs) associated with physically important p-adic primes have fundamental frequencies which are octaves of each other. Therefore a classical resonance via the formation of flux tubes becomes possible and real space-time sheets corresponding to preferred p-adic primes can form larger resonant structures. This universal resonance could explain why octaves are experienced similarly. The problem of this argument was that primary p-adic time scales would come as half octaves instead of octaves.

Octaves seem to have much deeper significance than I thought originally and seem to emerge at the level of fundamental formulation of quantum TGD rather than characterizing only a

very special kind of sensory experience. In the recent formulation of quantum TGD using zero energy ontology [K26, K25] one uses zero energy states which have their positive and negative energy parts at the light-like boundaries of causal diamonds consisting of future and past directed light-cones.

Physics as a generalized number theory vision, in particular the assumption that real physics and various p-adic physics result as algebraic completions of rational physics, motivates the hypothesis that the temporal distance T between the tips of the causal diamond is quantized and corresponds to powers of 2 using time scale defined by CP_2 size as a basic unit. This assumption allows to deduce p-adic length scale hypothesis ($p \simeq 2^k$, k integer), and to identify T as a secondary p-adic time scale. For electron this time scale is .1 seconds and corresponds to the fundamental 10 Hz biorhythm. For non-standard values of Planck constant T is scaled by a factor $\hbar/\hbar_0$. Thus octaves become a key element of fundamental physics. One can say that causal diamonds as space-time correlates of self appear naturally as octaves. Also rational multiples of fundamental frequency emerge via the hierarchy of Planck constants: in principle all rational scalings of the basic hierarchy are allowed.

2. Is sensory experience 2-adic in some sense?

A stronger hypothesis for the phenomenon of octaves is that cognitive music selves are 2-adic or that real music selves can transform easily to 2-adic selves. One might even consider the possibility that the phenomenon is much more general. Music metaphor has indeed turned out to be of crucial importance for the theory of qualia. Thus music metaphor could reflect the underlying 2-adicity of the sensory experience (at some level of self hierarchy). Perhaps at least some aspects of our experience result from a mimicry of the lowest level of the p-adic self-hierarchy. Taking 2-adicity seriously, one is forced to ask for the possible consequences of 2-adicity. For instance, could it be that at the level of primary qualia the intensity of sensation as function of stimulus depends on the 2-adic norm of the 2-adic counterpart of the stimulus and is thus a piecewise constant function if sensory input?

An observation supporting this speculation is following. When over-learning occurs in tasks involving temporal discrimination, the intensity of sensation as a function of stimulus deviates from smooth logarithmic form in small scales by becoming piecewise continuous function [?] such that the plateaus, where response remains constant are octaves of each other.

This observation suggests a generalization inspired by 2-adic version of music metaphor. Primary quale has a multiple of cyclotron frequency as its correlate and, being integer valued, is essentially 2-based logarithm of the 2-adic norm for the 2-adic counterpart of the intensity of the sensory input. Hence the increase of intensity of the sensory input by octave correspond to a jump-wise replacement of the n: th harmonic by $n+1$: th one and should be seen in EEG. Our experience usually corresponds to the average over a large number of this kind of primary experiences so that underlying 2-adicity is smoothed out. In case of over-learning or neurons involved act unisono and the underlying 2-adicity is not masked anymore.

At the level of MEs this would mean generation of higher harmonic when the number of nerve pulses per unit of time achieves threshold value allowing the amplification of corresponding frequency by the mechanism discussed already earlier. This certainly would mean that cognition is an important part of music experience. The strongest assumption is that the real note selves are able to transform to 2-adic selves by a phase transition changing local topology from real to 2-adic. Note however that p-adic length scale hypothesis might be enough.

6.5.4 Does Harmonic Complexity Reduce To 3-Adicity?

An interesting question relates to the conditions guaranteeing that a chord is experienced as harmonious in the Pythagorean sense [?]. Pythagorean tuning is based on the notion of perfect fifths identified as scalings by 3/2 producing the sequence C, G, D, A, E, .. In this tuning major-C scale corresponds to ratios $C = 1/1, D = 9/8, E = 81/64, F = 4/3, G = 3/2, A = 27/16, B = 243/128, C = 2/1$. E_b and $F_\#$ correspond to ratios $2^5/3^3$ and

$3^6/2^9$. All notes are expressible as powers of two and three. Since the multiplication of any note by a power of two does not affect the harmony it should be to drop the powers of two from the integers characterizing the notes in the ratio of three notes. For instance, C-E-G reduces $3 : 3^4 : 1$, $C - E_b - G$ to $3^4 : 1 : 3^3$, and tritonus $C - E_b - F_\#$ to $3^9 : 1 : 3^3$. The problem of Pythagorean tuning is that one cannot represent 2 as an exact integer power of $3/2$ and the scalings give infinite number of tones. If the construction starts from G_b then $F_\#$ and G_b correspond to frequencies, which are not quite identical in Pythagorean tuning. One could make compromize by introducing the geometric mean of $F_\#$ and G_b but this would bring in $\sqrt{3}$ and would force to leave the world of pure rationals. For string instruments and electronic instruments the Pythagorean tuning is practical but for instruments like piano the transposition of the scale is impossible.

One should be able to characterize a given chord harmonically by a function $F(a, b, c)$, which is symmetric under the permutations of the reduced pitches a, b and c obtained by dropping powers of two and is invariant under over all scaling of the reduce frequencies. The elementary symmetric functions $F(a, b, c) = [a^2(b + c) + b^2(a + c) + c^2(a + b)]/abc$ and $G(a, b, c) = [a^3 + b^3 + c^3]/abc$ are the simplest functions of this kind. Either of these functions or their product or ratio could be considered as a measure for the harmonic complexity. The value of the denominator abc equals to 3^n, $n = 3, 7, 12$ in the cases considered. The numerator has in all cases 3-adic norm equal to one for both F and G. This suggests that the 3-based logarithm of the 3-adic norm $1/|abc|_3 = |F|_3 = |G|_3$ having the values 3, 7, and 12 for C-major, C-minor, and tritonus could serve as the measure for the complexity. It is indeed smallest for major and largest for tritonus. 3-adic norm for the product $1/a_1 a_2 ... a_n$ of n notes of the chord defines a measure of complexity in more general case. A good guess is that the 3-adic norms of the elementary symmetric functions give rise to the same measure.

For the chords C-E-G, F-A-C, and G-H-D appearing as basic chords in C- major scale the values of the harmonic measure are 3, 2, and 8. This means that the basic chords are not harmonically equivalent in Pythagorean system whereas in equally tempered system they would be. One might think that this explains why the tonic is remembered. The anomalously low value for F-A-C relates to the fact that it is only tone for which the power of 3 is negative. Situation changes of F is identified as a minimal power of 3 giving F equivalent with Pythagorean F within the resolution of ear to pitch which is about $|\Delta f/f| = 4.3$ per cent. $F = 3^5/2^8$ gives $|\Delta f/f| = 4.8$ per cent. This F would give for F-A-C the harmonic measure 8 which equals to that for G. This looks more reasonable than the purely Pythagorean value. This definition would also allow to find a unique choice of powers of three for 12-chord system. For instance, $F_\#$ is favored over G_b since it corresponds to a positive power of 3.

6.5.5 The Notion Of Self And Music

The music experience allows also to test the ideas related to the notion of self.

(a) Summation hypothesis states that self is a sum of abstracted experiences of sub-selves and thus representing kind of averages about the experiences of sub-sub-selves.

   i. The conscious experience induced by music decomposes in a clear manner to basic elements identifiable as sub-selves. For instance, melody and more generally various tone progressions could define such sub-selves and the experiences of these sub-selves would sum up to music experience. In the same manner rhythmic patterns define their own sub-selves. Therefore it might make sense to speak about "frequency sub-selves" and "rhythm sub-selves".

   ii. At space-time level the magnetic body and massless extremals (MEs) are the natural candidate for the representation of "frequency sub-selves". One can say that MEs provide a universal music instrument at the level of magnetic body since they allow arbitrary superposition of collinear waves proceeding in the same direction which is non-dispersive (shape of the pulse is preserved) so that arbitrary harmonics are possible for a ME with fixed length. Maybe the temporal duration of sub-selves assignable to MEs is what distinguishes between these representations.

iii. A collection of sub-selves associated with ME at precisely defined periodically appearing positions could define rhythm whereas frequency selves would correspond to MEs with relatively long temporal duration. Interpreting MEs in terms of communications to the magnetic body, one expects that the rhythm automatically generates short-lasting MEs communication the pulses defining the rhythm to the magnetic body whereas pitch corresponds to long lasting MEs.

iv. This picture challenges the assumption that the mental images created during music experience are localized to brain. Rather, MEs and magnetic body would be the carriers of the mental images. Maybe one could say that nerve pulse patterns induce these MEs. In left hemisphere nerve pulse patterns induced by the beats of rhythm and having a total duration considerably below.1 second would send single ME to the magnetic body. In right hemisphere the pulse patterns would integrate to single ME having duration of the note.

(b) The hypothesis that entanglement creates wholes from parts and that there are three cognitive modes corresponding to reductionistic and holistic cognition and their hybrid based on negentropic entanglement is of special interest in the context of music experience.

i. Even admitting the dangers of naïve right-left thinking it would seem natural to assign the rhythmic aspects of the music to the reductionistic regions of brain and various aspects related to pitch to the right brain hemisphere. At least in the latter case MEs are highly suggestive as a fundamental representation of music at the level of magnetic body. Perhaps music experience actually involves in a very essential manner also magnetic body. That "eastern" music favors additive instead of divisive rhythm could be understood as higher right brain dominance. The extremely mechanical rhythms characterizing the popular music today, the lack of melodic aspects, and the use of the volume of music as the basic means to induce emotional effect, could in turn interpreted in terms of extreme left brain dominance.

ii. Music can have a strong emotional effects and this allows to test the hypothesis that the character of entanglement correlates with the emotional color. Maybe just the fact that these emotions are enjoyable irrespective of whether they are sad or joyful and have an undeniable healing effect can be interpreted in terms of the presence of the negentropic entanglement (see **Fig. http://tgdtheory.fi/ appfigures/cat.jpg** or **Fig. ??** in the appendix of this book). For instance, the ability of good music to generate vibrations in spine could relate to this negentropic aspects. Music as purely intellectual experience could induce essentially an analysis of what was heard based on the use of holistic-reductionistic dichotomy. Chopin's music has especially strong healing effect. Tempo rubato might reflect the profound integration of rhythmic aspects, melodic, and harmonic to single organic whole both at the level of representation and music experience.

(c) The model of subjective memory and the new view about time might be relevant for the understanding of how the basic key of the music piece can be remembered. If conscious experience for a given self is about the space-time region defined by corresponding CD, one could understand how Mozart was able to experience the entire composition as a single whole. If the music piece defines in the ideal case the fundamental CD inside which the sub-selves representing the elements of the music oiece reside, this CD could also define the fundamental "key" and would be more or less sensorily experienced and need not even to be remembered. This would explain why the return to the original key in classical is so important to relieve the tension created by modulations.

6.5.6   Harmony And Self-Organization

The phenomenon of harmony should be somehow related to quantum self-organization: perhaps the often used metaphor of harmonious co-existence could be turned around. Various notes correspond to sub-selves in the population of sub-selves and it might be that self-organization favours simultaneous conscious existence of sub-selves corresponding to subsets

of frequencies defining basic chords. One could even consider some kind of co-operation between the frequency selves belonging to same basic chord.

The simplest model for the phenomenon of harmony relies on the identification of the chords as "chord selves" formed by entangled "note selves" consisting of negentropically entangled "frequency selves". The listener is self having as sub-selves (mental images) note selves and chord selves which correspond to the same level of the self hierarchy. The entanglement between note selves could occur even at the level of ear between the mind-like space-time sheets sensitive to various frequencies. Topologically it would correspond to the formation of magnetic flux tubes between corresponding partonic 2-surfaces. The ability of the "note selves" of the chord to have stable flux tube bonds between themselves should depend crucially on the fact that the frequencies of the notes of the basic chords have simple rational ratios so that the oscillations involved are commensurate and match together. Hence a resonance phenomenon ins spirit of classical physics involving rational ratios of frequencies would be in question. During listening the chord self continually decomposes into sub-selves when listener consciously concentrates attention to some notes in the chord.

The ability of the music to occasionally create thrills in spine could correspond to whole-body consciousness in unusually large length scale. Note the this scale could correspond also to the secondary time length scale assignable to CD. It presumably involves a resonant fusion of also other than note sub-selves to larger negentropic sub-selves by the formation of stable flux tubes identifiable as magnetic flux tubes. The ability of certain sounds ("Om") to promote the emergence of whole-body consciousness could be due to the ability to very effectively generate negentropic entanglement direction. Perhaps the frequency spectrum of "Om" contains resonant frequencies of several sub-selves and induces large sub-selves. Also the healing effect of music and sounds could rely on this mechanism.

Focusing attention to some instrument producing melody creates kind of figure-background relationship. This requires that entire instrument playing the melody is represented by "instrument self". An interesting possibility is that various instruments give rise to their own ensembles of frequency-selves. Note that the model makes it easy to understand why experienced performance is not simply the sum of indidivual performances. Music experience is a complicated self-organization process in which parts compose to wholes by quantum entanglement and vice versa according to how the listener directs his/her attention.

6.5.7 Absolute Ear

Absolute ear means the existence of a preferred hardwired scale and ability to associate to the heard notes their names. Transposing an instrument is painful for an instrumentalist with perfect pitch since the notes she's playing are not the ones she's hearing.

Musicians with absolute ear can even decompose sounds that are usually regarded as a noise to a collection of notes with well-defined pitches. Obviously absolute ear means a well-developed ability of some part of brain to perform a Fourier analysis for the incoming sounds. It is known that the temporal planum part of the cortex is much more developed on the left side than on the right side for people with absolute ear [?]. The larger size of left temporal planum correlates also with right-handedness so that "absolutists" might be more strongly right-handed than usual. The increased size of the left temporal planum is also involved with reading: people with dyslexia tend to lack temporal planum asymmetry [?].

Perhaps the left temporal planum of the "absolutist" automatically assigns to the heard notes a symbolic representation as written notes. If only right brain hemisphere performs the Fourier analysis, this would require right-left communication which could be also carried out via the magnetic body inducing generalized motor action associating to the pitch pattern heard by right magnetic body their names in left temporal planum.

One can however imagine much simpler mechanism. During the recognition task the left temporal planum could simply send Josephson radiation from the points representing the names of notes to the right magnetic body at the frequency of the note in question. The recognition of the note would be based on resonance with the Josephson signal coming from

the signal representing the music percept. This would also allow to detect dissonance. The inability to adapt to a new scale would be due to the fact that the Josephson frequencies in the left temporal planum are hard wired.

6.6   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 [?] 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 2^{10} 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 [I8]. 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 [I3] 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 amino-acids 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.

6.6.1 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 th 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 space-time 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.

(a) 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.

(b) 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 do-decahedron is unique module rotations and reflection leaving dodecahedron invariant. Also in the case of tetrahedron and cube the Hamiltonian cycle is unique.

(c) For octahedron and icosahedron this is not the case [A8] 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.

(d) 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.

(a) 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.

(b) 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.

(a) 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:

$$n_0 = n_2 - 4 \ , \quad n_2 \geq 4 \ ,$$
$$n_1 = 24 - 2n_2 \ , \quad n_2 \leq 12 \ .$$

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 $N_{tot} = 2^k$, $k \geq 7$, so that the integers cannot characterize the topology of the path completely.

(b) The number of Hamiltonian cycles on icosahedron is known to be 2560 [A3]. Numerical calculations [A5] (`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`

(a) Everyone of the 12 quints $C - G$, $C_\# - G_\#$, ... would be contained to neighboring triangles tht 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 $p_{ij} \geq 0$ 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

$$p_{22} = 12 - p_{11} - p_{22} \ ,$$
$$p_{22} = p_{11} + n_2 - \tfrac{n_1}{2} \ ,$$
$$p_{22} = n_2 - \tfrac{p_{12}}{2} \ .$$

(b) 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.

$$p_{22} = p_{11} + n_2 - \tfrac{n_1}{2} \ ,$$
$$p_{22} = n_2 - \tfrac{p_{12}}{2} \ .$$

giving

$$p_{11} = (n_1 - p_{12})/2 \ ,$$
$$p_{22} = p_{11} + n_2 - \tfrac{n_1}{2} = n_2 - \tfrac{p_{12}}{2} \ . \qquad .$$

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 $p_{12} \in \{0, 2, ... Min\{12, 2n_2, n_1\}$ 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.

(c) 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`

(a) p_{12} 1-1 edges can be chosen in

$$N(1-1, p_{12}) = \begin{pmatrix} 12 \\ p_{12} \end{pmatrix}$$

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.

6.6.2 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 [K2]. Combined with the idea about connection between music scale and icosahedron this inspires the following consideration.

(a) 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.

(b) 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 triangles containing one edge, and 7 acidic polar and polar amino-acids to those containing two edges. One can criticize the combination of polar and acidic polar amino-acids in the same class. 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.

(c) As found Hamiltonian paths have also other topological characteristics and they could correspond to physical characteristics and it would be interesting to see what theyh are. 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.

Can one understand genetic code?

What remains open is the interpretation of genetic code [I3]. 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?

(a) 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.

(b) 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 $D = 4$.

(c) 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 6.3** 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 $N = 2^{10}$.

(d) 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.

d	6	4	3	2	1
N	3	5	2	9	2

Table 6.3: 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.

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.

(a) One can start by looking the **Table 6.3** 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.

    i. There are 3 amino-acids codes by 6 codons and 2 amino-acids coded by 1 DNA: $3 \times 6 + 2 \times 1 = 20$ codons altogether.
    Note: One could also consider 1 amino-acid coded by 2 codons instead of 2 coded by 1 codon $3 \times 6 + 1 \times 2 = 20$.

    ii. There are 5 amino-acids coded by 4 codons making $5 \times 4 = 20$ codons altogether.

    iii. 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.

(a) 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).

(b) 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.

(a) 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).

    i. 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.

    ii. 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.

(b) The 5 amino-acids coded by 4 codons must correspond to $n = 4$ and therefore to $\tilde{Z}_2 \times Z_2$. 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.

(c) 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 [I8]).

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.

(a) 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.

(b) 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.

(c) 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 Ile and base triangle to empty amino-acid. Base triangle would be coded by 1 tetrahedral codon plus 2 icosahedral codons.

(d) 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 (selenocysteine (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 $(n_0, n_1, n_2) = (3, 10, 7) \rightarrow (4, 11, 7)$.

(e) The two other outsider tetrahedral triangles could correspond to the orbits of Z_2 sub-group 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 icosatetrahedral 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 [K76] ?

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

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 amino-acid" 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.

(a) 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 $(n_0, n_1, n_2) \rightarrow (4, 11, 7)$.

(b) 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 $n_1 \to n_1 + 1$ since one icosahedral 1-quint triangle disappears and 2 tetrahedral ones appear. Icosahedral n_0 increases by 1 units. Hence the condition $(3, 10, 7) \to (4, 11, 7)$ would be met. It however seems that $(4, 8, 8)$ is more promising starting cycle as the argument below shows.

(c) 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 amino-acids 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.

(a) 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.

(b) 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 $n_2 \to n_2 - 2 + 1 = n_2 - 1 = 7$. 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 $n_1 \to n_1 + 3 = 11$.

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 [K41]. 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.

(a) The identification of the 3-chords assignable to the triangles of the icosahedron.

(b) 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 followingis a proposal for how one might proceeed. It relies on paper model for icosahedron.

(a) 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.

(b) 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 $b_(I, j)$.

(c) 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.

(d) 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.

(e) 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 $P(I)$, $I = 1, 2, 3$

(f) 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 $j - i \pm 1$.

(g) 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 uniqely 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.

(h) 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.

(i) The number n_1 of 1-quint triangles can be estimated as follows.

   i. 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.

   ii. $P(I)$ pentagonal boundary edges contribute $2 \times (P(I) - 1)$ additional 1-quint triangles.

   iii. T contributes at most 4 1-quint triangles.

   iv. t can correspond 1-quint triangle and would do so if the interpretation of extended code is correct.

(j) 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 [A5] (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.

(a) 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.

(b) 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.

(c) 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. ??, ??** and **??**) 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.

There are following isomorphic collections.
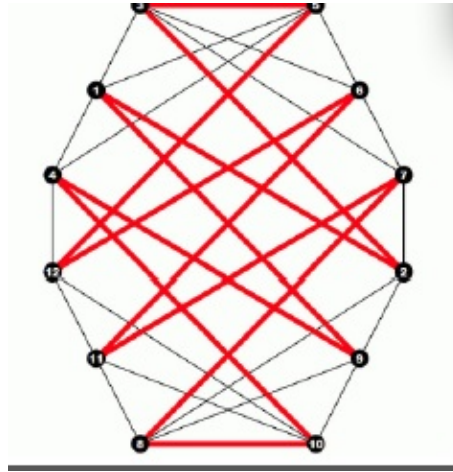
Figure 6.1: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2 reflection symmetries acting in vertical and horizontal directions.

(a) 6 asymmetric collections containing the maximal number of 48 cycles each. In this case images are not given.

(b) 3 collections with 2-fold rotation symmetry containing 48/2=24 cycles each. One has $(n_0, n_1, n_2) \in \{(0, 16, 4), (0, 16, 4), (4, 8, 8)\}$.

(c) 5 collections with reflectional symmetry containing 48/2=24 cycles each. One has $(n_0, n_1, n_2) \in \{(2, 12, 6), (2, 12, 6), (4, 8, 8), (2, 12, 6), (2, 12, 6)\}$.

(d) 2 collections with 2 reflectional symmetries containing 48/4=12 cycles each. One has $(n_0, n_1, n_2) \in \{(0, 16, 4), (4, 8, 8)\}$.

(e) 1 collection with 6-fold rotational symmetry containing 48/6= 8 cycles. One has $(n_0, n_1, n_2) = (2, 12, 6)$.

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. ??, ??** and **??**.

6.6.3 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.
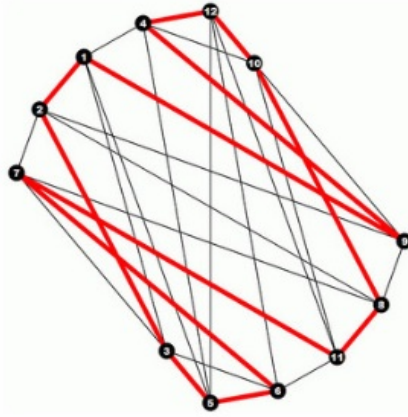
Figure 6.2: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold rotational symmetry acting as 6-quint rotation.

EEG and music

First of the key ideas relates to the idea that genetic code relates to the music scale.

(a) 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.

(b) 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 strengths at magnetic flux tubes as was proposed much earlier in the quantum model of hearing [K79]. 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
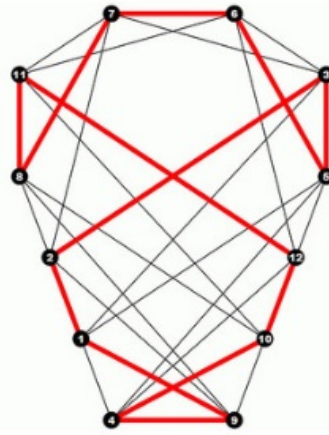
Figure 6.3: $((n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold refection symmetry acting as horizontal reflection.

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 non-empty 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 [K59]). 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

$$cos(x) + cos(y) = cos((x + y)/2) \times cos((x - y)/2) \ \ .$$

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.

Does DNA understand speech or should you sing to it?

There is an interesting popular web article (see `http://tinyurl.com/3ghkl7y`) [I37] about the work of Peter Gariaev with whom I have written a couple of articles. A more professional representation about wave DNA of Gariaev *et al* can be found from CASYS2001 conference proceedings [I25]. One of the findings of Gariaev's group is that the intronic portion of the DNA has a statistical resemblance to the structure of language (words of language correspond to DNA codons and Zipf's law (see `http://tinyurl.com/ycevt3jb`) appears to be obeyed [**?**]). The question whether introns could code language at molecular level comes to mind.

It is also reported that the connection with language is much more concrete. The words of spoken language generate response at the level of DNA: DNA "hears" and maybe understands language (or is it us who understand the language in this manner?). If one accepts that even water has memory and reacts to signals inducing emotions in living organisms, this would not be so surprising. In fact, in TGD framework water would be primitive life form with dark DNA consisting of protonic strings such that proton states would be in 1-1 correspondence with DNAs, RNAs, amino-acids and perhaps even tRNAs [L4, K42]. Vertebrate genetic code follows from natural assumptions between dark counterparts of DNAs and amino-acids.

So the claim is that spoken language modulating em radiation has effect on DNA. In standard physics context it is difficult to see how this could make sense. The energies of phonons at audible frequencies are simply so low that understanding the effect in terms of phonons does not seem to be possible. Could it make sense in TGD inspired quantum biology? One can at least try and this is what is done in the sequel. The explanation relies on the basic assumptions of TGD inspired quantum biology distilled during last 10 years.

(a) Dark matter corresponds to a hierarchy of phases labelled by the values of effective Planck constant given by $h_{eff} = n \times h$ [K37]. This hypothesis can be reduced to the failure of strict determinism for the basic variational principle of TGD and is consistent with the notion of gravitational Planck constant defined as $h_{gr} = GMm/2piv_0$, where v_0 is characteristic velocity assignable to the two particle system consisting of masses m and M [K93]. This formula holds true at flux tubes mediating gravitational interaction in terms of gravitonic "massless extremals" (MEs) topologically condensed at them.

For elementary particles, ions, atoms, even biomolecules this formula is consistent with $h_{eff} = h_{gr}$. Equivalence Principle implies that the formula for h_{gr} must be assumed only for them to explain approximate Bohr orbitology for planetary orbits. For Earth-charged particle system the formula predicts Planck constant for which dark cyclotron photon energies in endogenous magnetic fields are in visible and UV range at which also biophoton energies are. Gravitational Compton length does not depend on the mass of particle - essential for macroscopic quantum coherence and consistent with Equivalence Principle. For Earth-Sun system the gravitational Compton lengths is of the order Earth radius, which suggests that at dark matter level Earth is macroscopic quantum system.

(b) This picture conforms with the hypothesis that biophotons are ordinary photons resulting in h_{eff} changing phase transition conserving four-momentum [K22]. Since the energy levels of biomolecules belong to visible and UV range, dark photons could control biochemistry by dark-to-bio-photon transitions. This would give the missing interaction link between biochemistry and magnetic body. The standard hypothesis is that biophotons are side products of biochemistry: in TGD Universe biophotons would become active controllers of biochemistry and would be used by magnetic body.

(c) Living matter as a random soup of biomolecules is replaced with a highly organized structure. Dark matter can be seen as a library of "Akashic records" realized in terms of negentropic entanglement [K59]. Each dark particle, atom, molecule, etc is at its own magnetic flux tube characterized by $h_{eff} = h_{gr}$. One can say that each book in the Akashic library resides neatly at its own book shelf labelled by the value of magnetic field strength and h_{eff}. The communication between levels of dark matter hierarchy (book shelves) would take place by using h_{eff} changing transition of dark photons having a universal energy spectrum independent of the particle mass and depending on the strength of magnetic field at the flux tube. Visible photons correspond to single energy octave which suggests connection with music discussed in [K79].

In this framework it is not too difficult to understand how DNA could "hear" and maybe even "understand".

(a) DNA codons carry -2 units of em charge per single nucleotide due to the presence of one diphosphate in the sugar backbone. The ratio $Q_{tot}/M_{tot} = 2N(tot)e/M_{tot} = 2e/M(ave)$ to which cyclotron frequency is proportional, is inversely proportional to the average mass $M(ave)$ of the unit of DNA sequence. Hence DNA sequences are coded by cyclotron frequencies and to "wake up" given unit of DNA it is enough to irradiate it with dark photons at this cyclotron frequency. For long sequences of DNA cyclotron frequency becomes essentially constant if DNAs obey statistical a distribution with single Gaussian peak. One can consider the possibility that the distribution is many-peaked and fractal. This is not the only one possible option that one can imagine. Cyclotron frequencies could be also assignable - not to DNA itself but - to charged particles at the flux tubes associated with the basic units of DNA.

(b) There are two ways to "wake up" DNA: frequency resonance at the level of dark matter and energy resonance at the level of visible matter. The first manner to wake up DNA is by a transformation of acoustic signal to dark photons at cyclotron frequencies which are also cyclotron frequencies assignable to DNA molecules. DNA units would be analogous to the frequency specific hair cells in cochlea. The TGD inspired model of hearing indeed assumes that the hair cells carry out this transformation. Second manner to wake up DNA is to transform the dark photons first to biophotons with a transition energy of DNA molecule and thus inducing the chemical transition. These dark photons could then excite the DNAs resonantly at cyclotron frequencies or a chemical transition energies after transition to bio-photon. This mechanism breaks quantum coherence.

If the excited DNAs correspond genes or to a portion of DNA inducing gene expression, acoustic signal (say speech) would be transformed to genetic expression and thus generate a physiological response. Introns could also generate em signals transformed to acoustic signals giving eventually rise to internal speech. Here the cyclotron resonance mechanism could be at work. This mechanism respects quantum coherence.

(c) Right brain sings - left brain talks metaphor suggests an interpretation for these two mechanisms. For the singing right brain the cyclotron resonance for dark photons could dominate. For the talking left brain the chemical excitation using biophotons could dominate.

The experiments of Gariaev *et al* [I37, I25] suggest that amplitude modulation of light signal by acoustic signal, say speech, is enough.

(a) The carrier wave with single frequency modulated by single frequency would consist of a superposition of signals with frequencies which correspond to sum and difference

for the frequencies involved. They could naturally correspond to parallel space-time sheets (MEs) (but this is not necessary): the test particle touching both sheets indeed experiences the sum of the effects caused by the two signals. The naïve expectation would be that these signals are detected as such. This would not however allow the proposed mechanism.

Another possibility is that the resulting photons at either or both space-time sheets having frequency and energy of (say) visible photons are transformed to dark photons with the frequency of phonon in the frequency range involved with the speech. This condition fixes the value of h_{eff} to be essentially the ratio of visible and audible carrier frequencies and fixes also the value of the endogenous magnetic field strength from the condition that cyclotron energy scale is same as the energy of visible photon. The MEs in question should be topologically condensed at the magnetic flux tubes.

(b) These dark photons transform to biophotons inducing a response both at the level of biochemistry and at the level of DNA sub-units (talking and singing): if h_{eff} in question is correct, the DNA sub-unit corresponding to flux tubes with the value of h_{eff} associated with dark photons is excited and can induce protein translation or some other form of gene expression so that the incoming signal finds expression.

(c) One can consider also acoustic signals transformed directly to dark photon electromagnetic signals propagating along flux tube-massless extremal pairs to DNA since living matter consists of piezo-electrets performing these transformations. These would correspond to communication by "singing": singing could correspond basically frequency modulation induced by the modulation of magnetic field strength ("whale's song"). The variation of membrane voltage by waves and by nerve pulses induce similar frequency modulation.

6.7   Geometric Theory Of Harmony

For some time ago I introduced the notion of Hamiltonian cycle as a mathematical model for musical harmony and also proposed a connection with biology: motivations came from two observations [L16], [K79, K114]. The number of icosahedral vertices is 12 and corresponds to the number of notes in 12-note system and the number of triangular faces of icosahedron is 20, the number of amino-acids and the number of basic chords for the proposed notion of harmony. This led to a group theoretical model of genetic code and replacement of icosahedron with tetra-icosahedron to explain also the 21st and 22nd amino-acid and solve the problem of simplest model due to the fact that the required Hamilton's cycle does not exist.

This article was meant to be a continuation to the mentioned article providing a proposal for a theory of harmony and detailed calculations. It however turned out that the proposed notion of bio-harmony was too restricted: all isosahedral Hamilton cycles with symmetries turned out to be possible rather than only the 3 cycles forced by the assumption that the polarity characteristics of the amino-acids correlate with the properties of the Hamiltonian cycle. This working hypothesis had to be given up. The fuel of the minirevolution was the observation the symmetries of the Hamiltonian cycles (Z_6, Z_4, Z_2) are nothing but the icosahedral symmetries needed to predict the basic numbers of the genetic code and its extension to include also 12st and 22nd amino-acids. Thus icosahedral Hamiltonian cycles predict genetic code without further assumptions.

One also ends up with a proposal for what harmony is leading to non-trivial predictions both at DNA and amino-acid level.

(a) 3-adicity and also 2-adicity are essential concepts allowing to understand the basic facts about harmony. The notion of harmony at the level of chords is suggested to reduce to the notion of closeness in the 3-adic metric using as distance the distance between notes measures as the minimal number of quints allowing to connect them along the Hamilton's cycle. In ideal case, harmonic progressions correspond to paths connecting vertex or edge neighbors of the triangular faces of icosahedron.

(b) An extension of icosahedral harmony to tetra-icosahedral harmony was proposed as an extension of harmony allowing to solve some issues of icosahedral harmony relying on quint identified as rational frequency scaling by factor $3/2$.

This extension is kept also now. One must however give up the idea about correlation between polarity characteristics of proteins and properties of Hamilton cycles. One must allow *all* 11 icosahedral harmonies with symmetries as bio-harmonies: their symmetry groups Z_6, Z_4, Z_2 can be identified as the symmetry groups defined the decomposition of 60 DNA codons to 20+20+20 codons in the model of the genetic code. The 4 remaining DNAs and amino-acids can be assigned to both tetra-icosahedron and tetrahedron and icosahedron regarded as defining separate genetic codes. This explains why stopping codons can code for the 21st and 22nd amino-acid under some circumstances.

Tetrahedral code is second member in the hierarchy of genetic codes [K41] inspired by the notion of Combinatorial Hierarchy $M(n + 1) = M_{M(n)} = 2^{M(n)} - 1$ giving the numbers $2, 4, 7, 64, 2^{126}, ...$ as numbers of DNA codons. The fourth member would correspond to what I called "memetic code" allowing representation of codons as sequences of 21 DNAs. It is not known whether the Combinatorial Hierarchy of Mersenne primes continues as Hilbert conjectured.

(c) The notion of bio-harmony is partially characterized by the triplet $n = (n_0, n_1, n_2)$, characterizing the numbers of 0-, 1-, and 2-quint chords which in turn correspond to DNA codons in consistency with the observation that codons indeed correspond to triplets of nucleotides. n-quint chord corresponds to a triangle (face of icosahedron) containing n edges of the Hamiltonian. Particular bio-harmony requires a selection of a specific Hamiltonian cycle from each class of cycles (1 Z_6 symmetric cycle having $n = (2, 12, 6)$, 2 Z_4 symmetric cycles $n \in \{(0, 16, 4), (4, 8, 8)\}$, 3 $Z_2 = Z_2^{rot}$ with $n \in \{(0, 16, 4), 1(2, 12, 6), (4, 8, 8))\}$ and 5 $Z_2 = Z_2^{refl}$ symmetric cycles with ($n \in \{(2, 12, 6), (4, 8, 8)\}$. Note that the are only three different triplets n.

(d) The original idea was that the rules of bio-harmony could be applied to amino-acid sequences interpreted as sequences of basic 3-chords. DNA would have represented the notes of the music. For *given choice of harmony* as Hamiltonian cycle meaning selection of of 4, 5 or 10 amino-acids coded by the 20 DNAs in question, the hypothesis had to be modified by replacing amino-acid sequences with DNA sequences.

These DNA sequences however define also amino-acid sequences identifiable as specific triangle at the orbit of Z_n defining the DNA codons assigned to that amino-acid (there is a singular fiber space structure). Together the three 20-plets of DNAs define an amino-acid harmony with (4+5+10 =19 chords with tetrahedral extension defining a harmony with 22 chords/amino-acids). Hence both DNA sequences and amino-acid sequences define "bio-music".

(e) The assumption that harmonic transitions between chords (DNA codons) minimize the distance between chords defined by quint-metric leads to highly non-trivial and testable predictions about both DNA sequences and amino-acid sequences. Negentropy Maximization Principle (NMP) [K59] suggests that evolution favors the generation of harmony which should thus increase in the proposed sense for DNA sequences defining particular genes or other functional units of DNA during evolution. Large quint-distances between subsequent codons/chords would tend to polished out under evolutionary pressures.

(f) Could icosahedron, tetrahedron, and tetra-icosahedron have direct physical counterparts in living matter? For instance, water molecules form icosahedral clusters and the chlathrates associated with synaptic contacts have icosahedral symmetries. Tetra-icosahedron has 13 vertices with the added vertex representing one note- say E- in C-key as note with slightly different frequency to resolve the basic problem of rational number based 12-note scale (12 quints give slightly more that 7 octaves). Intriguingly, microtubules consist of basic structures consisting of 13 tubulins with 2 states defining bit: could these bit sequences define representation for the 3-chords and thus representation of sequence of DNA codons and realization of genetic code.

(g) Music is language of emotions and peptides are molecules of emotion as Candace Pert [**?**] expressed it. Could bio-harmonies serve as direct correlates for emotions? What is bio-music? A natural TGD inspired guess is that sounds can be replaced with $h_{eff} = n \times h$ dark photons with low frequencies and having energies in the range of bio-photons (visible and UV range maximally effective biologically) as proposed on basis of some physical facts and theoretical ideas [K79]. The frequency spectrum of dark cyclotron photons along magnetic flux tubes would define bio-music as "music of dark light" and bio-harmonies would correlate with emotions and moods.

If one can find various icosahedral Hamilton's cycles one can immediately deduce corresponding harmonies. This would require computer program and a considerable amount of analysis. My luck was that the all this has been done. One can find material about icosahedral Hamilton's cycles (see `http://tinyurl.com/pmghcwd`) in web, in particular the list of all 1024 Hamilton's cycles with one edge fixed [A3, A5] (this has no relevance since only shape matters). If one identifies cycles with opposite internal orientations, there are only 512 cycles. If the cycle is identified as a representation of quint cycle giving representation of 12 note scale, one cannot make this identification since quint is mapped to fourth when orientation is reversed. The earlier article about icosahedral Hamiltonian cycles as representations of different notions of harmony is helpful [L16].

The tables listing the 20 3-chords of associated with a given Hamilton's cycle make it possible for anyone with needed computer facilities and music generator to test whether the proposed rules produce aesthetically appealing harmonies for the icosahedral Hamiltonian cycles. Biologist with access to DNA sequences could experiment with DNA codons to see whether their are harmonious in the sense that the distance between subsequent chords assignable to DNA codons tend to be small in quint metric. Note that DNA decomposes to pieces corresponding to different Hamiltonian cycles (harmonies) so that the comparison is not quite straightforward.

6.7.1   What Could Be The Basic Principles Of Harmony?

It indeed seems that the idea about definition of notion of harmony in terms of Hamiltonian cycles makes sense.

Icosahedral harmonies

(a) Chords (major and minor) are labeled by their basic tones and comes either as major or minor. Harmony in classical sense requires that the transitions from key to another take place by a small number of quints and that the piece does not wander too far from the major key, say C.

   If quint corresponds to a step along the edge of the cycle in the direction of its orientation, the notion of tonal closeness corresponds to the closeness in the metric of icosahedron. For instance C, F, and G are commonly used keys in same piece and correspond to 3 subsequent points along Hamiltonian cycle. Note that the number of ♯s of the key increases by one unit in standard direction and the number of ♭s by one unit in opposite direction.

(b) It turns out that major and minor 3-chords and are mapped to each other in the orientation reversal for icosahedral path so that basic moods "happy" and "sad" in music have this orientation as a geometric correlate. The effect of orientation reversal does not actually depend on the icosahedral representation but is implied by quint cycle representation alone. C and half-octave $F\sharp$ defining the tritonus interval are the fixed points of the orientation reversal. Orientation reversal induces pairings ($C \leftrightarrow C$, $F\sharp \leftrightarrow F\sharp$, $G \leftrightarrow F$, $D \leftrightarrow B\flat$, $A \leftrightarrow D\sharp$, $E \leftrightarrow G\sharp$, $H \leftrightarrow C\sharp$. Quints of cycle correspond to the fourths of oppositely oriented cycle so that majors and minors are mapped to each other and one can say that the moods "happy" and "sad" have geometric correlates in the sense that majors and minors are transformed to each other in the reversal of orientation of the cycle.

The notion of harmony can be characterized in terms of numbers of basic 3-chords identified as faces of the icosahedron and their neighborhood relationship telling when corresponding chords are near to each other or vertex or face neighbours. The wall neighbours assignable to given edge are expected to be in very special relationship harmonically since they possess a common quint.

The basic classification is according to the number $n = 0, 1, 2$ of edges of cycle contained by them and the triplet $n = (n_0, n_1, n_2)$ for the numbers of faces of various kinds gives the first rough classification. 2-quint chords have common edge and thus two common notes with two 1-quint chords and are therefore natural intermediates in transitions between them. 0-quint chords are tonal loners having no edge neighbours turns out that they involve dissonances since they consists of three notes spanning length of 1 or 3/2 steps (say EFG, $EF\sharp G$ or $D\sharp EF$). Maximally symmetric harmony is an exception: 0-quint chords correspond to augmented chords of type $CEG\sharp$ with two major thirds.

The numbers of three different kinds of face neighbor pairs for the 12 edges of the path serve as an additional classification criterion in terms of the $p = (p_{1,1}, p_{1,2}, p_{2,2})$ for the numbers $p_{i,j}$ of different kind of edges. Note that the neighbor faces of an edge correspond to 3-chords, which possess two common notes and are in this sense close to each other. These numbers characterize the most natural transitions between the chords of the harmony. A further criterion is the distribution of these neighbor pairs along the cycle.

Why quints are near to each other harmonically?

The naïve expectation would be that frequencies near to each other (using half-note as unit) are close to each other. This is not true. Their simultaneous presence is experienced as dissonance. This probably has a neurophysiological correlate: in ear the hair cell groups detecting notes which are near to each other in frequency space are overlapping. This explanation does not however tell why the conscious experience is dissonance.

The distance measure for notes could be formulated in terms of distance defined as the number of quints connecting them. For quint the distance would be minimal. This measure applies also to chords and allows to understand the basic rule of classical harmony stating that harmonic transitions take place the chords related by quint shift of the basic note (adding either one $\sharp$ or one $\flat$ to the scale). Also the key changes can be understood using the same rule: consider the changes C→ G and C→F as examples. Note that in this case the chords have common note.

One could of course question the assumption that it is possible to choose the shortest route. The notes obtained by quint scaling are not quite same in the two directions and means that $\sharp$ is the inverse of $\flat$ in well tempered scale only. Could it be that people with absolute ear are able to distinguish between the two slightly differing scales and experience notes of quint C-G as harmonically close when 1 quint connects them but as harmonically distant 11 quints in opposite direction connects them?

If cognition is p-adic, one can ask whether the notion of harmony can be formulated in terms of p-adic distance concept.

(a) By octave equivalence the scaling by power of two means nothing so that the scalings by 3/2 are equivalent with scalings by 3 and the distance defined by 3-adic norm having values 3^k, where k is the number of quints makes sense. The distance defined as quints could be identified the absolute value of k along the quint cycle in the direction in which the distance is shorter. If so, the maximal distance is 6 units.

(b) 3-adic measure of distance seems to be rather realistic. Quint corresponds to 1 unit distance. Half step corresponds to a distance of 5 units and 6 units defines the largest distance and corresponds to the tritonus interval which was forbidden by catholic church. Fourth (C-F) corresponds to 1- step in opposite direction and 11 steps in standard direction.

(c) There is also a problem. Second (C-D) corresponds to 3 quints but third (C-E) corresponds to 4 quints and small third to 3 quints in opposite direction. Major third would

thus correspond to a longer harmonic distance than second. This is a genuine problem, whose solution might be provided by the extension of icosahedral scale to icosatetrahedral one bringing in one additional note which is very near to one of the icosahedral notes and is major or minor third of icosahedral note.

(d) Could one use the number of icosahedral edges as distance between notes but not as a minimal distance along the Hamiltonian cycle but along a minimal edge path along icosahedron? The icosahedral measure of distance would be analogous to a distance between points of object along shortest route in space that it inhabits and depends on harmony characterized by the shape of icosahedral cycle. C and E (and also C and $F\sharp$!) could be close to each other in some harmony and distant from each other in some other harmony. Icosahedral geometry would become an active determinant of the harmony.

To sum up, music seems to have both 2-adic (octave equivalence) and 3-adic (12-note scale by quint scalings) characters. The principle of tonal unity for classical music stating that modulations of key should not lead too many quints away from the basic chord would have 3-adic interpretation.

What could be the rules for building a harmony?

What guarantees good harmony when one has fixed the key/harmony/representation of particular Hamilton cycle?

(a) One should pose conditions on the allowed transitions between chords. Are there principles would imply harmonic smoothness in geometric sense? Could the transitions occur only between chords with a common note? Or can one require a common pair of notes? Or can one require even a common quint. If so, 0-quint chords would become tonal hermits and could not be used at all. In practice their dissonant character has eliminated them in popular music and much of classical music too.

The standard quint and fourth transitions (say C to G and C to F) are basic examples in which there is only one common note between chords, and it seems that one cannot require more than this in the general case. Playing with the chords of bio-harmony however suggests that smooth bossa nova/jazz emotionally ambivalent mood is created if common pair of notes or even quint connects the neighboring chords. The rule is that only transitions between chords with same basic note are allowed. Obviously this is too stringent a condition.

(b) Could 2-quint chords act as bridges between two 1-quint chords? For instance, for the maximally symmetric harmony consisting of disjoint groups of chords related by half-octave scaling the augmented chords ($F^{aug} = FAC\sharp$ and G^{aug} mapped to each other both by half-octave scaling and reversal of orientation could serve as mediating bridges.

(c) Could harmonic transitions take place only between neighboring faces of icosahedron (see `http://tinyurl.com/ns9aa`) or should it only tend to minimize the quint distance between subsequent chords (this distance vanishes if they have a common note)? For the 0-quint distance harmony, the harmonic movement could be seen as a path in dodecahedron which is dual of icosahedron. In the most general case the transition can take place to both wall and vertex neighbors, whose total number is 3+3=6. In this geometric picture harmony and melody could be seen as duals of each other.

Dodecahedron is dual of icosahedron and one can ask whether the harmonic motion could correspond to a path at dodecahedron. The vertex of dodecaehdron is pentagon and has 3 neighbours (see `http://tinyurl.com/mp5d8`). The above argument gives 3+3 > 3 neighbors for the triangle of icosahedron. Are the wall neighbors of icosahedral triangle mapped to nearest neighbor vertices? If so then transitions between vertex neighbor triangles should correspond to longer steps at dodecahedron. By the duality triangles of icosahedron correspond to three pentagons associated with the vertex of dodecahedron. The rule that comes in mind is that steps can occur between vertices for which the 3-pentagons have one or 2 common pentagons.

Note that if the dodecahedral path is Hamiltonian cycle, it is unique apart from isometries of dodecahedron and would define a unique chord progression. One can - and of course must - allow self-intersecting harmonic paths. The condition that there exists a basic chord from which everything begins and to which everything ends implies that closed but in general self-intersecting path is in question.

(d) An interesting test for the idea would a computerized generation of random chord sequences satisfying at least one common vertex rule and finding whether they are aesthetically appealing. Incidence matrix (see Appendix) for the icosahedral (and tetra-icosahedral) triangles wholes element tells how many common vertices two chords have have allows computational construction of the allowed chord sequences as random sequences.

(e) For most harmonies 0-quint chords involve dissonances induced by three nearby notes (such as $CC\sharp D$) and spanning large number of quints (maximally symmetric harmony has 2 0-quint chords, which do not have dissonances and second harmony with 2 reflection symmetries has no 0-quint chords). Also $maj7_-$, $sus4_+$, and 6_- 1-quint chords have half-note dissonances. Dissonances as such are however not un-sesthetical. For instance, Bach used them to create a deeply melacholic feeling.

More general notion of harmony

The notion of harmony discussed in previous section is rather conservative and certainly too stringent.

(a) 0-quint rule is too restrictive already in chord based music. For instance, the downwards progression Am, G, F, E appearing in Spanish music and music forms like Passacaglia would have chords with 1-quint distance. Hence one must consider also a weaker notion of harmonic chord progression according to which this distance is minimized and below some maximum value k_{max}. One quint would define the smallest non-vanishing maximal distance. One can define incidence matrices for chords with n-quint distance. The incidence matrices with different values of k_{max} have disjoint sets of non-vanishing elements and the total incidence matrix is their sum.

(b) Even this is not enough. The direction of step matters for scales (major-minor difference) and it seems to matter also for chord harmonies. The inverse E, F, G, Am of the above mentioned progression does not sound harmonic in the same Am key. The impression of achieving the goal/ending down to something dictated by fate is lost.

Instead of $EFGA$ one often has $EF\sharp G\sharp A$ as a melodic progression and with $E, B7, E7, Am$ as a chord progression having only 0-quint steps. The rule seems to be that 1-quint steps are possible only downwards in minor harmony, whereas upwards steps are 0-quint steps. Climbing slowly upwards by 0-quint steps and falling down by 1-quint steps! Could this "gravitational analogy" serve as a metaphor?

Also the number of n-quint steps between chords matters. The larger this number, the closer the chords are. Two 0-quint steps means that chords have two common notes, 1 0-quint stet that they have single common note. The two 1-quint steps for downwards step $Am - G$ are between 3rd and 1st ($C \to G$) and 5th and 3rd ($E \to H$). For upwards 0-quint steps $E - H7$ 1-quint steps are between 5th and 5th ($H \to F\sharp$) and 1st and 1st ($E \to H$). For $H7 \to E$ the reversals of these steps occur. For $E7 \to Am$ one has 3 1-quint steps: (the reversals 1-quint steps $E \to A$ and $H \to E$ steps and 1 quint step $D \to A$. The laste step seems to be the smallest one in a well-defined sense.

For G-F step the number of 1-quint steps is one ($C \to C$): same is true for F-E step (A and E).

Using geometry language, for chords connected by 1-quint step(s) the mutual orientation of corresponding triangles with shape defined by the intervals involved matters since the number of 1-quint steps depends on the orientation.

The notion of chord harmony does not apply as such to polyphonic music with several simultaneous melodies unless on can say that it involves definite chord sequence. One could

try to apply the concept of harmony for melody also in this case. The challenge is to guess what harmony for melodies could mean.

(a) A conjecture inspired by the genetic code is that the codons defining the allowed melody notes associated with a given chord are in one-one correspondence with the triangles at the orbit of the triangle associated with the chord under the group Z_6, Z_4, or Z_2 characterizing the chord as a counterpart of amino-acid. In table 6.6 the Z_6 orbits are represented as groups of 6 similar chords (2 for 1-quint chords and 1 for 2-quint chords). In table 6.7 for Z_4 chords the groups consist of 4 similar chords and in the tables 6.8 and 9.1 for Z_2 harmony the chord groups consist of 2 similar chords.

(b) The first guess is that the union of the notes of these chords could define the chords, whose notes are compatible with chord in the time scale shorter than the duration of the chord. Note that same triangle can appear at orbits of several chords since the orbits of each group span entire icosahedron.

If the note lasts for a duration of several chords, the notes must be consistent with all the chords involved. The rule would explain why fast chromatic sequences (in the scale of chord duration) sound harmonic but slow chromatic sequences do not.

For melodies in Am key $EFGA$ is rare and does sound harmonic being often replaced with $E, F\sharp, G\sharp, A$. As far as intervals are considered, this is the inversion $D\sharp, F, G, G\sharp$ of $AGFE$ shifted upwards by 5 quints. Could one regard progressions (say Am, G, F, E) breaking the strongest rule for chord harmony as polyphonic progressions satisfying the rules for polyphonic progressions.

To conclude whether the DNA inspired notion of harmonic is realistic, one should understand how the sub-groups Z_n, $n = 6, 4, 2$ of the isometries of the icosahedron and defining the genetic code act on the Hamiltonian cycles.

(a) The simplest guess is that these groups are represented as subgroups of Z_{12} (also a subgroup of icosahedral group) representing quint cycle. Z_n generator would shift the basic note of the chord by $12/n$ - that is $2, 3, 6$ quints.

(b) Z_n maps chords of same type to chords of same type only if it is a *rotational* symmetry of the harmony. For instance, the action of Z_6 (see **Fig. ??**) on icosahedron allows doublet orbit consisting of $Xaug$ type chords, since Z_3 maps 2 0-quint triangles in the middle of the figure to themselves and reflection group Z_2 permutes them. 6-element orbits consist of either minor or major chords. More generally, the inspection of the cycles shows that the cyclic orbits of triangle under Z_n correspond to the orbits of corresponding subgroups of icosahedral group.

(c) $Z_2 refl$ maps the shape of the chord to its mirror images and so that the character of the chord can vary along Z_4 orbits. The rules are $(M \leftrightarrow m), (6 \leftrightarrow 7))$. For other chords the character is unaffected.

(d) Any subgroup of icosahedral isometry group $A_5 \times Z_2^{refl}$ having 120 elements must map chords to chords (faces to faces). In particular any Z_n) even if it is not a symmetry of a particular harmony. The character of the chord is not preserved and the number of quints can change. Whether these maps have interpretation in terms of music remains unclear.

These considerations forced me to finally realize that the 3 groups Z_6, Z_4, and Z_2 that I had assigned to 20+20+20 DNA codons in the model of the genetic code are nothing but Z_6-, Z_4-, and Z_2-symmetric Hamilton cycles! The numbers of amino-acids associated with various types would be 3+1=4, 5, and 10 (with empty amino-acid included). Tetrahedral extension based on gluing of tetrahedron at triangle corresponding to $X6$ type chord possessed by all Z_2^{refl} type harmonies would give 3 additional real amino-acids giving altogether real 22 amino-acids as required. This has implications.

(a) All 11 Hamilton cycles are realized separately as DNA level harmonies. Amino-acid level harmonies would correspond to selection of three Hamiltonian cycles, one for each Z_n.

(b) To get something one must give something away. Now one must give up the idea that $(4, 8, 8)$ is special via the corresponding of n-quint property with polarity properties. This is a pity, since just taking this correspondence seriously led to the extension of the icosahedral cycles to tetra-icosahedral ones. Fortunately, the extension itself makes sense for all Hamiltonian cycles.

To understand the action of symmetries one must look how the groups Z_n act on C major chord.

(a) Z_2 would induce half-octave shift and map $C = (C, E, G)$ to $F\sharp m = F\sharp, B\flat, D\sharp)$. The assignment of $F\sharp$ -tritonus - with C note sounds strange in the ears of harmonic conservatives.

(b) Z_4 would map $C = (C, E, G)$ to $A = (A, C\sharp, E)$, $F\sharp = (F\sharp, B\flat, C\sharp)$ and $D\sharp = D\sharp = (D\sharp, G, B\flat)$. These would span 8 notes since $E, G, B\flat, C\sharp$, appear twice. Note that C, E, G, A are the notes assignable to the tetrahedron in the extension of the scale and pentatonic scale corresponds to C, D, E, G, A. Z^4 orbit does not contain the notes $DFG\sharp H$ but the orbit of G chord does so. The orbit of C chord plus $G7$ chord alone define the notes of C major key.

(c) Z_6 would map C and E to the same "impressionistic" 6-note scale consisting of 6 whole notes. Together with the Z_6 image of G one obtains all 12 notes of the scale.

6.7.2 Harmony And Biology

Could harmonic principles be realized in biology?

The basic idea behind icosahedral harmony is connection with biology suggested by the fact that the number of icosahedral basic chords is 20 which is also the number of amino-acids. Actually there are two additional amino-acids and one ends up to an extension of genetic code by attaching to icosahedron a tetrahedron and thus adding one vertex more. The number of DNA codons increases from 60 for icosahedral code to 64 for the real code. The triangle along which icosahedral and tetrahedral amino-acids are attached together corresponds to punct coded by stopping codons. Also the following amusing observation supports the notion of bioharmony. Simple music pieces tend to begin with the basic chord CM or Am. Interestingly, mRNA starts always with a codon coding met which could correspond to $CM = CEG$ for one of the tetrahedral faces (see `http://tinyurl.com/3b9ymnq`)

Could the application of harmonic principles to biology make sense? The triangles of icosa-tetrahedon correspond to amino-acids or DNA codons for the amino-acids coded by 20 codons in question.

(a) The strictest rule stating that there must be common edge of Hamiltonian cycle between the amino-acids/DNAs cannot be satisfied since 0-quint amino-acids/DNA codons would be total loners and effectively eliminated from biology.

(b) The weaker "common edge or vertex" rule could however make sense. A given codon in the group of 20 codons/amino-acid could be followed only by 3+3 different nearest neighbor similar codons/amino-acids. If the first amino-acid is fixed there would be only 6^N N-amino-acid sequences instead of 20^N sequences. This kind of symmetry would have been probably observed if exact but one can ask whether harmonic pairs could more probable than completely random pairs.

(c) A more plausible formulation is obtained by restricting the rule to the level of DNA sequences and generalizing it so that it applies also to transitions between harmonies with different symmetries so that a transition between corresponding amino-acids is induces.

(d) An even weaker formulations states that the transitions occur with highest probabilities between codons/amino-acids having shortest quint distance.

A natural conjecture is that evolution favors the generation of harmony even in the very concrete sense that proteins defined by harmonious chord sequences for bio-harmony are emerge as what Darwinist would call the fittest ones.

1. Icosahedral water clusters made from tetrahedra

The obvious questions concern the concrete realization of the icosahedron - or more generally icosahedral symmetries. One should also understood what the attachment of tetrahedron to icosahedron means (note that tetra-icosahedron is not the same thing as icosi-tetrahedron, which is Archimedean (not Platonic) solid (`http://tinyurl.com/6onvry`)). What comes in mind is attachment of an information molecule to the receptor of cell membrane.

Water molecules form icosahedral structures and - what is amazing to me - Plato regarded icosahedron as a symbol of water (`http://tinyurl.com/y7bo9omm4a3378c13bcad793a52213a325db7db0-30.html`)! The page "Water structure and science" of Martin Chaplin gives illustrations about the rather complex icosahedral structures. Icosahedral structures of size 3 nm can be formed from 20 14-molecule tetrahedral water molecule clusters containing 280 water molecules altogether. They can also consists of cyclic pentamers and tricyclo-decamers and also from bi-cyclo-octomers. The 20 tetrahedrons correspond to the faces of the icosahedron and tetra-icosahedron would be formed as tetrahedron is glued to the icosahedron along one of the faces.

The bioharmonies could manifest themselves already in the structure of water molecules. Second - more plausible - option is that they differ only at the level of the magnetic body of the biomolecule. Bio-harmony suggests that 3 radial magnetic flux tubes or flux tube pairs emerge from each water tetrahedron. Hamilton's cycle could be realized as a flux tube connecting the vertices of the icosahedron and assigning the quint cycle to the cyclotron frequencies (magnetic field strengths).

This scenario raises several questions related to the pairings between ordinary DNA/amino-acids, their icosahedral representations, and their representations as dark proton sequences.

Suppose that one takes seriously the idea that genetic code is represented as dark proton sequences with the states of dark protons formed from 3 quarks representing DNA and RNA codons, amino-acids, and even tRNA.

(a) How dark proton sequences are realized? Could one regard them as icosahedral bound states of 20 dark protons? Or with a Hamiltonian cycle consisting of penta-quarks and representing dark nuclear string? Could the icosahedral representation as dark nucleus consisting of 20 dark protons and dodecahedral representation as dark nucleus consisting of 12 dark 5-proton states be dual ways to interpret the state or are they different states related duality. Equivalence of the two pictures would require that dark protons are color excited and in an entangled state.

(b) Could dark proton sequences correspond to sequences of icosahedrons connected by flux tubes connecting the dark protons assignable to the dark proton states assignable to the faces of the icosahedrons? These dark nuclei would be definitely different from those possibly associated with the Hamiltonian cycle.

(c) What about the tetrahedral part of the genetic code in relation to dark protons sequences? What dark proton states could tetrahedral codons and amino-acids correspond? Are they associated with water tetrahedrons representing the faces of the water icosahedron? Note the amusing numerological co-incidence that the vertices of tetrahedron have 3 quarks associated with them and those of icosahedron 5 and that the quint for icosahedral edge is replaced with third for tetrahedral edge.

(d) Could the chords correspond to triplets of cyclotron frequencies for quarks associated with the three flux tubes emanating from the each face of the icosahedron? Could the breaking of the rotational symmetry from SO(3) to SO(2) - now actually $Z_3 \subset SO(2)$ - assumed to occur for dark proton states correspond to the reduction forced by the triangular geometry?

(e) How DNA -amino-acid correspondence is represented at the level of dark DNA? The correspondence should be realized in terms of magnetic flux tube triplets connecting dark DNA and dark amino-acid and resonance condition would be essential. When the chords at the orbits of Z_n are of same type, different DNAs correspond to the same chord but with different key. When Z_2^{refl} is involved, the two chords at the orbit are not of same type (note the analogy with left and right-handed biomolecules). The only manner to circumvent the problem is to assume that the chord associated with amino-acids magnetic body is that of DNA. Information is not actually lost in translation, it is only transformed to different kind of information perhaps representing correlates of emotions.

(f) Could the non-representability of one of the Z_6 codons as amino-acid have an analog?

The fiber space having icosahedron as a base and 3 copies of icosahedron assigned with 3 regions of icosahedron corresponding to Z_n, $n = 6, 4, 2$, defines a formal geometric representation of genetic code. Could this space represented in terms of water icosahedra?

(a) Perhaps one should first try to identify the function of water icosahedrons. The first guess is that they serve as local bridges between dark DNA/amino-acid sequences and ordinary DNA/amino-acid sequences. This would suggest that dark proton of dark DNA forms a flux tube connection with the face of water icosahedron dictated by the state of the dark proton: this would take place by flux tube reconnection and cyclotron resonance. Water icosahedron in turn couples with the DNA/amino-acid like DNA conjugate codon with codon so that kind of double helix is formed.

(b) What about the pairing of ordinary DNA/amino-acids and water icosahedrons? Water icosahedron has size of about 3 nm. The size of single DNA codon is about 1 nm. Single codon corresponds to a twist of $3\pi/5$=36 degrees, an angle closely related to Golden Mean. If the radius of the helix consisting of water icosahedrons is above some minimal radius which is easy to estimate from an equation for the helix. There are 10 DNAs per $L(151) = 10$ nm and they correspond to a total twist of $3 \times 2\pi$. Therefore the twist angle is $\Delta\Phi = \pi/5 = 36$ degrees for single codon and corresponds to a distance of $L(151)/10 = 1$ nm). From this one has equation for DNA and icosahedron helices as $z = k\Phi$, $k = h/(6\pi)$, $h = L(151) = 10$ nm (radii are constant). Single codon corresponds to a distance $s = \sqrt{dz^2 + R^2 d\phi^2}\Delta\Phi$ along the water icosahedron helix of radius R accompanying DNA helix. One must have $s \geq L = 3$ nm defining the size of water icosahedron in order to avoid overlap. $\Delta s \geq L = 3$ nm gives the condition $R \geq 10 \times \sqrt{2}/(3\pi)$ nm $\simeq 1.5$ nm.

(c) If the representation of genetic code is possible, do the fiber icosahedrons correspond to subsets of faces of the icosahedron itself? Or do they correspond to faces the of icosahedrons in some manner associated with the amino-acid icosahedron. Direct attachment is not possible but association could be achieved by connecting the icosahedrons by flux tubes with the tetrahedron at the ends of flux tubes identified as representation of the same amino-acid. This kind of structure with three icosahedra emanating from a given icosahedron could be iterated and one would obtain a fractal structure representing a binary tree. Could the water icosahedrons organize in this manner to form larger clusters?

What could be the physical correlates of Hamilton cycles representing harmonies?

(a) Could Z_6, Z_4 and Z_2 orbits associated with the Hamiltonian cycles be realized even in the structure of water icosahedrons? Could they be realized as structures formed by the water tetrahedra and correspond to three separate regions of these icosahedral structures? Could one assign to each of the three regions of icosahedron icosahedron such that the attached icosahedron decomposes to the orbits associated with that particular region? Could the hierarchy of the icosahedral symmetry breakings have a direct counterpart at the level of the icosahedral structures formed by water molecules? My intuitive feeling is that the answer to these questions is negative.

(b) Could Hamiltonian cycles be realized only at the level of dark photons as quint cycles defined by closed flux tube giving rise to dark nucleus, that is in terms of 3-chords formed by dark photons propagating along flux tubes emanating from the icosahedron? If cyclotron frequencies of dark quarks are in question then the magnetic fields associated with the flux tubes would define the notes.

(c) The breaking of Z_2^{refl} symmetry is of special interest since it could serve as a prebiotic analog of chiral selection and could relate to dark variant of weak physics with effectively massless weak bosons in nano-scales. This would require dark magnetic body. Half-octave scaling is second broken symmetry and would have also an analog in Z_2^{refl} variant of icosahedron. Note that 256 variants of the bio-harmony are predicted and could be realized for magnetic body naturally. The presence of electric fields at flux tubes is possible and if the electric and magnetic fields are non-orthogonal, U(1) instanton density is non-vanishing and induces parity breaking. Is this breaking associated with Z_2^{refl} only?

2. Clathrin molecules as icosahedral structures

Clathrin (http://tinyurl.com/y8ho23zf is a structure appearing at the ends of microtubules and necessary for the transmission of signals between the presynaptic and postsynaptic neurons. Clathrin consists of triskelions - kind of triangular structures with three spiral like legs and having as symmetries the rotational symmetry group Z_3 of equilateral triangle. Clathrins can form hexagonal planar lattices and pentagonal icosahedral lattices consisting of 12 pentagonal faces - the number of vertices of icosahedron. One can associate 3 triskelions with each pentagonal face: this makes $12 \times 3 = 36$ triskelions altogether. One can regard the centers of the 12 faces as vertices of icosahedron and assign to this structure 20 faces, which are triangles formed by 3 pentagons.

If proteins and other molecules attach to the faces of clathrin, one can ask whether each icosahedral triangle of this kind has an address formed by the three notes associated with it and serving as a password: only those molecules, which "know" this password can attach to the face. The realization would be in terms of three U-shaped magnetic flux tubes emerging from the 3 pentagonal faces representing the three notes as frequencies of dark $h_{eff} = n \times h$ cyclotron photons with ELF frequencies but energies of bio-photons (in visible and UV range). The binding of the molecule to the face triangle would be preceded by reconnection of U-shaped flux tubes of the clathrin and molecule, by a resonant interaction by dark cyclotron photons, and by an h_{eff} reducing phase transition bringing the molecule to the face.

3. Microtubules as music instruments?

It has become clear that microtubules have a central role in biology, neuroscience and perhaps also in consciousness theory and the evidence that they are quantum coherent systems is accumulating. Could music metaphor could help to understand microtubules?

(a) Tetra-icosahedron has 13 vertices with the added vertex representing one note- say E- in C-key as note with slightly different frequency to resolve the basic problem of rational number based 12-note scale (12 quints give slightly more that 7 octaves). Intriguingly, microtubules consist of basic structures consisting of 13 tubulins with 2 states defining bit: could these bit sequences define representation for the 3-chords and thus representation of sequence of DNA codons and realization of genetic code.

(b) The recent TGD inspired model of microtubules [L13], [K76] was inspired by the findings of the group of Bandyopadhyay (see http://tinyurl.com/ze366ny) [?], [?] relies on the general vision about bio-communications and control as being based on dark cyclotron photon radiation travelling along magnetic flux tubes.

These dark photons have a universal energy spectrum in the range of bio-photons (visible and UV) to which they transform as the value of $h_{eff} = n \times h$ reduces to its standard value. Frequencies would span a wide energy range but EEG frequencies would be of special importance since they would also couple to acoustic vibrations. The precise

value of the energy scale of cyclotron photons would be determined by the strength of the magnetic field at flux tube.

(c) Frequency modulation would be the general manner to code information in living matter: "whale's song" would be a good metaphor for it. This is assumed in the model for cell membrane as generalized Josephson junction: the modulation would be now induced by the variations of generalized Josephson frequency by variations of the membrane potential. Also microtubules have been proposed to base their communications on frequency modulation.

(d) The first possibility coming in mind is that the continually varying microtubule length codes for the frequency [L13]. The change of the frequency by say octave would however require quite fast and large variations of microtubule length. Neither does this realization conform with the idea that the state of single tubulin corresponds to frequency. Microtubule length could also code for the length of the music piece represented by the microtubule serving as a music instrument or musician at the bio-molecular level. It would also the number of microtubular units and thus the size of the orchestra consisting of 13-units.

(e) Another possibility inspired by the proposal is that magnetic flux tubes form an analog of 3-D grid ideal for communication purposes using 12-note (or actually 13-note) system as a code equivalent with genetic code. Also microtubules would involve three kinds of flux tubes [L13] defining coordinate grid of cylindrical coordinates: longitudinal, radial and those which rotate along the microtubule. Radial flux tubes would be ideal for communication using 13-note system as a realization of genetic code.

(f) 13-note system as cyclotron frequency spectrum for given value of h_{eff} would be determined by the spectrum of the magnetic field strengths going transversally through the microtubule and each tubulin would correspond to one particular note represented as magnetic field strength. The system would be highly analogous to the system formed by hair cells in cochlear. Note would indeed characterize single tubulin molecule rather than entire microtubule as required if one wants to code chords using the two tubulin conformations as a bit. Tubulin conformation would determine whether the tubulin serves as a sending/receiving antenna or not.

(g) Melody in 12-note system can be interpreted as a discretized version of frequency modulation with frequency being piece-wise constant in time. Obviously the 13 bit sequences defined by tubulin conformations code for the chords of rational 12-note scale involving a representation of one particular note (the third note of the Pythagorean scale) with two slightly different frequencies in order to avoid problems caused by the rational number ratios of frequencies. 13th bit could also serve as a kind of period. Also chords could be coded up to a chord with 13 notes so that microtubules would have quite a high representative power.

The is an objection against the model.

(a) One could argue that a unit consisting of 13 tubulins allows only one octave to be represented. One can of course assume that the magnetic field strengths for subsequent units differ by octave. What makes this interesting is that microtubules allow two variants, called A and B. B type microtubules appear as 13-units since microtubular surface has a gap so that the helical symmetry is broken. For variant A, which is not found in vivo or in vitro, 13-units integrate to form longer helical units. This is assumed in Penrose-Hameroff model and the experimental absence of A type microtubules is one of the basic objections against Penrose-Hameroff hypothesis.

(b) The TGD inspired proposal is that A type microtubules corresponds to a critical state having therefore an enhanced symmetry and long range correlations: criticality would explain their experimental absence. The experiments of the group of Bandyopadhyay support that the critical state is induced by a resonant excitation at specific AC frequencies [L13]. Long range correlations would mean enchance helical symmetry - that is fusion of several 13-units to form a longer helical structure. This structure would allow

an interpretation as a structure with frequency spectrum of several octaves represented coherently in terms of magnetic field strength: the 10 octave span for hearing would mean the integration of 10 microtubule units meaning length scale of order micrometer assuming that tubulin size is of order 10 nm.

(c) If the field strength for subsequent units differ by octave, one can argue that for variant B various octaves play their own music without knowing of each other and thus without coherence. In state A they would play together forming something analogous to orchestra or choir.

If the octave is same for all 13-units, the phase transition would involve octave scaling of the magnetic field strength at the flux tubes. The flux tube radius should suffer p-adic scaling by an integer number of half-octaves, which makes sense if one accepts p-adic length scale hypothesis. This kind of phase transition have been proposed as candidate for a basic step of energy metabolism since they can store or liberate cyclotron energy as metabolic energy.

(d) Microtubules could directly couple with both DNA and clathrin molecules if they represent 12 note system as a resonant system able to receive the radiation with corresponding frequencies. 12-note system and the 3-chord system associated with it could define universal communication code allowing communications between DNA, proteins, and microtubules.

To sum up, 13-note extension of 12-note system could be seen as a realization of the genetic code in terms of frequencies. The existence of kind of realization was obvious from the beginning and I proposed it in the model of microtubules as quantum antennas during the first years of TGD inspired theory of consciousness [K68]. Discovering the precise realization of the proposal has however required time.

Could biology help in the understanding of musical harmony?

One can also ask whether biology could provide ideas about the notion of harmony. Could icosatetrahedral harmony possessing additional 13th note very near to the fourth of basic major chord provide a better view about harmony?

(a) The extension of the ideas about harmony to the case of isosatetrahedron is a non-trivial task. If one assumes that the extended Hamiltonian cycle is obtained by deforming tetrahedral Hamiltonian cycle according to the proposal made earlier, one ends up with a problem since the cycle makes a wedge while making a side track of two steps via the new vertex. The two steps must give one quint so that the new vertex must correspond to either minor or major third of note where it started from (and ended to). This would add to the scale a chord of type CGD a chord of type CEG or $CE\flat G$ (plus two other chords containing major or minor third. Depending on the orientation of the cycle one would obtain major or minor key. The remarkable feature of icosahedral harmonies is that they often lack a unique basic chord. Could it be that the addition of tetrahedron breaks the symmetry and fixes the key?

(b) The added third could be slightly different from the icosahedral third and this could allow to resolve the problems due to the fact that quint cycle does not quite close $((3/2)^1 2 = 2^7$ does not hold true exactly. The problems can be of course solved by introducing well-tempered scale defined in terms of powers of $2^{1/12}$: for this choices the topologically induced by these scalings is same as that induced by real topology in frequency space. Algebraically this means introduction of an algebraic extension of rationals. The problem is that persons with absolute ear prefer rational number based scale and experience tempered scale as unaesthetic.

The problem with 3-adic distance of notes was already described: the distance is 4 quints for major third (C-E) and 3 quints for minor third ($C - E\flat$). A smaller distance is suggestive for major third.

(a) The proposed extension of the scale would break symmetry by bringing a third which is indeed nearest neighbor of the basic note plus two other notes, which are in corners of a *1-quint* triangle in the biological realization. Thus chord CEGandchord containing EG and third note would be introduced.

(b) Using the general results one can readily find the possible extensions of harmony if one assumes that both major and parallel minor with same number of ♯s or ♭s are obtained. The chord chosen for extension must be CGA, which an be seen as part of $C6$ or $Am7$. If the added vertex corresponds to E one obtains $C = CEG$, $Am = CEA$, and the GEA which is part of $C6/Am7$ as also the lost chord. In amino-acid analog CGA would become "empty" amino-acid, punct, and would be replaced with GEA contained also in C6. One can perform this kind of realization for all 11 harmonies and/or their mirror images. The modification induces symmetry breaking and defines a key which is otherwise not obvious for the icosahedral harmonies. Also half-octave symmetry is broken.

(c) One can perform the modification also for the inverted harmony. The transformation to reverted harmony $X \to Y$ corresponds to $X7 \leftrightarrow Y6$ and vice versa so that the presence of $X7$ type chords in harmony guarantees the existence of the required type extension in the reverted harmony. One can of course define extension also using X^7 type chords. This would generate besides CEG two dissonant chords of type $GEE\flat$ and $CEE\flat$.

(d) In maximally symmetric harmony $(2, 12, 6)$ with 6-fold rotation symmetry, there are as many as 6 ways to perform this modification so that any note of the 6-note scale spanning "impressionistic" octave can define the key. The key is either F, G, A or $Dm, E, F\sharp m$. The harmony contains however no $X7$ type chords and since the transition to the reverted harmony acts as $X6 \leftrightarrow Y7$, it does not allow a modification generating both major and parallel minor. There are also other harmonies possessing no $X6$ type chords such as $(2, 12, 6)$ and bio-harmony $(4, 8, 8)$ with 2-fold rotational symmetry so that the extension in the simplest form can be performed only for their reversals.

(e) For the two harmonies with 4-fold reflection symmetry there are 2 ways to perform the modification and modified chords are related by half-octave shift. With the conventions of Table **??** the modification introduces key which is either A ($F\sharp m$) or $D\sharp$ (Cm) for both harmonies (second one is bio-harmony $(4, 8, 8)$).

About the interpretation of bio-harmonies

1. How ideas about harmony evolved?

A brief summary about the evolution of the notion of bio-harmony is in order.

(a) The first guess [L16] was that amino-acids could be understood as chords of icosahedral bio-harmony characterized by 3-tuples $(3, 10, 7)$, where the integers tell the numbers of icosahedral triangles with 0, 1, or 2 edges of the Hamiltonian cycle and identifiable as 3-chords with 0, 1, or 2 quints. The interpretation was that 3 0-quint chords correspond to 3 basic polar amino-acids, 10 1-quint chords to the 10 non-polar amino-acids, and 7 2-quint triangles to the 7 polar and acidic polar amino-acids. It turned out however that $(3, 10, 7)$ does not appear as Hamiltonian cycle although it satisfies the necessary conditions.

(b) I introduced also a model of genetic code motivated by the properties of the code table suggesting that 60 DNA codons are grouped into 3 groups of 20 codons. The idea that DNA codons coding for a given amino-acid form an orbit of a subgroup of icosahedral group with order which is not smaller than the number of these DNAs and has the aminocid at it. Three subgroups Z_6, Z_4, and Z_2 would predict 3 amino-acids coded by 6 codons and two amino-acids coded by 1 codon, 5 amino-acids coded by 4 codons, and 10 amino-acids coded by 2 codons. The total number of codons would be $3 \times 6 + 2 + 4 \times 5 + 10 \times 2 = 20 + 20 + 20 = 60$ rather than 64. The number of doublets is 10

instead of 9. Could one Z_2 orbit corresponds to punct coded by two stopping codons? But what about the codon triplet associated with Ile? Something is clearly missing.

There is also second problem: a really realistic model of genetic code should include also 21st and 22nd amino-acids (Pyl and Sec). Pyl or pyrrolysine is modification of Lys and is basic polar amino-acid so that the number 3 of basic polar amino-acids increases to 4. Contrary to the original naïve extrapolation Sec (selenocystein) is acidic polar rather than non-polar so that the number 2-quint triangles increases from 7 to 8. For the properties of amino-acids see `http://tinyurl.com/y8b7fumq`. The notion of hydrophobicity is discussed at `http://tinyurl.com/9qr8e7q`).

(c) The solution of the problems came from the extension of icosahedral code with tetrahedral code bringing 4 additional codons and 3 amino-acids assigned with the external faces of the tetrahedron (Ile, Pyl, and some standard non-polar amino-acid), and increasing the number of stopping codons from 2 to 3. This gives 60+3+1=64 codons but one should code also Pyl and Sec. The solution of the problem would be that stopping codons code also these under some conditions. Are DNA codons or their mRNA counterparts pairing with tRNAs - perhaps their magnetic body - modified somehow?

For instance, Pyl and Sec could correspond to icosahedral codons before fusion. After fusion they cease to be coded - most naturally because the group orbits containing punct are replaced with those associated with tetrahedron. The 3 ordinary amino-acids represented by tetrahedron are Ile, 1-quint amino-acid and 2-quint amino-acid. As fusion is broken temporarily Pyl and Sec are coded.

(d) The geometric correlate for the fusion of the codes is gluing of tetrahedron to icosahedron along one face which corresponds to "empty" face identifiable as punct coded by stopping codons. The icosahedral Hamiltonian cycle (4, 8, 8), which exists as two variants, is extended to (4, 10, 8) with two new amino-acids.

(e) The music analogy for the fusion of tetrahedron is symmetry breaking bringing in a definite key by introducing the major and minor chords as 1-quint chord (but with 2-edges since tetrahedral edges correspond to major and minor thirds).

2. Understanding the misunderstanding

This was the picture as I started to work again with the notion of bio-harmony. Just when I thought that I understand the notion, I realized that something very essential is missing and even wrong.

(a) One could argue that the assumption about the correlation of forms of amino-acid polarity with character of Hamiltonian cycle leading to (4, 4, 8) identification is ad-hoc: why not allow all harmonies? One can also wonder whether the group structure behind the genetic code leading to the identification of sets of DNA codons coding for a given amino-acid as orbit of the corresponding triangle can be totally dependent on the group structure emerging from the construction of the Hamiltonian cycles.

(b) The question whether the group structures associated with genetic code and with the Hamiltonian cycles might have something to do with each other leads to the realization of the obvious: the groups involved are the same: Z_6, Z_4, and Z_2! The symmetries of DNA are the symmetries of cycles. DNA code would be inherent to the Hamiltonian cycles, and the triangles of the icosahedron representing the harmony would correspond to DNA codons! 20+20+20 icosahedral triangles to 60 genetic codons and 4 icosahedral triangles the remaining 4! The three 20-plets corresponds to 3+1 amino-acids coded by 6 (resp 2) codons, to 5 amino-acids coded by 4 codons, and to 10 amino-acids coded by two codons.

By direct inspection of the illustrations of the appendix one can indeed convince oneself that the groups in question map chords to chords of same type and one obtains appropriate number of orbits. This of course follows from group theory alone.

(c) One must give up the assumption that the integers $n = (n_0, n_1, n_2)$ correspond to the numbers of the basic polar, non-polar, and polar and acidic polar implying that only

$n = (4, 4, 8)$ would define bio-harmony. All Hamiltonian cycles with symmetries define bio-harmonies and both Z_2^{rot} and Z_2^{refl} define Z_2 type bio-harmonies assignable to 10 amino-acids coded by 2 codons. This is somewhat frustrating outcome, since just this correspondence served as guideline leading to the extension of the icosahedral code. The extension as such is however independent of this identification and needed in order to get the 4 missing DNA codons and to understand the coding of 21st and 22nd amino-acids Pyl and Sec.

What do the Hamiltonian triplets n then correspond? Harmonies correlate with moods in music: maybe the serve as mathematical correlates for emotions and moods.

(d) Harmonies are not for amino-acids but for DNAs coding them. One can however identify amino-acids as specific triangles the orbits and the chords associated with the amino-acids define much more restricted notion of harmony involving one representative of each basic type of chord. Perhaps the additional chords correspond to modulations of the harmony.

(e) The rules of harmony generalize as such to transitions between DNA codons regarded as chords. If chords are near to each other with respect to the distance measured as quints, the transition between the chords respects harmony. One must think that DNA codons form a singular fiber space such that the union of fibers for type n gives the space of 20 amino-acids. The "gauge group" Z_n acting in the fiber is different in the 3 regions of the amino-acid space and the number of elements in the fiber is factor of n actually equal to n for $n \neq 6$ and having values 6 and 2 for $n = 6$. Each choice for the 3 Hamilton cycles of type Z_n, $n = 6, 4, 2$ defines a variant of this fiber space. The distance along the fiber isomorphic to the space of amino-acids is measured as minimal quint distance.

Note that the DNA codons for two different variants of the fiber space need not define same kind of chord so that also given amino-acid can correspond to several different chords. It is enough that the notes of the chords are specified - as they indeed are. The Z_n, $n = 6, 4, 2$ in turn can correspond to any Hamilton cycle with symmetry Z_n so that for $n = 1, 4, 2$ one can have $1, 2, 3 + 5 = 8$ different fiber spaces. The hierarchy of Fibonacci numbers is involved. A hierarchy of symmetry breakings is highly suggestive and leads to increasingly richer harmonies.

Z_6 has maximal symmetry but Z_4 is not a subgroup of Z_6 so that only the symmetry breakings $Z_4 \to Z_2^{rot}$ and $Z_4 \to Z_2^{refl}$ can be said to occur. Note that transition between different realizations of the covering space has interpretation as a phase transition and that it could occur at RNA rather than DNA level. These phase transitions need not relate to the biochemistry but to serve as correlates for emotions and moods. Also the degeneracy due to the existence of several DNAs coding given amino-acid could have similar interpretation.

One can of course play with more stringent scenarios for the transitions between DNAs or RNAs). For instance, the assumption that transitions can occur between chords of same type, leads to contradiction since the $Xaug$ chords of Z_6 harmony do not appear in any other harmony.

In any case, the quint-rule in its various forms is readily testable for DNA sequences.

(f) An open question concerns the change of the key. The convention of the illustrations is that 1-2 edge corresponds to C-G quint. Should one allow the DNAs at various sheets of covering space to be in different keys? Change of the key could be identified as a rotation by some number of quints. It would change the graph representing icosahedron and change the chords. Z_{12} would allow to realize all keys. Z_{12} is not however a subgroup of the icosahedral isometries (whereas $Z_6 = Z_3 \times Z_2^{rot}$ is) so that the transformation should be interpreted as a translation in quint space acting as coordinate transformation.

The active transformations induced by isometries of icosahedron do not change the graph and would map chords to new ones. The action of Z_6 is well-defined also for other harmonies than Z_6 symmetric ones. Could the modulations of the basic key correspond to Z_6 transformations. If so, one would have 6 keys. Unfortunately, the most common modulation by quint ($G \to G$) would be missing.

The change of key could correspond also the change of the chords defined by the extension to tetra-icosahedral harmony. One can choose the chord for extension in several ways for Z_2^{rot} and Z_2^{refl} and these choices could define the allowed modulations of the key.

(g) What would be the correlates of different keys the level of DNA? An attractive assumption is that notes are realized in terms of dark photons, which could also transform to ordinary sound since living matter is piezo-electric system. The general hypothesis is that dark photons have universal energy spectrum, which is that of bio-photons. Change of key corresponds to a change of frequency scale and would correspond the change of either Planck constant or of magnetic field strength the flux tubes of the magnetic body associated with DNA codon (or amino-acid perhaps). This would mean that 12-note scale would correspond to 12-note scale for the magnetic fields strength to which cyclotron frequency is proportional or equivalently for the thickness of the flux tube since magnetic flux is quantized if monopole fluxes are in question. 12-note scale could mean in biology a standardization of frequencies used.

One must modify the extension of the icosahedral Hamiltonian cycles to tetra-icosahedral ones appropriately.

(a) The Z_6 symmetric 20-plet contains 3 6-plets and 1 doublet and the Z_2 symmetric code contains 10 doublets so that here is one 11 DNA doublets in the icosahedral code. "Ordinary" amino-acids have only 9 doublets. The interpretation is that the Z_6 doublet corresponds to ile and the additional ile is coded by tetrahedral codon. The second surplus doublet can be identified as 2 codons coding for punct, "punct". This gives 4+5+ 10 =19 amino-acid if "punct" is counted.

(b) What is lacking is one ile, met, trp, plus Pyl and Sec. Also 4 DNA codons are needed. One of them must code ile, one met, one for punct, and one for trp. The tetrahedral codons would thus correspond to orbits of Z_1. This is actually the only possible subgroup since for the choices $Z_n = 2, 3, 4$ the numbers of codons and amino-acids are not correct. This exhausts all DNA codons.

(c) The only manner to proceed is to assume that icosahedral and tetrahedral codes can appear also as unfused versions. This would naturally occur for Z_2^{ref} for which all cycles contain $X6$ type chord but can occur also for Z_2^{rot} if the completion is done for the inverse harmony and then mapped to the harmony back. The icosahedral code would be as already described. The "free" tetrahedral codes would correspond to Z_1 and the faces coding punct in the two codes would code for Pyl and Sec. The fusion of the tetrahedral and icosahedral codes codes gives just the ordinary genetic code so that the proposal is consistent with the proposal that dark proton sequences realize genetic code [K42].

(d) Note that geometrically this extension means only that the amino-acid sheet of the fiber space is extended by tetrahedral sheet.

The challenge is to construct the covering space of the icosahedron representing amino-acids.

(a) The has as a local fiber the orbit under Z_n associated with the amino-acid defining base point. The space of amino-acids decomposes to disjoint regions corresponding to the 20+20-20 DNA codons. Z_n is the analog of gauge group and by symmetry breaking is different from three different regions of amino-acid space. There are $1 \times 2 \times 8 = 16$ variants of this space due to existence of several harmonies for given symmetries. There are actually only three different options for n given by $n = (0, 16, 4)$, $(2, 12, 6,$ and $(4, 8, 8)$.

(b) The Z_n orbits of the three disjoint amino-acid regions (containing 3+1=4, 5, resp. 10 amino-acids) intersect each other. The challenge is to choose the representative amino-acids from the orbits of Z_n in such a way that the chosen amino-acids belong to the three disjoint regions. It remains to be proven that this is possible. One must also understand how uniquely this can be done.

(c) One could think of choosing a set P_2 of 10 representatives from the 10 orbits of Z_2 related by 6-quint scaling along Hamiltonian cycle. The 3+1+5=9 amino-acids associated with Z_6 and Z_4 would belong to the mirror images $P(S)$ of this 10-element set. $P(S)$ decomposes into set P_6 of 3+1 triangles and set P_4 of 5 triangles and there are 2-element, 4-element and 6-element orbits connecting the elements of the sets P_2, P_4, and P_6.

The following observations lead to a rather detailed and surprisingly simple picture.

(a) The key observation is that the construction of the covering space - that is identifications of amino-acids at the orbits of the groups involved - depends only on whether the choice of Z_2 as Z_2^{rot} or Z_2^{refl}! Thus the two codes (ordinary one and code with Pyl and Sec coded by stop codons) are distinguished by different DNA-amino-acid covering spaces. The details of the Hamiltonian cycle do not matter. Only the structures and mutual relationships of the groups $Z_6 = Z_3 \times Z_2^{refl}$, $Z_4 = Z_2^{rot} \times Z_z^{refl}$ and Z_2^{rot} and Z_2^{refl} matter. Furthermore, the actions of the groups Z_2^{rot}, Z_3 and Z_2^{refl} determine also the actions of Z_6 and Z_4. Only Z_2^{rot} and Z_3 are non-commuting actions.

(b) One can decompose amino-acids to 10 pairs of Z_2^{ref} orbits and visualize the 20 codons involved as two layers on top of each other such that two on top of each other correspond to the same 2-orbit - 2 boxes on top of each other. The choice of the two layers is not unique since one can permute the members of any vertical box pair.

(c) By a suitable choice of the members of vertical box pairs one can arrange that Z_3 and Z_2^{rot} act along the two layers horizontally. Z_2^{rot} orbits divide each layer to 5 pairs of horizontal boxes. One can also permute the vertical pairs horizontally in such a way that the 5+5 Z_2^{rot} orbits correspond to neighboring horizontal boxes along upper and lower layer giving 2+2+2+2+2 decomposition. This still leaves the possibility to permute these 5+5 horizontal pairs defining 4-orbits of Z_4 horizontally with each other.

Simply by drawing one find that Z_3 orbits divide each layer to 3 triplets and 1 singlet and by a suitable choice Z_3 singlets correspond to the 10th box on the right for both layer. The Z_3 orbits and Z_2^{rot} orbits overlap in such a way that the middle Z_3 orbit contains entire Z_2^{rot} orbit.

(d) It is clear how to choose amino-acids from the orbits.

  i. Consider first the $Z_2 = Z_2^{refl}$ case. The lower layer corresponds to the 10 Z_2^{refl} amino-acids (punct included) coded by 2 codons. One must choose from each Z_4 orbit consisting of a square of 4 boxes one upper box to represent Z_4 amino-acid (ala, val, gly, pro, thr). Each 4-unit contains one free upper box to which one can assign 1 Z_6 amino-acid. One cannot however put two amino-acids on 3-orbit. There are 3+1 Z_6 amino-acids and 5 boxes so that one box remains unused. This must be the case. The used box must belong to either second or third horizontal Z_2^{rot} 2-box: if it were filled, the middle Z_3 3-orbit would contain 2 Z_6 amino-acids and the fiber space-structure would fail.
  Contrary to the original intuition, the unfilled box is *not* at the 2-orbit of Z_6 containing as Ile but at the middle upper 3-orbit, which would contain 2 amino-acids if filled. It is associated with one of the 10 amino-acids coded by two codons and is same for both Z_2^{rot} and Z_2^{refl}. One expects that this amino-acid is somehow special: maybe it is punct. Also the corresponding 6-amino-acid (Ser, Arg, or Leu) might be somehow special.

  ii. $Z_2 = Z_2^{rot}$ can be treated similarly. The upper row of boxes is filled in the same manner as in the previous case. The horizontal box pairs in the lower row contain one $Z_2 rot$ box and one Z_4 box. The difference to the previous case is that Z_2 boxes are now shared by the both rows: in the previous case they belonged to the lower row.

(e) The assignment of amino-acids to the orbits is not unique: for n similar orbits there are n! different assignments. Inside orbit there is also some non-uniqueness.

4	6	4	6	4		4	6	4	6(2)
2	2	2	2	2	2	2	2	2	2
2	6	2	6	2		2	6	2	6(2)
4	2	4	2	4	2	4	2	4	2

Table 6.4: The representations of the associations of amino-acids to the orbits of of Z_n, $n = 6, 4, 2$ for $Z_2 = Z_2^{refl}$ (upper two rows) and $Z_2 = Z_2^{rot}$ (lower two rows). The integer n in box tells that the amino-acid associated with that box corresponds to Z_n type amino-acid. "(2)" tells that the Z_6 orbit in question consists of 2 codons.

Table 6.4 represent the two situations graphically.

3. Music and physical correlates of emotions

Peptides are regarded as molecules of emotion and also information and positive/negative coloring of emotions would naturally correlate with the increase/reduction of negentropic resources of the system as negentropy is transferred to or from it away or increases as a whole. Music induces and expresses emotions. Therefore the idea that music in generalized form - say represented by dark photons with ELF frequencies and having energy spectrum in visible and UV energy range of bio-photons- could be the fundamental correlate of emotions and whether tetra-icosahedral music could be in special role (note that one can associated Hamilton's cycles and "music" with any graph).

There are 11 candidates for the icosahedral harmony and its extensions. The candidates have either Z_6 (**Fig. ??**, Z_4 reflection symmetry (**Figs. ??, ??**), or Z_2 rotation symmetry (**Figs. ??, ??, ??**), and Z_2 reflection symmetry (**Figs. ??, ??, ??, ??, ??**). For the first case Z^2 reflection symmetry and for the second case Z_2 rotation symmetry are represented as as half-octave shift. Second reflection symmetry corresponds geometrically to reflection in horizontal direction. The extension assigns to them definite key and adds to 1-quint chords minor and major chords absent for the icosahedral bio-harmonies. The question is whether one of these harmonies is selected in biology or whether all three can appear and are perhaps realized at the level of magnetic bodies of amino-acids.

The reversal of the harmony differs from the original one and major-minor transformation takes place. Could it be that both "moods" are realized at the level of magnetic body and even serve as the physical correlates of moods and emotions? Could emotions be realized at the level of amino-acid magnetic bodies as phase transitions affecting parts of organism or even entire organisms and in this manner changing the mood. Peptides are regarded as molecules of emotion: could these phase transitions occur only for peptides and other information molecules involving proteins? Could peptides also serve as seeds of these phase transitions? Could even the Hamiltonian cycle be changed for the magnetic body of the entire organism and correspond to some importance two-valued characteristic of emotional profile?

Could orientation reversal relate to time reversal, which in Zero Energy Ontology (ZEO) corresponds to state function at opposite boundary of causal diamond (CD)? This reversal would occur in volitional acts: the subsequent reduction would not affect the quantum state in positive energy but in TGD framework they affect the state at opposite boundary CD and in this manner give rise to the experience flow of time.

The simplest extension of the harmony in the proposed form requires that harmony possesses X_6 chord. It does not exist for for the candidate with Z_2^{rot} symmetry but for its reversal 4 of them are present as images of $D7, E7$ and $G\sharp 7, B\flat 7$ which are chords of type X^6. One can however map the harmony to its reversal, perform the completion for it, and perform the reversal back to the original harmony. The reversal depends on what note remains invariant in the reversal. One can require that it is the basic note of the chord to itself: with this condition one would obtain $Dm, Em, G\sharp m, B\flat m$ and major keys $C\sharp, F, A, H$. 4 different

harmonies would result. Without the restriction the number of harmonies is different and each has different emotional characteristics.

4. Religious myths, music, and biology

These symmetries define a hierarchy of symmetry breakings. This hierarchy has amazing connections with the myths, which I believe to reflect deep facts about consciousness and biology at fundamental level expected if also consciousness is fractal. The story of genesis is a good representative in this respect.

(a) The hierarchy of symmetry breakings proceeding from Z_6 down to Z_2^{refl} brings strongly in mind evolution as loss of innocence. For Z_6 one as 4 orbits. One orbit contains 2 triangles (chords, DNA codons assignable to ile). The other orbits correspond to six codons assignable to amino-acids ser, arg, and leu. The chords at the orbits are major chords and 7-chords, and minor chords and 6-chords for the inverse of the harmony.

There are no dissonant chords in 0-quint sector: dissonances appear only for the remaining groups as 0-quint chords. This is musical representation of paradize. This harmony is based on 6-note scale for the basic notes of the chords and used by impressionistic composers. Amino-acids correspond to selections of preferred chord from each orbit and there are only four different chords: this sub-harmony is very simple. Life in paradize is simple!

(b) Next comes an intriguing observation. The number of amino-acids obtained as projections of the icosahedral DNA orbits is 19, not 20. Could it be impossible to have 20 amino-acids as projections of the orbits and that 19 is the maximum number? The reason for 19 is that the number of amino-acid of type Z_6 is $3 + 1 = 4$ rather than 5. Therefore there is one "non-playable" chord - located at some "paradize orbit" -, which does not correspond to any amino-acid.

The first guess for the non-playable chord is as one of the *aug* type chords (say $CEG\sharp$, which is the last breath in many finnish tangos telling about unhappy love end - it is something between happy CM and sad Am, "raueta" is finnish word for this manner to come to an end: "expire" might be the nearest english counterpart). This chord is located at the 2-chord orbit related to the other chord of the orbit by half-octave shift (chords could be $CEG\sharp$ and $F\sharp B\flat D$), the tritonus denied by church.

Unfortunately, this identification is not consistent with the argument identifying the amino-acid chords at Z_n orbits (see table 6.4) the non-playable chord must belong to an intersection of 6-orbit and 4-orbit and is not completely unique without further assumptions. It belongs to a 2-orbit of Z_2^{refl}: if it is somehow special, it could belong to the 2-orbit assignable to punct. If the chords at the 2-orbit have basic notes differing by tritonus, the inspection of the Table 9.1 shows that it is possible to find a unique chord pair having this property for all 5 Z_2^{refl} cycles.

One cannot avoid the associations between non-playable chord and the denied fruit hanging in the tree of good and bad knowledge in the story of Adam and Eve, and its analog in many fairy tales. The non-playable chord also brings in mind the hilarious story of Gödel-Escher-Bach about non-playable record (a truth unprovable in given axiom system).

(c) The hierarchy of symmetry breakings leading from Z_6 to Z_2^{refl} encourages one to continue with the biblical analogies. Z^6, Z_4 and Z_2^{rot} cycles have half-octave shift as a symmetry: good and evil do not exist in paradise, but dissonances are already there for Z_4 and Z_2 harmonies - the evil snake! These states correspond to the consciousness of animals, children, and saints. Note that bio-harmony corresponds to the presence of one sub-harmony of type Z_n, $n = 6, 4, 2$.

(d) The banishing from the paradize takes place as Z_2^{refl} symmetric harmony replaces Z_2^{rot} harmony: half-octave shift is not a symmetry anymore, and one can tell between good and evil, and eventually church decides to deny tritonus as a symbol of evil! Paradise is left as icosahedral and tetrahedral code are fused to form the tetra-icosahedral code - the ordinary genetic code leading to the breaking of Z_2^{refl} symmetry.

(e) In banishment punct ("empty" amino-acid) as a counterpart of chord shared by tetrahedron and icosahedron emerges and means stopping of the music piece altogether. Death of the sinner! For unfused codes this chord is playable as Sec/Pyl and the music piece is never-ending: life is eternal in paradise! No notion of time, no sin, no death! Amusingly, impressionist music with 6-note scale is music of "now", attempt to catch this moment.

(f) Also the holy trinity finds an analog as $Z_6 - Z_4 - Z_2$ trinity of the bio-harmony. Holy Spirit, Father, Son: perhaps in this order. Even more, Z_2^{rot} can be associated with Son in Heaven and $Z_2 refl$ with Son at Earth as ordinary mortal!

5. What do DNAs/amino-acids sound like?

If DNA/amino-acid sequences correspond to chord sequences of tetra-icosahedral harmony, one can ask what they sound like. The best manner to study this question is to build concrete simulations of the DNA/amino-acid sequences.

(a) This requires specification of harmony by selecting one Hamiltonian cycle from the cycles belonging to the groups of cycles with Z_n, $n = 6, 4, 2$ symmetry and decomposing amino-acids to 3 groups correspondingly (those coded by 6, 4, and 2 codons). One must include tetrahedral codons and amino-acids.

(b) The basic rule of harmony would be the minimization of quint distance between initial and final chords of the transition. One can consider probabilistic versions of this rule or pose strict form of the rules stating in the most stringent form that only transitions with vanishing quint distance (between neighboring triangles) are possible.

(c) The transitions between different amino-acid regions would be governed by this rule. Aso the transitions between different variants of the DNA-amino-acid space defined by different choices of the Hamilton cycles would be governed by the same rule

(d) The most plausible looking model considers only transitions between DNA codons since DNA sequences induce amino-acid sequences.

Appendix represents an example about randomly generated chord sequence assignable to bio-harmony defined as a composite of 3 harmonies - one from each symmetry type and $Z_2 = Z_2^{refl}$ involving tetra-icosahedral extension. Anyone having garage band skills in guitar playing can check what these chord sequences sound like and maybe try to build a melody on the background. One could also test the proposal that codons at the orbit of amino-acid define the melody by finding a concrete representation for the orbits and building random melodies defined by DNA sequences coding for the chord sequence.

Magnetic body, bio-harmonies, morphogenesis, and epigenetics

What TGD can possibly give to biology is the vision about magnetic body as an intentional agent using biological body as a sensory receptor and motor instrument and about various mechanism used by magnetic body for control and communication purposes. A new element is brought in by Zero Energy Ontology: magnetic body is 4-dimensional and thus correlate for a behavioral pattern rather than 3-D state for part of organism. Also the notion of bio-harmony suggests itself as a correlate for quantum coherence at the level of basic bio-molecules. The discussion below raises and tries to answer general questions.

The finding that behavioral patterns of planaria can be remembered also by the piece of split planaria without the brain is consistent with the idea that replication of magnetic body coding for behaviors is behind biochemical replication. That alleles of the same gene have different expression could be understood if the bio-harmony assignable to gene carries additional information besides the biochemical information. An alternative explanation is that emotional memories associated with conditioning are realized at the level of the body of planaria.

These notions might also provide a fresh approach to epigenetics. Histone modification and DNA methylation are believed to induce kind of geometric locking preventing transcription. They could also affect the frequency assignable to DNA codon or some key unit so

that the resonance condition making possible reconnection of U-shaped flux tubes allowing biomolecules to get in contact fails and transcription cannot proceed. Epigenetic inheritance could reduce to the inheritance of bio-harmony: the magnetic bodies of cells of offspring get in tune with those of parent. To how high degree magnetic body and bio-harmony are inherited? This becomes the key question.

1. Basic ideas related to magnetic body

Recall first some key ideas of TGD inspired quantum biology.

(a) In TGD framework magnetic body extends the pair formed by organism and environment to a kind of holy trinity. Magnetic flux tubes and the realization of genetic code in terms of dark proton sequences has been the key hypothesis. The model for cold fusion [L20] suggests that also more general dark nuclei must be allowed. Dark neutron sequences could correspond to genes separated by dark protons. Dark weak interactions with large value of h_{eff} effectively massless below neuron size scale would play central role and induce large parity breaking effects (chiral selection).

The chemistry would not be all that matters. DNA-nuclear/cell membrane as topological quantum computer with braided magnetic flux tubes would explain why organisms with virtually identical genomes are so different (we and our ancestors for instance). The hierarchy of magnetic bodies would be responsible for the development of intelligence and for cultural evolution. Flux tubes connecting DNA and mRNA as well as mRNA and tRNA molecules are present but it is difficult to say anything concrete.

(b) Ontogeny could be seen as a kind of editing process for the text defined by the DNA. Control of control of... is involved so that situation is very complex. Who performs the editing? Does DNA edit itself and is the editing process defining evolution of genome coded by genome? Or is the editing performed by Darwinian selection at cell level (see `http://tinyurl.com/nd9a9ks`)? Or is the magnetic body the editor using genome also as its tool as TGD would suggest? What is important that in TGD framework self-organization in 4-D sense implied by Zero Energy Ontology replaces ordinary self organization leading to asymptotic spatial patterns and select spatiotemporal patterns as asymptotic behavioral patterns defining various biological functions. The role of magnetic body is central in this process.

(c) Magnetic body contains cyclotron Bose-Einstein condensates and cyclotron frequencies determined by the strength of magnetic field would give for DNA and other biomolecules additional characteristics. In TGD based model for musical harmony DNA codons would correspond quite concretely to 3-chords but played using dark photons (also ordinary music represented as sounds could be transformed to dark photon music). If one accepts the icosahedral model of bio-harmonies predicting genetic code correctly, there would be 256 fundamental harmonies characterised by the allowed collection of 3-chords and they would add to the information carried by DNA molecules. I have constructed a program building random sequences of the allowed chords using the additional harmonic rule that two subsequent chords contain at least one common note and this music sounds rather harmonic (albeit boring in absence of any other elements!)

(d) Could one distinguish between different states/phases of DNAs, mRNAs, tRNAs, and amino acids in terms of harmony? Could their functioning depend on the harmony? With the inspiration coming from the connection of emotions and musical harmonies I have proposed that the harmony associated with a gene or organ could correlate with something analogous to an emotional state or mood - maybe micro-mood or microemotion could be the proper notion. Could amino-acids be happy, hilarious, melancholic, sad, depressed? Could one distinguish between different phases of DNA, RNA, tRNA, aminoacid collections characterized by the harmony in turn characterizing the of a cell, organelle, organ, or even organism? tRNA defines the map of the harmony associated with DNA codons to amino-acid harmony. Is the information about DNA codon and about corresponding 3-chord represented at the level of magnetic body of amino-acid-that is as the 3-chord, which it represents, and realized as the rules telling with which tRNAs amino-acid can reconnect?

In contrast to DNA codons, which represent local information, harmony could represent holistic information and characterize entire genes or their intronic portions.

2. Problem

There is however a problem. DNA codons coding for the same amino-acid correspond to different 3-chords of harmony. One of these chords corresponds to amino-acid itself and the codons coding for amino-acid correspond to the orbit of this chord under subgroup of isometries of icosahedron moving the triangles of icosahedron along the orbit. This would apply also to mRNA and maybe also to tRNA. The chords at the orbit of amino-acid are isomorphic (intervals are same) and obtained as transposes of each other.

The chords are isomorphic but not identical and this leads to the problem with resonance paradigm unless one gives up the idea that amino-acid corresponds to a unique DNA codon and assumes that there is analog of gauge invariance allowing to choose the preferred codon freely.

(a) The assumption about preferred DNA codon could be given up if one can choose the preferred DNA codon freely so that also the magnetic bodies of amino-acids are characterized by 3-chords and thus carry information about what DNA codon coded them. This is possible if one has the analog of fiber space structure with DNA codons coding for amino-acid defining the fiber and amino-acids defining the base. This fiber structure with discrete gauge invariance is strongly suggestive and I have proposed it for two decades ago but it seems that it poses strong conditions on the orbits of the subgroups of isometries of icosahedron.

This condition is very restrictive. Simplifying somewhat: one considers 60 codons decomposing into 20+20+20 codings and each group of 20 codons codes for amino-acids belonging to different groups. There are twenty of them. The 20 triangles of icosahedron correspond to 3 DNA codons each and each of them corresponds to one and only one amino-acid. One has 3 subgroups of isometries corresponding to 20+20+20 decomposition.

Can one perform a global gauge transformations realized as isometries and moving triangles along the orbits of one of the 3 subgroups involved - say isometry g_1 of G_1? These transformations would move the entire orbits of 2 subgroups involved - call them G_2 and G_3. What happens to the chords of G_2 and G_3: is their character changed completely so that these harmonies would be destroyed? It seems that this cannot work. Should one replace G_2 and G_3 with their automorphs $g_1 G_2 g_1^{-1}$ and $g_1 G_3 g_1^{-1}$. Does this make sense? 3-chords defining give orbit should be invariant under automorphisms of G_i? This does not seem to be a realistic condition.

(b) Could different automorphs correspond to different collections of chords physically just as global gauge transformations generate different physical situations? Isometries of groups G_i would therefore define physically different realizations of bio-harmonies such that for each of them only one of the DNA codons coding for given amino-acid could actually perform the coding. Ordinary genetic code with many-to-one correspondence would make sense in statistical sense only. If this is true, the cyclotron frequency 3-chord assignable to amino-acid depends on the DNA coding it and implies physical distinctions.

(c) One can consider also a third alternative. DNA codon with same 3-chord as coding for amino-acid is in special role in that only it can resonate with the amino-acid! Could DNA codons codons correspond to same cyclotron frequency triplet (magnetic fields) but different value of h_{eff} so that one would have chord with respect to energy rather than frequency. Different values of h_{eff} for DNA codons coding for the same amino-acid would scale their cyclotron frequencies to the same amino-acid frequency while keeping cyclotron energies invariant? Cyclotron energy ratios for codons correspond to rational valued ratios $E_i/E_j = h_{eff}(i)/h_{eff}(j) = n(i)/n(j)$. Amino-acid would correspond to fixed h_{eff} and this creates a problem: can DNA codon code for amino-acid with different value of h_{eff}. This option does not look attractive.

Second option looks most plausible. Of course, it is early to talk about a prediction: it might well be that I have mis-understood something.

3. Questions about bio-harmony

One can pose a lot of questions about bio-harmony.

(a) It is not necessary to assign any interpretation on the harmony. Just the harmony could be enough if it is forced to be same for DNA, corresponding mRNA, tRNA, and aminoacids. One can however make questions. Is the harmony inherited invariant and could it distinguish between different personality types about which we learned in old books of psychology? Or could the harmonies correlate with our own moods?

(b) Could differentiation selecting particular genes as expressed genes apply also to harmonies so that given gene would correspond only to a particular harmony and different copies of gene could correspond to different harmonies. Could this selection rely on the same mechanisms as ordinary differentiation realized in terms of epigenetic mechanisms and DNA editing? From the magnetic bodies of genes the harmony would be automatically transferred to the magnetic bodies of mRNA, tRNA and aminoacids since otherwise the transcription and translation do not work since magnetic bodies do not have common resonance frequencies and reconnection and resonant interaction is not possible.

(c) Does given harmony characterize given gene or the entire cell? All basic biomolecules associated with a gene would naturally correspond to the same harmony. If the rRNAs associated with ribosomes are in harmony mutually cellular harmony seems to be the only option. If ribosomes have their own harmonies, only certain ribosomes can translate given gene. This would bring in additional control tool. The most plausible picture is that the situation depends on what happens in the self-organization process. Some organs/organisms are more harmonious, others not so harmonious. Harmony need not be given fixed to remain the same: magnetic body can have motor actions changing the cyclotron frequencies. Moods could reflect the character of harmony at gene level.

(d) Does magnetic body control the differentiation by posing restrictions on gene expression or vice versa? The idea about magnetic body as intentional agent suggests that the first option is correct. There would be hierarchy of magnetic bodies with magnetic bodies at the higher level controlling bodies at the lower level. The value of Planck constant would label the hierarchy levels and also DNA codons would be characterized by "intelligence quotient" defined by h_{eff}/h. This would be nothing but the analog for the hierarchy of program modules and I have earlier considered the realization of this hierarchy [L23].

(e) The selection of harmony could take place and be analogous to cell differentiation. This would be a self-organization process in which magnetic bodies of genes, cells, etc.. tune themselves to resonance with each other by modifying their magnetic fields by controlling their thickness (for monopoles flux the flux is invariant). Something analogous to the development of social skills. This could pose resonance as a constraint on processes like replication, transcription, reverse transcription, silencing, enhancing, editing, etc.... It might induce the differentiation at gene level.

Editing processes for genome could be seen as being induced by the motor actions of the magnetic body involving reconnection and change of the value of h_{eff} changing the length of the flux tube and bringing biomolecules near to each other or separating them. This selection would also apply to the intronic part of DNA proposed to be responsible for topological quantum computation like processes. The copies of same fragment appearing in intronic portion and copies of genes could correspond to different harmonies.

4. Can the notions of magnetic body and bio-harmony explain something that ordinary genetic cannot?

It would be nice to identify some biological phenomenon difficult to understand in standard framework but having an elegant explanation in terms of magnetic body.

(a) The notion of harmony could manifest itself at the level of genes as different expressions for the copies of same gene if they correspond to different notions of harmony. The copies of gene are known as alleles (see `http://tinyurl.com/bpee49t`). The alleles can indeed give rise to different phenotypic traits such as different pigmentation.

(b) Morphogenesis provides examples of this kind of phenomena [I47, I48, I62]. The first key idea is that DNA and cell replication is induced by the replication of magnetic bodies serving as information carriers [K76]. The second key idea is that in zero energy ontology (ZEO) magnetic body is 4-dimensional and represents behavioral patterns rather than only 3-dimensional patterns. For instance, memory as behavioral patterns can be inherited by the piece of planaria worm not containing the brain. The explanation could be that the magnetic body carries behavioral patterns replicated in the splitting of the worm.

(c) Epigenetics (see `http://tinyurl.com/4xpwcm`) studies changes of gene expression not caused by the change of DNA itself. Epigenome (see `http://tinyurl.com/y9xkfb2u`) is the highly dynamic part of DNA controlling expression of the rather stable part of genome. One might regard stable part of genome as hardware and epigenome as topological quantum computer programs assignable to magnetic body and modifying gene expression epigenetically. Comment sign in computer code serves as a computer scientific metaphor for epigenetic control by repression.

The modelling of epigenesis in terms of magnetic body and bio-harmonies deserves a separate discussion.

(a) The modification of transcription rate is the basic tool of epigenetic regulation. There are two basic mechanisms involved. Histone modification (see `http://tinyurl.com/y8ywse5v` affects the histones of chromatin so that the transcription is repressed or activated. Histone modification takes place by several mechanisms. DNA methylation occurs for CpG pair and if it occurs for a promoter region it represses the transcription and serves as a kind of gene lock. The degree of methylation serves as a measure for the effectiveness of repression. I do not know whether the locking is absolute at the level of single gene or whether only the transcription rate is reduced. Two mechanisms are mentioned in the Wikipedia article (see `http://tinyurl.com/y9kwrvwx`). Methylation can impede geometrically some step in the transcription. Methylated site can be also accompanied by proteins affecting histones in chromatin and in this manner impede transcription.

(b) The notions of magnetic body and bio-harmony suggest an alternative - one might even hope fundamental - mechanism of repression. Methylation (histone modification) could affect some cyclotron frequency associated with DNA codon (histone). In the optimal situation for transcription the DNA and protein catalyzing the transcription or mRNA are in resonance. When cyclotron resonance condition is not exactly satisfied, the reconnection rate for the U-shaped flux tubes associated with the molecules involved in the process is reduced and also transcription is repressed.

I have considered also the radical possibility that the dynamics at the level of magnetic body is fundamental for biology and that magnetic body defines templates for the bio-molecular self-organization making dark matter dynamics visible. This is probably too extremist view and it would seem that biochemistry affects the cyclotron frequencies assignable to the magnetic body by affecting the strengths of magnetic fields also at dark magnetic flux tubes.

(c) The notions of epigenetic code (see `http://tinyurl.com/y8ztzzza`) and histone code (see `http://tinyurl.com/y854w58p`) have been proposed. Epigenetic code would consist of histone modifications and additional modifications such as DNA methylation. The codeword of the epigenetic code could code for some larger unit than protein: say gene or entire cell. The hypothesis is that the chromatin-DNA interactions are induced by histone tail modifications (such as methylation, acetylation, ADP-ribosylation, ubiquitination, citrullination, and phosphorylation). There are 4 histones and the position

of modification varies as well as the modifier (the above modifications are not the only ones) so so that the number of modifications is very large.

The addition of bioharmonies to the genetic information could simplify the situation dramatically since the modifications could be seen as defining of of the 256 bio-harmonies with 64 chords each (this for fixed scale which varies if the value of magnetic field strength is varied: biophoton spectrum in visible is proposed to represent the range of values of magnetic field). The most plausible starting hypothesis is that given harmony characterizes the gene. Much simpler option would be that the harmony characterizes entire cell or even group of cells.

If the modification by kicking cyclotron frequency out of harmony is enough to repress transcription, almost endless number of bio-chemical ways to achieve would exist but the epigenetic code could be very simple at the basic level as TGD would predict. Each bio-harmony [L12] [K79] would provide a representation of genetic code in terms of 3-chords predicting correctly the DNA-amino-acid correspondence (there are actually two slightly differing codes explaining the presence of 21st and 22nd amino-acid and deviations from the standard code). The states of dark protons (or neutrons) are also proposed to realize genetic code [L4, K42]: it is an open question whether these codes imply each other as they should.

(d) The understanding of transgenerational epigenetic inheritance (see `http://tinyurl.com/h6qg64c`) raises difficult challenges. One should understand how histone modification and DNA methylation are transferred to daughter cells in cellular division or inherited by the offspring. Transgenerational interaction of the genomes seems necessary. In TGD framework the interaction of magnetic bodies of via resonance mechanism could transfer the epigenetic programs to the offspring. Offspring could "learn" the epigenetic programs of the mother by tuning.

(e) Gregory Carey (see `http://tinyurl.com/ydyznsaq`) gives nice real life examples about the complexities of epigenesis identified quite generally as gene regulation (see `http://tinyurl.com/zb97cgs`). He compares the gene regulation involved with the handling of a stressful situation to "nightmarish Rube Goldberg mousetrap" and sees the process as extremely ineffective from engineering point of view. For instance, the hormones secreted to blood circulation are distributed to the entire body. The whole thing could be carried out in brain! He also wonders why evolution is so inefficient. All cells have same genome although most of the genes are silenced. Second strand of DNA is totally un-used and most of DNA consists of introns. His explanation is that evolution does not make long term plans but finds just a solution to a particular without thinking it from a wider perspective: "If it ain't broke, don't fix it".

I tend to see this differently. If entire body is coherent quantum entity, engineering based thinking does not make sense. Entire body and also magnetic body must be informed from the stress situation since the reaction is holistic. The genes which are not used for gene expression might be used for other purposes. Topological quantum computation could be this purpose in TGD framework and repressed genes could be thus used for quantum information processing. Information processing could be actually the dominating function of the DNA of higher vertebrates.

To sum up, magnetic body could be seen as the "boss" controlling the gene expression and also the evolution of genome in longer scales. Magnetic body would use bio-molecular mechanisms for its purposes. This would bring in a new kind of inheritance: bio-harmony would be inherited. The most spectacular almost-prediction would be that genetic code is many-to-one only in statistical sense.

5. RNA is transferred between soma cells and germ cells

The basic question of epigenesis is how the information between soma cells and germ cells is transferred. In standard genetic the transfoer RNA or DNA molecules is necessary to achieve this. In TGD dark DNA, RNA, tRNA, and aminocids consisting of dark nucleons realized as nuclear strings and accompanied by the corresponding biomolecules is one possibility. The

extremist view would be that the dynamics of the dark variants of basic bio-molecules induces the dynamics of their molecular shadows making them only visible. Also the transfer of information as cyclotron radiation can be considered in TGD framework and cyclotron resonance could serve as a fundamental mechanism of epigenetic control. The above model suggest that epigenetic control mechanisms rely on resonance mechanism for 3-chords associated with DNA codons and other biomolecules giving them "names" is also at work besides purely geometrical silencing.

The popular article "No Sex Required: Body Cells Transfer Genetic Info Directly Into Sperm Cells, Amazing Study Finds" (see `http://tinyurl.com/hhdth5j`) summarizing the findings discussed in the article [I24] (see "Soma-to-Germline Transmission of RNA in Mice Xenografted with Human Tumour Cells: Possible Transport by Exosomes" (see `http://tinyurl.com/yde7wb55`) as very interesting concerning this basic question.

The abstract of the article gives for a professional a readable summary.

Mendelian laws provide the universal founding paradigm for the mechanism of genetic inheritance through which characters are segregated and assorted. In recent years, however, parallel with the rapid growth of epigenetic studies, cases of inheritance deviating from Mendelian patterns have emerged. Growing studies underscore phenotypic variations and increased risk of pathologies that are transgenerationally inherited in a non-Mendelian fashion in the absence of any classically identifiable mutation or predisposing genetic lesion in the genome of individuals who develop the disease. Non-Mendelian inheritance is most often transmitted through the germline in consequence of primary events occurring in somatic cells, implying soma-to-germ line transmission of information. While studies of sperm cells suggest that epigenetic variations can potentially underlie phenotypic alterations across generations, no instance of transmission of DNA- or RNA-mediated information from somatic to germ cells has been reported as yet.

To address these issues, we have now generated a mouse model xenografted with human melanoma cells stably expressing EGFP-encoding plasmid. We find that EGFP RNA is released from the xenografted human cells into the bloodstream and eventually in spermatozoa of the mice. Tumor-released EGFP RNA is associated with an extracellular fraction processed for exosome purification and expressing exosomal markers, in all steps of the process, from the xenografted cancer cells to the spermatozoa of the recipient animals, strongly suggesting that exosomes are the carriers of a flow of information from somatic cells to gametes. Together, these results indicate that somatic RNA is transferred to sperm cells, which can therefore act as the final recipients of somatic cell-derived information.

Some background is needed to understand this rather technical summary.

(a) Darwinism has dominated biology since Darwin. The rules of classical Mendelian inheritance conform with the Darwinian view and can be reduced to genetic level. Various traits are inherited genetically by sexual reproduction and genome would change during lifetime only through mutations. Genome changes exremely slowly by random changes for offspring from which selection pressures choose the survivors.

Lamarckian view in turn assumed that the external circumstances experienced by organism leave a trace, which can be inherited but it could not be formulated in terms of modern molecular biology whereas the Darwinian dogma could be formulated in terms of Weissman's genetic barrier. Information flows from germ cells to soma but never in opposite direction. If it would do so, the soma interacting with environment could transfer information to germ cells and the experiences during lifetime could leave inheritable trace to germ cells.

An analogous dogma is that information is always transcribed from DNA to RNA to proteins but never in opposite direction. It is now known that this takes place in case of viruses and retroviruses: there are so called jumping genes which can also make copies of themselves. 5 per cent of human genome conists of endogenous retroviruses capable of doing the same. The huge genome of maize is due to this kind of proces.

(b) The development epigenetics has started to shatter the belief on Wessimann's genetic barrier. Gene expression is not fixed by genome alone and can be change even when

genes are unaffected. Silencing of genes by DNA methylation and histone modification allow to modify gene expression. Silencing is essentially a locking of gene preventing its expression by transcription followed by translation.

It is now known that epigenetic changes in the gene expression can be inherited. The mechanisms are still poorly understood. What seems however clear the genome is more like a slowly changing hardware and gene expression or whatever is behind it is the software and programs can change very rapidly by just adding or deleting comment signs in the code. A deeper understanding of this software is needed.

(c) Epigenetic inheritance requires that genetic information is transferred from soma cells to germ cells. If only DNA or RNA are capable of representing genetic information, then DNA or RNA must be transferred from soma cells to germ cells. No instance of direct DNA or RNA mediated information from soma to cells had been observed before the above mentioned experiments. One can of course challenge the assumption about DNA and RNA as the only representations of genetic information.

The basic idea of the experiment was simple. Use a marker for RNA by using plasmids (DNA strands not belonging to chromosomes) genetically engineered to code for a marker protein making itself visible by fluorescence. Then one just follows the fate of these proteins generated in soma cells and looks whether they end up inside germ cells and how this happens.

More technically: mouse model was xenografted with human melanoma cells stably expessing EGFP-coding plasmid (expressed in a way possibly evoking emotions: human melanoma cancer tissue was implanted in mouse). EGFP-RNA is released from xenografted human cells to blood. One just looks whether it eventually ends up to the sperm cells of mice and tries to identify the transfer mechanism. Only transfer to sperm cells was studied. One might expect that the transfer of RNA can happen also to ovum. I guess that the sperm cells are easier to study.

What was observed?

(a) The transfer of RNA from soma cells to sperm cells was indeed found to occur. The transferred RNA can in turn induce epigenetic effects in germ cells known to be inherited by a mechanisms, which however remain poorly understood. Epigenetic mechanisms seem to be involved in the cases considered so that DNA is not changed, only its expression.

(b) The transfer mechanism was identified. The transferred RNA is contained by exosomes analogous to synaptic vesicles transferring neurotransmitters from presynaptic to postsynaptic cell. Transfer of RNA takes place via fusion of the membranes just like transfer of neurotransmitters. Maybe genetic engineering using exosomes or analogous structures to transfer the needed material to cells has been tried.

The implications of the findings are dramatic but already implied by the earlier work in epigenetics. What is important that Lamarckian view can be now defended by a concrete genetic mechanism. Lamarckism implies that the time scale of inheritance becomes the time scale for the appearence of a new generation. Nutrition, environment, lifestyle and even meditation and similar practices, are already now known to affect gene expression on daily basis: we are not victims of genetic determinism and are epigenetically responsible for our own well-being. Epigenetic information can be transferred also to germ cells so that we responsible also for the well-being of our children. Our children suffer our sins and share our sufferings.

The precise mechanism of inheritance of epigenetic modifications remains still poorly understood although it seems that the transfer or RNA to germ cells occurs. There are also other hints: it is known that alleles (variants of game gene) can express themselves differently. One allele can also induce other allele to express in the same manner. Somekind of "social pressure" like interaction seems to be involved.

As explained, TGD suggests the notion of magnetic body and cyclotron resonance as this interaction. The DNA of offspring get tuned to the DNA of mother during pregnancy and

this gives to epigenetic inheritance. Various epigenetic mechanisms such as methylation and histone modification could affect cyclotron frequencies besides purely geometric modifications of DNA and locking at the level of gene could be accompanied kicking out of tune at the level of magnetic body. In this framework the transfer of RNA to germ cells would be necessary to affect the cyclotron frequencies.

E_8 symmetry, harmony, and genetic code

Bee gave in Facebook a link to an article about a connection between icosahedron and E_8 root system [B18] (see `http://tinyurl.com/zotpm4b`). The article (I have seen an article about the same idea earlier but forgotten it!) is very interesting.

The article talks about a connection between icosahedron and E_8 root system (see `http://tinyurl.com/y7csb6uh`). Icosahedral group has 120 elements and its double covering $2 \times 120 = 240$ elements. Remarkably, E_8 root system has 240 roots. E_8 Lie algebra is 248 complex-dimensional contains also the 8 commuting generators of Cartan algebra besides roots: it is essential that the fundamental representation of E_8 co-incides with its adjoint representation. The double covering group of icosahedral group acts as the Weyl group E_8. A further crucial point is that the Clifford algebra in dimension $D = 3$ is 8-D.

One starts from the symmetries of 3-D icosahedron and ends up with 4-D root system F_4 assignable to Lie group and also to E_8 root system. E_8 defines a lattice in 8-D Euclidian space: what is intriguing that dimensions 3,4, 8 fundamental in TGD emerge. To me this looks fascinating - the reasons will be explained below.

1. What I might have understood

I try to explain what I have possibly understood.

(a) The notion of root system is introduced. The negatives of roots are also roots but not other multiples. Root system is crystallographic if it allows a subset of roots (so called simple roots) such that all roots are expressible as combinations of these simple roots with coefficients having the same sign. Crystallographic root systems are special: they correspond to the fundamental weights of some Lie algebra. In this case the roots can be identified essentially as the quantum numbers of fundamental representations from which all other representations are obtained as tensor products. Root systems allow reflections as symmetries taking root system to itself. This symmetry group is known as Coxeter group and generalizes Weyl group. Both H_3 and H_4 are Coxeter groups but not Weyl groups.

(b) 3-D root systems known as Platonic roots systems (A_3, B_3, H_3) assignable to the symmetries of tetrahedron, octahedron (or cube), and icosahedron (or dodecahedron) are constructed. The root systems consist of 3 suitably chosen unit vectors with square equal to 1 (square of reflection equals to one) and the Clifford algebra elements generated by them by standard Clifford algebra product. The resulting set has a structure of discrete group and is generated by reflections in hyper-planes defined by the roots just as Weyl group does. This group acts also on spinors and one obtains a double covering SU(2) of rotation group SO(3) and its discrete subgroups doubling the number of elements. Platonic symmetries correspond to the Coxeter groups for a "Platonic root system" generated by 3 unit vectors defining the basis of 3-D Clifford algebra. H_3 is not associated with any Lie algebra but A_3 and B_3 are.

Pinors (spinors) correspond to products of arbitrary/even number of Clifford algebra elements. Spinors induced orientation preserving transformations and pinos also orientation reversing ones. They mean something else than usually a bein identified as elements of the Clifford algebra acting and being acted on from left or right by multiplication so that they always behave like spin 1/2 objects since only the left(right)-most spin is counted. The automorphisms involve both right and left multiplication reducing to SO(3) action and see the entire spin of the Clifford algebra element.

(c) The 3-D root systems (A_3, B_3, H_3) are shown to allow an extension to 4-D root systems known as (D_4, F_4, H_4) in terms of 3-D spinors. D_4 and F_4 are root systems of Lie algebras (see http://tinyurl.com/y97dzqc2). F_4 corresponds to non-simply-laced Lie group related to octonions. H_4 is not a root system of any Lie algebra.

(d) The observation that the dimension of Clifford algebra of 3-D space is $2^3 = 8$ and thus allows embedding of at most 8-D root system must have inspired the idea that it might be possible to construct the root system of E_8 in 8-D Clifford algebra from 240 pinors of the double covering the 120 icosahedral reflections. Platonic solids would be behind all exceptional symmetry groups since E_6 and E_7 are subgroups of E_8 and the construction should give their root systems also as low-dimensional root systems.

2. McKay correspondence

The article explains also McKay correspondence stating that the finite subgroups of rotation group SU(2) correspond to simply laced affine algebras assignable with ADE Lie groups.

(a) One considers the irreducible representations of a finite subgroup of the rotation group. Let the number of non-trivial representations be m so that by counting also the trivial representation one has $m+1$ irreps altogether. In the Dynkin diagram of affine algebra of group with m-D Cartan algebra the trivial representation corresponds to the added node. One decomposes the tensor product of given irrep with the spin 2 representation into direct sum of irreps and constructs a diagram in which the node associated with the irrep is connected to those nodes for which corresponding representation appears in the direct sum. One can say that going between the connected nodes corresponds to forming a tensor product with the fundamental representation. It would be interesting to know what happens if one constructs analogous diagrams by considering finite subgroups of arbitrary Lie group and forming tensor products with the fundamental representation.

(b) The surprising outcome is that the resulting diagram corresponds to a Dynkin diagram of affine (Kac-Moody) algebra of ADE group with Cartan algebra, whose dimension is m. Cartan algebra elements correspond to tensor powers of fundamental representation: can one build any physical picture from this? For $m = 6, 7, 8$ one obtains E_6 , E_7 , E_8. The result of the article implies that these 3 Lie-groups correspond to basis of 3 3-D unit identified as units of Clifford algebra: could this identification have some concrete meaning as preferred non-orthogonal 3-basis?

(c) McKay correspondence emerges also for inclusions of hyper-finite factors of type II_1 [K118] The integer m characterizing the index of inclusion corresponds to the dimensions of Cartan algebra for ADE type Lie group. The inclusions of hyperfinite factors (HFFs) are characterized by integer $m \geq 3$ giving the dimension of Cartan algebra of ADE Lie groups (there are also C, F and G type Lie groups). $m = 6, 7, 8$ corresponds to exceptional groups E_6 , E_7 , E_8 on one hand and to the discrete symmetry groups of tetrahedron, octahedron, icosahedron on the other hand acting as symmetries of corresponding 3-D non-crystallographic systems and not allowing interpretation as Weyl group of Lie group.

3. Connection with the TGD based model of harmony

These findings become really exciting from TGD point of view when one recalls that the model for bioharmony [K79] [L12] (see http://tinyurl.com/yad4tqwl) for 12-note harmonies central in classical music in general relies on icosahedral geometry. Bioharmonies would add something to the information content of the genetic code: DNA codons consisting of 3 letters A,T,C,G would correspond to 3-chords defining given harmony realized as dark photon 3-chords and maybe also in terms of ordinary audible 3-chords. This kind of harmonies would be roughly triplets of 3 basic harmonies and there would be 256 of them (the number depends on counting criteria). The harmonies could serve as correlates for moods and emotional states in very general sense: even biomolecules could have "moods". This new information should be seen in biology. For instance, different alleles of same gene are known

to have different phenotypes: could they correspond to different harmonies? In epigenetics the harmonies could serve as a central notion and allow to realize the conjectured epigenetic code and histone code. Magnetic body and dark matter at them would be of course the essential additional element.

The inspiring observations are that icosahedron has 12 vertices - the number of notes in 12-note harmony and 20 faces- the number of amino-acids and that DNA codons consist of three letters - the notes of 3-chord.

(a) Given harmony would be defined by a particular representation of Pythagorean 12-note scale represented as self-non-intersecting path (Hamiltonian cycle) connecting the neighboring vertices of icosahedron and going through all 12 vertices. One assumes that neighboring vertices differ by one quint (frequency scaling by factor 3/2): quint scale indeed gives full octave when one projects to the basic octave. One obtains several realizations (in the sense of not being related by isometry of icosahedron) of 12-note scale. These realizations are characterized by symmetry groups mapping the chords of harmony to chords of the same harmony. These symmetry groups are subgroups of the icosahedral group: Z_6, Z_4, and two variants of Z_2 (generated by rotation of π and by reflection) appear. Each Hamiltonian cycle defines a particular notion of harmony with allowed 3-chords identified by the 20 triangles of icosahedron.

(b) Pythagoras is trying to whisper me an unpleasant message: the quint cycle does not quite close! This is true. Musicologists have been suffering for two millenia of this problem. One must introduce 13th note differing only slightly from some note in the quint cycle. At geometrical level one must introduce tetrahedron besides icosahedron - only four notes and four chords and gluing along one side to icosahedron gives only one note more. One can keep tetrahedron also as disjoint from icosahedron as it turns out: this would give 4-note harmony with 4 chords something much simpler that 12- note harmony.

(c) The really astonishing discovery was that one can understand genetic code in this framework. First one takes three different types of 20-chord harmonies with group Z_6, Z_4, and Z_2 defined by Hamiltonian cycles: this can be done in many different maners (there are 256 of them). One has 20+20+20 chords and one finds that they correspond nicely to 20+20+20=60 DNA codons: DNA codons coding for a given amino-acid correspond to the orbit of the triangle assigned with the amino-acid under the symmetry group of harmony in question.

The problem is that there are 64 codons, not 60. The introduction of tetrahedron brings however 4 additional codons and gives 64 codons altogether. One can map the resulting 64 chord harmony to icosahedron with 20 triangles (aminoacids) and the degeneracies (number of DNA codons coding for given amino-acid in vertebrate code) come out correctly! Even the two additional troublesome amino-acids Pyl and Sec appearing in Nature and the presence of two variants of genetic code (relating to two kinds of Z_2 subgroups) can be understood.

4. What could the interpretation of the icosahedral symmetry?

An open problem is the proper interpretation of the icosahedral symmetry.

(a) A reasonable looking guess would be that it quite concretely corresponds to a symmetry of some biomolecule: both icosahedral or dodecahedral geometry give rise to icosahedral symmetry. There are a lot of biomolecules with icosahedral symmetry, such as clathrate molecules at the axonal ends and viruses. Note that dodecahedral scale has 20 notes - this might make sense for Eastern harmonies - and 12 chords and there is only single dodecahedral Hamiltonian path found already by Hamilton and thus only single harmony. Duality between East and West might exist if there is mapping of icosahedral notes and to dodecahedral 5-chords and dodecahedral notes to icosahedral 3-chords and different notions of harmony are mapped to different notions of melody - whatever the latter might mean!).

(b) A more abstract approach tries to combine the above described pieces of wisdom together. The dynamical gauge group E_8 (or Kac-Moody group) emerging for m=8 inclusion of HFFs is closely related to the inclusions for the fractal hierarchy of isomorphic sub-algebras of super-symplectic subalgebra. $h_{eff}/h = n$ could label the sub-algebras: the conformal weights of sub-algebra are be n-multiples of those of the entire algebra.

The integers n_i resp. n_f for included resp. including super conformal sub-algebra would be naturally related by $n_f = m \times n_i$. $m = 8$ would correspond to icosahedral inclusion and E_8 would be the dynamical gauge group characterizing dark gauge degrees of freedom. The inclusion hierarchy would allow to realize all ADE groups as dynamical gauge groups or more plausibly, as Kac-Moody type symmetry groups associated with dark matter and characterizing the degrees of freedom allowed by finite measurement resolution.

(c) E_8 as dynamical gauge group or Kac-Moody group would result from the super-symplectic group by dividing it with its subgroup representing degrees of freedom below measurement resolution. E_8 could be the symmetry group of dark living matter. Bioharmonies as products of three fundamental harmonies could relate directly to the hierarchies of Planck constants and various generalized super-conformal symmetries of TGD! This convergence of totally different theory threads would be really nice!

5. Experimental indications for dynamical E_8 symmetry

Lubos (see `http://tinyurl.com/htjp55h`) (thanks to Ulla for the link to the posting of Lubos) has written posting about experimental finding of E_8 symmetry emerging near the quantum critical point of Ising chain at quantum criticality at zero temperature. Here is the abstract (see `http://tinyurl.com/zulzk9y`):

Quantum phase transitions take place between distinct phases of matter at zero temperature. Near the transition point, exotic quantum symmetries can emerge that govern the excitation spectrum of the system. A symmetry described by the E_8 Lie group with a spectrum of eight particles was long predicted to appear near the critical point of an Ising chain. We realize this system experimentally by using strong transverse magnetic fields to tune the quasi–one-dimensional Ising ferromagnet CoNb2O6 (cobalt niobate) through its critical point. Spin excitations are observed to change character from pairs of kinks in the ordered phase to spin-flips in the paramagnetic phase. Just below the critical field, the spin dynamics shows a fine structure with two sharp modes at low energies, in a ratio that approaches the golden mean predicted for the first two meson particles of the E8 spectrum. Our results demonstrate the power of symmetry to describe complex quantum behaviors.

Phase transition leads from ferromagnetic to paramagnetic phase and spin excitations as pairs of kinks are replaced with spin flips (shortest possible pair of kinks and loss of the ferromagnetic order). In attempts to interpret the situation in TGD context, one must however remember that dynamical E_8 is also predicted by standard physics so that one must be cautious in order to not draw too optimistic conclusions.

In TGD framework $h_{eff}/h \geq 1$ phases or phase transitions between them are associated with quantum criticality and it is encouraging that the system discussed is quantum critical and 1-dimensional.

(a) The large value of h_{eff} would be associated with dark magnetic body assignable to the magnetic fields accompanying the E_8 "mesons". Zero temperature is not a prerequisite of quantum criticality in TGD framework.

(b) One should clarify what quantum criticality exactly means in TGD framework. In positive energy ontology the notion of state becomes fuzzy at criticality. For instance, it is difficult to assign the above described "mesons" with either ferromagnetic or paramagnetic phase since they are most naturally associated with the phase change. Hence Zero Energy Ontology (ZEO) might show its power in the description of (quantum) critical phase transitions.

Quantum criticality could correspond to zero energy states for which the value of h_{eff} differs at the opposite boundaries of causal diamond (CD). Space-time surface between

boundaries of CD would describe the transition classically. If so, then E_8 "mesons" would be genuinely 4-D objects - "transitons" - allowing proper description only in ZEO. This could apply quite generally to the excitations associated with quantum criticality. Living matter is key example of quantum criticality and here "transitons" could be seen as building bricks of behavioral patterns. Maybe it makes sense to speak even about Bose-Einstein condensates of "transitons".

The finding suggests that quantum criticality is associated with the transition increasing $n_{eff} = h_{eff}/h$ by factor $m = 8$ or its reversal - maybe the standard value $n_{eff}(i) = 1$. $n_{eff}(f) = 8$ could correspond to the ferromagnetic phase having long range correlations. Could one say that at the side of criticality (say the "lower" end of CD) the $n_{eff}(f) = 8$ excitations are pure gauge excitations and thus "below measurement resolution" but become real at the other side of criticality (the "upper" end of CD)?

(c) The 8 "mesons" associated with spin excitations naturally correspond to the generators of the Cartan algebra of E_8. If the "mesons" belong to the fundamental (= adjoint) representation of E_8, one would expect 120+120 additional particles with non-vanishing E_8 charges. Why only Cartan algebra? Is the reasons that Cartan algebra is in preferred role in the representations of Kac-Moody algebras in that charged Kac-Moody generators can be constructed from Cartan algebra generators by standard construction used also in string models. Could this explain why one expects only 8 "mesons". Are charged "mesons" labelled by the elements of double covering of icosahedral group more difficult to excite?

6.7.3 Icosahedral Harmonies

In the following the icosahedral harmonies are discussed in detail. This includes overall summary and tables giving the 20 3-chords of the harmonies and illustrations of the Hamiltonian cycles.

About symmetries of the icosahedral harmonies

Some words about the symmetries associated with the icosahedral harmonies and genetic code are in order.

There are 3 different kind of bio-harmonies characterized partially by the symmetry group which can be Z_6, Z_4 or Z_2 which acts either as rotations or reflections.

(a) The first variant as $Z_3^{rot} \times Z_2^{refl}$ subgroup of icosahedral group as symmetries and its orbits correspond to 3 6-plets and 1 2-plets for which Z_3 leaves the triangle invariant. The counterparts for the orbits are 3 DNA 6-plets and one 2-plet.

(b) The second variant has Z_4 symmetry generated by two commuting reflection as symmetries as is obvious from figures **??**, **??**: the reflections act on vertical and horizontal coordinates. The orbits are five 4-plets of chords. Vertical reflection induces half-octave shift and horizontal one permutes the note sequences $B\flat C D G\sharp F\sharp E$ and $D\sharp C\sharp H F G A$.

(c) Z_2^{rot} or Z_2^{refl} acts as symmetries of the remaining 3+5 cycles. The covering space of 10 amino-acids involved defined by 20 DNA codons decomposes to 10 2-plets.

The 2-fold rotation symmetry of the Hamiltonian cycles is obvious from the illustration **??**: it corresponds to 6-quint rotation and the chord sets must be invariant under this rotation. This rotation corresponds to the 1/2 octave shift realized as rotation. These symmetries are realized as "coordinate transformations" for the cycle - a curve in the "embedding space" defined by icosahedron but induced from the "embedding space symmetries" acting as isometries of icosahedron.

DNA codons have also almost exact Z_2 symmetry discussed in [K114, K2, **?**].

(a) For the last codon the reflection A-T, C-G is an almost symmetry broken only for special cases. This approximate symmetry could be understood as following from the

fact that the number of DNAs coding given amino-adic is even in most cases. The exceptions are ile, met, trp coded by odd number of DNA codons. By mapping DNAs to binary sequences one can order the situation so that the 6: th binary digit is the almost-symmetry digit.

(b) What is trivial is that RNA has chosen the third bi-digit to be the almost symmetry digit with the ordering UCAG of the nucleotides so that a genuine physical symmetry is in question. An interesting question is how this symmetry relates to the model of genetic code based on tetra-icosahedral orbits.

The restriction of DNAs to 60 icosahedral DNAs demonstrates that this symmetry originates from the icosahedral Z_2. The tetrahedral extension of the code breaks this symmetry by extending ile and punct multiples by one codon and introducing also 4 singlets met, trp, Pyl, and Sec.

The detailed correspondence between chords of the harmony and DNA codons is also a problem to be solved.

(a) The correspondence matters in the proposed scenario since the chords at at the orbits are different and the gluing of tetrahedron breaks the symmetry in Z_2 sectors so that quint rule determining harmonic DNA sequences is different.

(b) The common face of tetrahedron and icosahedron corresponds to punct so that the quint rule for different representations says something about the pairs of form codon-stop codon that is about the codon preceding the last codon of gene! This codon could allow to recognize what Hamiltonian cycle is in question. If C-major is one of the added chords, stop codons correspond to what was $C6 = CGA$ chord and its Z_2 image, which is $X7$ type chord. By the strongest form of the quint rule only the chords having common notes with these chords would correspond to DNA codons of Z_6 and Z_4 cycles which can precede stopping codon.

(c) There are some restrictions on the correspondence. Z_2^{refl} symmetry would correspond to the flipping of the 6th bit for the bit representation defined by nucleotides representing 2-bits in the case of $Z^3 = Z_3 \times Z_2^{refl}$. $Z_4 = Z_2^{rot} \times Z_2^{refl}$. For $Z_2 = Z_2^{rot}$ the role of Z_2^{refl} must be taken by Z_2^{rot}. One can of course ask whether Z_2^{rot} cycles are realized at all. For Z_4 cycles Z_2^{rot} would correspond to symmetry permuting the AT, CG doublets for the first nucleotide. For Z_6 subgroup Z_3 would cyclically permute the 3 doublets with respect to third nucleotide. These constraints do not fix the correspondence completely.

To sum up, there is a connection between genetic code and the groups acting along the Hamiltonian cycle. The simplest option fixes the orbits of the triangles and therefore also the representation of genetic code.

Summary of the basic results

One can find the list of Hamiltonian cycles at `http://tinyurl.com/yacgzm9x`. The edge $\{1, 2\}$ is fixed and cycles are oriented so that there are 1024 of them. All of them are relevant from the point of music interpretation and the change of orientation corresponds to major-minor duality, albeit not in the simplest sense. Note that this duality does not affect the characteristics listed above.

The general following general results hold true as one can learn at `http://tinyurl.com/pmghcwd`. One can classify the cycles using their symmetries which can correspond to isometries of icosahedron leaving them fixed or to a reflection taking the vertex n at the cycle to vertex $12 - n$. This symmetry is not same as change of orientation which is purely internal operation and cannot change the cycle.

One can even find images of the cycles possessing symmetries at `http://tinyurl.com/y8ek7ak8` and deduce the triplets n and p characterizing them by visual inspection. Also one can write explicitly the 3-chords defined by the three kinds of faces. I have deduced the triplets n and the 3-chords defining the harmony by the inspection of the images. "Bio-harmony" (4, 8, 8) forced by the model of extended genetic code involving also the 21st and

$$CEG \equiv C \; , \qquad CD\sharp G \equiv Cm \; , \qquad CD\sharp F\sharp \equiv C^o \; , \qquad CEG\sharp \equiv Caug \; ,$$
$$CFG \equiv C4 \; , \qquad CF\sharp G \equiv C4_+ \; , \qquad CGG\sharp \equiv C6_- \; , \qquad CGA \equiv C6 \; , \qquad (6.7.1)$$
$$CGB\flat \equiv C7 \; , \qquad CGB \equiv Cmaj7 \; , \qquad CGC\sharp \equiv C9_- \; , \qquad CGD \equiv C9 \; .$$

Table 6.5: Notation of chords inspired by popular music notations.

22nd amino-acids is of special interest. The classes of cycles with symmetries 6-fold rotational symmetry and two distinct reflection symmetries realize it.

Before continuing some terminology and notation is in order. Take C as the major key. Submediant or relative minor corresponds to Am, subdominant (sharp or flat) to F major (F) or Fminor (Fm), dominant to G. The notation for chords is such that quints correspond to subsequent notes in the chord. For 1-quint chords this means that first two notes define the quint. **Table 6.5** the notation inspired by the popular music notation. The basic different is that the third is in most cases excluded so that the emotional character of the chord is not fixed.

Besides these notions it is convenient to introduce additional notations for various dissonant chords appearing as 0-quint chords.

$$CC\sharp D \equiv Cex1 \; , \qquad CC\sharp D\sharp \equiv Cex2 \; , \qquad CDD\sharp \equiv Cex3 \; , \qquad CDE \equiv Cex4 \; ,$$
$$CD\sharp E \equiv Cex5 \; , \qquad CC\sharp E \equiv Cex6 \; , \qquad CDF\sharp \equiv Cex7 \; , \qquad CDG\sharp \equiv Cex8 \; .$$
$$(6.7.2)$$

Clearly, the sets {ex1}, {ex2, ex3}, {ex4, ex5, ex6}, {ex7}, {ex8}, corresponds to the span of 2, 3, 4, 6, 8 half notes for the chord. The following summarizes the results. Note that $Cex7$ can be seen as part of $D7$ chord.

(a) There are 6 collections of cycles without any symmetries containing 48 cycles each: these 48 cycle are mutually isometric so that one can say that there 6 different harmonies.

(b) There is a collection with 6-fold rotational symmetry, 48/6=8 examples. $n = (2, 12, 6)$. The chords of this scale define 6-note scale involving only total steps. CDF and its 6 translates by integer number of steps define 6 1-quint chords. $CE\flat G$ (Cm) and its 6 translates (they obviously correspond to the 6-fold rotational symmetry) define also 6 1-quint chords. The reflection transforms these series to those defined by $GB\flat G$ and its translate and by FAC (F major) and its translates. Impressionists like Debussy used 6-note scale of this kind. Half-octave shift is an exact symmetry. 1-chords lack the third so that one cannot assign to 3-chords any emotional quality. The extension to 4-chord can however bring either "happy" or "sad" quality. Clearly, these harmonies have "jazzy" character.

0-quint chords are $Faug \equiv FAC\sharp$ and $Gaug \equiv GHD\sharp$ are transformed to each other by both half-octave shift and inversion.

(c) There are 2 collections with 2 distinct reflectional symmetries with 12=48/4 representatives in each. Half-octave scaling is a symmetry of both these scales as one might guess.

The first cycle (see **Fig. ??**) has $n = (0, 16, 4)$ so that there are no 0-quint chords which in general are dissonant. Second cycle (see **Fig. ??**) realizes $n = (4, 8, 8)$ bio-harmony and deserves some comments. It will be discussed in detail later.

   i. The 8 2-quint chords consist of $B\flat FG \equiv B\flat 9$, C9, F9, G9 and their half-octave scalings. Clearly, the simple four-note scale appears here.

   ii. Using the popular notion introduced earlier 1-quint chords consist of two 4-plets $Dmaj7$, $E9_-$, $A7$, $A6$ and $G\sharp maj7$, $B\flat 9_-$, $D\sharp 7$, $D\sharp 6$ related by half-octave shift. The harmony contains no "simple" major or minor chord and only the extension

to tetrahedral harmony can provide them. The same is true for the second bio-harmony.

    iii. The 4 0-quint chords are $Cex3 \equiv CDD\sharp$ and $Eex2 \equiv EFG$ and their half-octave scalings $F\sharp ex3 \equiv F\sharp G\sharp A$ and $B\flat ex2 \equiv B\flat BC\sharp G$.

(d) There are 3 collections with Z_2 rotational symmetry with $48/2 = 24$ representatives in each. The triplets n are $(0, 16, 4)$ (see **Fig. ??**), $(2, 12, 6)$ (see **Fig. ??**), and $(4, 8, 8)$ (see **Fig. ??**). All these harmonies are symmetric with respect to half-octave shift (tritonus), which obviously corresponds to the Z_2 rotation. Tritonus would not have been tolerated by catholic church! This symmetry characterizes all 3 harmonies. Basic 3-chords do not contain pure minor and major chords. The reflection of the scale does not leave the collection of chords invariant but it is not clear whether this corresponds only to a change of scale, probably not.

Consider the (4, 8, 8) case (see **Fig. ??**).

    i. The 8 2-quint chords appear as four-plet $H9, C\sharp 9, D\sharp 9, F9$ and its half octave shift (tritonus interval) acting as a symmetry of the harmony. 2-quint chords are always of type X^9 (note that the third is missing) but also 1-quint chord can be of form X^9 as explicit construction of chords demonstrates: I have denoted these 1-quint chords by symbol $X4$ (CDG is obviously equivalent with CDG).

    ii. Using the popular music notation introduced earlier, the 8 1-quint chords are $D7, Amaj7, A4_+, E7$ and their half-octave shifts $G\sharp 7, D\sharp 7, D\sharp 4_+, B\flat 7$.

No major and minor chords are included and only the extension to tetra-icosahedral harmony can provide them and also break the symmetry giving rise to well-defined key.

(e) The four 0-quint chords appear in two types. $D\sharp ex2 \equiv D\sharp EF\sharp$ and its half-octave shift $Aex2 \equiv AB\flat C$ plus $Hex3 \equiv HC\sharp G$ and its half-octave shift $Fex3 \equiv FGC\sharp$. According to usual thinking these chords involve dissonances. This dissonance character is a rather general phenomenon for the harmonic loners and classical views about harmony would exclude them as asocial cases! In the case of maximally symmetric harmony the loners are diminished chords and thus not so dissonant. In some cases there are no 0-quint chords.

There are 5 collections with Z_2 reflection symmetry having 24 representatives in each (see **Figs. ??, ??, ??, ??, ??**). The integer triplets n are $(2, 12, 6), (2, 12, 6), (4, 10, 6), (2, 12, 6), (2, 12, 6)$. Bio-harmony has representative also in this class (see **Fig. ??**). The half-octave scaling symmetry is broken for these harmonies. I have not found simple characterization for the symmetry which corresponds to reflection in the direction of x-axis since it changes the interval structure of the chords.

Some comments $(4, 8, 8)$ case are in order (see **Fig. ??**).

(a) 2-quint chords appear as reflection related multiplets $C9, D9, H\sharp 9, D\sharp 9$ and $C\sharp 9, H9, F9, B\flat 9$.

(b) 1-quint chords appear as symmetry related mutiplets $G, D7, Amaj7, E7$ and $C\sharp m, F\sharp 6, H6_-, E6$. Key G major and $C\sharp$ minor would be natural looking keys even without tetrahedral extension. For the mirror image $B\flat$ minor and E major would be the natural looking keys. For extension E major would be the key.

To sum up, half octave shift is a symmetry of all harmonies expected those having only Z_2 reflection symmetry, and fails thus also for the corresponding bio-harmonies.

Tables of basic 3-chords for the icosahedral harmonies with symmetries

The tables below give list for the three types of 3-chords for the 11 harmonies possessing symmetries. One must remember that the reversal of the orientation for the cycle induces the transformation $C \leftrightarrow C$, $F\sharp \leftrightarrow F\sharp$, $H \leftrightarrow C\sharp$, $F \leftrightarrow G$, $D \leftrightarrow B\flat$, $E \leftrightarrow G\sharp$, $A \leftrightarrow D\sharp$ and produces a new scale with minor type chords mapped to major type chords and vice versa. Also one must remember that all 3-chords except those which are simple majors or minors

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(2, 12, 6)	$(Faug, Gaug)$	$(Cm, Dm, Em, F\sharp m, G\sharp m, B\flat m)$, $(F6, G6, A6, B6, C\sharp 6, D\sharp 6)$.	$(C9, D9, E9, F\sharp 9, G\sharp 9, B\flat 9)$.

Table 6.6: Table gives various types of 3-chords for harmonies with Z_6 rotational symmetry. Note that half-octave shift is an exat symmetry. Note that $G^{aug} = CEG\sharp$, F^{aug} act as bridges between the groups related by half octave shift. The chords have been arranged so that they form orbits of Z_6. "Amino-acid chords" correspond to preferred chords at the orbits.

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(0, 16, 4)		$(D7, D6, G\sharp 7, G\sharp 6)$, $(G4+, A9-, C\sharp 4+, D\sharp 9-)$, $(Emaj7, Gmaj7, B\flat maj7, C\sharp maj7)$, $(C9-, A9-, F\sharp 9-, D\sharp 9-)$.	$(B\flat 9, B9, E9, F9)$.
(4, 8, 8)	$(Cex3, Eex2, F\sharp ex3, B\flat ex2)$.	$(Dmaj7, E9-, A7, A6)$, $(G\sharp maj7, B\flat 9-, D\sharp 7, D\sharp 6)$.	$(B\flat 9, F9, C9, G9)$. $(E9, B9, F\sharp 9, C\sharp 9)$.

Table 6.7: Table gives various types of 3-chords for the two harmonies with $Z_4 = Z_2^{rot} \times Z_2^{refl}$ symmetry. 4-plets represent the orbits. First cycle has no harmonic loners. Second cycle gives rise to bio-harmony (4, 8, 8) for which 0-quint chords are dissonant. Both cycles have Z_2 rotation symmetry acting as a vertical reflection symmetry in figures and realized also as half-octave shift so that 4-plets contains chords and their half-octave shifts. The genuine reflection symmetry acts as a horizontal reflection symmetry in figures. The cycles correspond to figures **??, ??**

lack the third so that their emotional tone remains uncharacterized. For instance, $C6$ does could be replaced with $Cm6$ and $G7$ with $Gm7$. The reader can check the chords by direct inspection of the figures. The convention used is that vertex number one corresponds to C note.

6.7.4 Appendix

Chord tables for some harmonies and their inverses

The formula for inversion of the harmonic keeping note X as fixed can be represented as a product of translation takin X to C, inversion keeping C fixed, and translation taking C back to X. The inversion maps the chord having C as basic note to its mirror image so that the order of notes can change and basic note can change. For instance, the major chord

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(0, 16, 4)		$(Em, B\flat m), (Cm, F\sharp m)$, $(G6, C\sharp 6), (A6, D\sharp 6)$, $(D4+, G\sharp 4+), (B4+, F4+)$, $(Cmaj7, F\sharp maj7), (G6-, C\sharp 6-)$.	$(D9, G\sharp 9)$, $(E9, B\flat 9)$.
(2, 12, 6)	$(Aex4, D\sharp ex2)$.	$(Am, D\sharp m), (G9-, C\sharp 9-)$, $(C4, F\sharp 4), (E4+, B\flat 4+)$, $(Dmaj7, G\sharp maj7)$, $(Bmaj7, Fmaj7)$.	$(C9, F\sharp 9)$, $(A9, D\sharp 9)$, $(D9, G\sharp 9)$.
(4, 8, 8)	$(Aex2, Hex8, D\sharp ex2, Fex8)$.	$(D7, G\sharp 7), (Amaj7, D\sharp maj7)$, $(A4+, D\sharp 4+), (E7, B\flat 7)$.	$(G9, C\sharp 9), (A9, D\sharp 9)$, $(B9, F9), (E9, B\flat 9)$.

Table 6.8: Table gives various types of 3-chords for harmonies with Z_2 rotation symmetry acting as half-octave shift. The doublets represent 2-chord orbits. The cycles correspond to figures **??, ??, and ??**.

(n_0, n_1, n_2)	0-chords	1-chords	2-chords
(2, 12, 6)	$(F\sharp ex3, Hex4)$,	$(Am, D\sharp), (A6, D\sharp 7)$, $(D7, B\flat 6), (G6-, Fmaj7)$, $(D4+, B\flat 9-), (E9-, G\sharp 4+)$,	$(C9, F9), (B9, F\sharp 9)$, $(E9, C\sharp 9)$.
(2, 12, 6)	$(Dex4, Hex4)$.	$(F, Fm), (C6-, B\flat maj7)$, $(D7, G\sharp 6), (Gmaj7, D\sharp 6-)$. $(C\sharp 4-, A4+), (E4+, F\sharp 6)$.	$(C9, D\sharp 9)$, $(D\sharp 9, C\sharp 9)$, $(E9, B9)$.
(4, 8, 8)	$(Fex1, D\sharp ex3, G\sharp ex1, Aex2)$.	$(E7, E6), (Amaj7, B9-)$, $(G, C\sharp m), (D7, F\sharp 6)$.	$(D9, B9), (C9, C\sharp 9)$, $(F9, G\sharp 9), (D\sharp 9, B\flat 9)$.
(2, 12, 6)	$(Hex3, Eex7)$.	$(D7, G\sharp 6), (G, D\sharp m)$, $(F, Fm), (C6-, B\flat maj7)$, $(A9-, C\sharp 4+), (E7, F\sharp 6)$.	$(C9, D\sharp 9)$, $(D9, C\sharp 9)$, $(E9, B9)$.
(2, 12, 6)	$(F\sharp ex2, Fex3)$.	$(F, B\flat m), (C7, G\sharp 6)$, $(Amaj7, B9-), (E6, E7)$, $(G, C\sharp m), (D7, B6)$.	$(B\flat 9, D\sharp 9)$, $(C9, C\sharp 9)$, $(D9, H9)$.

Table 6.9: Table gives various types of 3-chords for harmonies with single reflection symmetry. The cycles correspond to figures **??, ??, ??, ??, ??**.

C	G	D	A	E	H	F+	C+	G+	D+	B-	F
C	F	$B\flat$	D+	G+	C+	F+	H	E	A	D	G

Table 6.10: Inversion of the scale leaving C (and also $F\sharp$) invariant.

$CM = CEG$ goes to minor chord $CG\sharp F = Fm$ so that $k = 0$ goes to $k \equiv \Delta k_{inv} = 11$. This delicacy must be taken into account. If X remains fixed inversion is just the transformation

$$k \to k_{inv} = (2 \times k(X) - \Delta k_{inv}) \bmod 12 \ . \tag{6.7.3}$$

Table 6.10 gives the inversion of the scale leaving C (and also $F\sharp$) invariant:

The inversion for the types of the chords does not depend on the basic note as is clear from the distance preserving character of the inversion. **Table 6.11** gives the inversion of for the types of the chords leaving C fixed. The elements of the rows give the type of the chord and the number of quints k corresponding to it. For chords having C as basic note one has $k = 0$. It is easy to deduce the transformation formula in more general case from the table.

The following tables give the chords and corresponding inverse chords for the 11 icosahedral harmonies.

Calculation of incidence matrices

The most stringent definition of harmonic chord progression is as a chord sequence in which two subsequent chords have at least one common note: the distance between subsequent

M, 0	m, 0	sus4, 0	aug, 0	4, 0	9, 0	4+, 0	9-, 0	6-, 0	maj7, 0
m, 11	M, 11	sus, 0	aug, 0	4, 0	9, 10	9-, 11	4+, 11	maj7, 11	6-, 11

6, 0	7, 0	ex1, 0	ex2, 0	ex3, 0	ex4, 0	ex5, 0	ex6, 0	ex7, 0	ex8, 0
7, 11	6, 11	ex1, 10	ex3, 3	ex2, 3	ex4, 8	ex6, 8	ex5, 80	ex8, 6	ex7, 6

Table 6.11: Table gives the transformation of inversion leaving C invariant on the basic chords having C as basic note.

ro6	iro6	re41	ire41	re42	ire42	ro21	iro21
F.aug	F.aug	D.7	A.6	C.ex3	A.ex2	E.m	F.M
G.aug	D+.aug	D.6	A.7	E.ex2	F.ex3	B-.m	B.M
C.m	F.M	G+.7	D+.6	F+.ex3	D+.ex2	C.m	A.M
D.m	D+.M	G+.6	D+.7	B-.ex2	B.ex3	F+.m	D+.M
E.m	C+.M	G.4+	E.9-	D.maj7	B.6-	G.6	D.7
F+.m	B.M	A.9-	D.4+	E.9-	A.4+	C+.6	G+.7
G+.m	A.M	C+.4+	B-.9-	A.7	E.6	A.6	C.7
B-.m	G.M	D+.9-	G+.4+	A.6	E.7	D+.6	F+.7
F.6	C.7	E.maj7	G.6-	G+.maj7	F.6-	D.4+	G.9-
G.6	B-.7	G.maj7	E.6-	B-.9-	D+.4+	G+.4+	C+.9-
A.6	G+.7	B-.maj7	C+.6-	D+.7	B-.6	B.4+	B-.9-
B.6	F+.7	C+.maj7	B-.6-	D+.6	B-.7	F.4+	E.9-
C+.6	E.7	C.9-	B.4+	F.9	D+.9	C.maj7	A.6-
D+.6	D.7	A.9-	D.4+	C.9	G+.9	F+.maj7	D+.6-
C.9	C.9	F+.9-	F.4+	G.9	C+.9	G.6-	D.maj7
D.9	B-.9	D+.9-	G+.4+	E.9	E.9	C+.6-	G+.maj7
E.9	G+.9	B.9	G.9	B.9	A.9	D.9	D.9
F+.9	F+.9	E.9	D.9	F+.9	D.9	G+.9	G+.9
G+.9	E.9	F.9	C+.9	C+.9	G.9	E.9	C.9
B-.9	D.9	B-.9	G+.9	B-.9	B-.9	B-.9	F+.9

Table 6.12: Pairs "X" and "iX" of columns give the chords of the bio-harmonies and their inversions depicted in figures **??**, **??**, **??**, **??**.

ro22	iro22	ro23	iro23	re21	ir21	re22	ir22
A.ex4	G.ex4	A.ex2	B-.ex3	F+.ex3	D+.ex2	D.ex4	E.ex4
D+.ex2	C.ex3	H.ex8	B-.ex7	H.ex4	B-.ex4	H.ex4	F+.ex4
A.m	B-.M	D+.ex2	E.ex3	A.m	E.M	F.M	E.m
D+.m	E.M	F.ex8	F.ex7	D+.M	B-.m	F.m	E.M
G.9-	C.4+	D.7	A.6	A.6	E.7	C.6-	A.maj7
C+.9-	F+.4+	G+.7	D+.6	D+.7	B-.6	B-.maj7	B.6-
C.4	C.4	A.maj7	D.6-	D.7	B.6	C.9-	A.4+
F+.4	F+.4	D+.maj7	G+.6-	B-.6	D+.7	D.7	G.6
E.4+	D+.9-	A.4+	D.9-	G.6-	F+.maj7	G+.6	C+.7
B-.4+	A.9-	D+.4+	G+.9-	F.maj7	G+.6-	G.maj7	D.6-
D.maj7	F.6-	E.7	G.6	D.4+	B.9-	D+.6-	F+.maj7
G+.maj7	B.6-	B-.7	C+.6	B-.9-	D+.4+	C+.4	C+.4
B.maj7	G+.6-	B-.9	G+.9	G+.4+	F.9-	A.4+	C.9-
F.maj7	D.6-	G.9	B.9	E.9-	A.4+	E.4+	F.9-
C.9	D.9	C+.9	F.9	C.9	G+.9	F+.6	D+.7
F+.9	G+.9	A.9	A.9	F.9	D+.9	D+.9	C+.9
A.9	F.9	B.9	G.9	B.9	A.9	C+.9	D+.9
D+.9	B.9	F.9	C+.9	F+.9	D.9	E.9	C.9
D.9	C.9	E.9	D.9	E.9	E.9	B.9	F.9
G+.9	F+.9	D+.9	D+.9	C+.9	G.9	D+.9	C+.9

Table 6.13: Pairs "X" and "iX" of columns give the chords of the bio-harmonies and their inversions depicted in figures **??**, **??**, **??**, **??**.

re23	ire23	re24	ire24	re25	ire25		
F.ex1	F.ex1	H.ex3	G.ex2	F+.ex2	F.ex3		
D+.ex3	G+.ex2	E.ex7	F+.ex8	F.ex3	F+.ex2		
G+.ex1	D.ex1	D.7	A.6	F.M	B-.m		
A.ex2	D.ex3	G+.6	D+.7	B-.m	F.M		
E.7	B.6	G-.M	B.m	C.7	D+.6		
E.6	B.7	D+.m	G+.M	G+.6	G.7		
A.maj7	F+.6-	F.M	F+.m	A.maj7	F+.6-		
B.9-	E.4+	F.m	F+.M	B.9-	E.4+		
G.M	G+.m	C.6-	B.maj7	E.6	B.7		
C+.m	D.M	B-.maj7	C+.6-	E.7	B.6		
D.7	C+.6	A.9-	D.4+	G.M	G+.m		
F+.6	A.7	C+.4+	B-.9-	C+.m	D.M		
B-.9	C.9	E.7	G.6	D.7	C+.6		
D.9	G+.9	F+.6	F.7	B.6	E.7		
B.9	B.9	C.9	F+.9	D+.9	G.9		
C.9	B-.9	D+.9	D+.9	C.9	B-.9		
F.9	F.9	D.9	E.9	C+.9	A.9		
G+.9	D.9	C+.9	F.9	B-.9	C.9		
D+.9	G.9	E.9	D.9	D.9	G+.9		
C+.9	A.9	B.9	G.9	H.9	B-.9		

Table 6.14: Pairs "X" and "iX" of columns give the chords of the bio-harmonies and their inversions depicted in figures **??**, **??**, **??**.

chords defined as the minimal distance between triangles representing them vanishes. Some general comments are in order.

(a) Incidence matrices can be computed by using expressions of chords as sets of three notes (possible in Python) and just counting the number of common notes defining the value of the element of the incidence matrix. The quint distance between the chords vanishes if they have common notes. More general incidence matrices would correspond to a larger quint distance.

(b) In the case of genetic code and amino-acids one Hamilton cycle from each class labelled by Z_n, $n \in \{6, 4, 2\}$ is involved.

    i. There are $N = 1 \times 3 \times 8 = 24$ cycle combinations if one does not allow the inverse harmonies. Allowing them gives $N = 8 \times 24$ combinations. If transitions between all representations are possible, there are $M = N^2$ 20×20-dimensional incidence matrices to be calculated for the icosahedral restriction of the code. Incidence matrices are symmetric so that only $D(D+1)/2 = 20(20+1)/2 = 210$ independent matrix elements need to be calculated for given 20×20-D incidence matrix.

    ii. Equivalently, one can calculate the incidence matrix for a space with $N \times 20$ points which is Cartesian product of N amino-acid spaces with 20 points. N has values 24 and 8×24. Remarkably, the magic number 24 of also stringy mathematics appears.

    iii. If the transitions can be restricted to single triplet of cycles, one must calculate 6 20×20-dimensional incidence matrices. This situation could be realistic for portions of the genetic code if the transitions between different cycle triplets are analogous to phase transitions. The number of incidence matrices (one can also use single 60×60 incidence matrix) is still reasonably small and can be documented in written form. In a model for random chord sequences one must specify the probabilities for the transitions between chords with different n for Z_n. Simplest starting point assumption is that the probabilities are identical.

(c) For the extended genetic code the most natural assumption is that the extension of the code to icosa-tetrahedral code take places place only in Z_2 sector meaning the extension of amino-acid space by 4 amino-acids and the increase of the number of DNA codons from 60 to 64. There are two kinds of transitions between icosahedral and tetrahedral codons. Tetrahedral codon can correspond to a codon, which is outside the icosahedron

having at least one common vertex with the icosahedral codon: this allows 3+3 transitions. Tetrahedral codon can correspond also to punct. Unless the codon/amino-acid contains at least one of these notes, it cannot precede stopping codon. These chords extend the harmony by the counterparts of CM and Am and punct corresponds to $C6 = CGA$.

(d) Also the situation in which tetrahedral and icosahedral codes are disjoint must be considered. In this case there are no transitions between tetrahedral and icosahedral sectors. In tetrahedral sector the distances between faces always vanish so that the calculation of this part of the incidence matrix is trivial. Icosa-tetrahedral part of the incidence matrix can be readily written. The difficult part of the calculation of incidence matrices reduces to that for the icosahedral case such that the common face corresponds to either punct or Sec/Pyl. This gives selection rules telling which codons/amino-acids can precede stopping codon/punct in given bio-harmony.

Simulation of harmonic DNA sequence

The following sequence represents a random harmonic sequence based on zero quint distance between neighboring chords (at least one common note). The harmony if combination 3 harmonies **??**, **??**, and **??** extended by adding chords $B\flat$, Gm and $G7$ and associated $B\flat 6$ representing stopping codon and punct in tetra- icosahedral codeandSec or Pyl in their unfused variants. These three harmonies correspond to groups of 20, 20, and 24 DNA codons at orbits of Z_6, Z_4, and Z_2 which is now taken to be Z_2^{refl}. To deduce DNA sequence one must assume detailed correspondence between the codons at the orbits and corresponding chords.

It is assumed that all transitions between neighboring DNAs occurs with the same probability and induce the transitions between amino-acids.

```
Faug, A6,  Dm,  G6,  G6,  G6,  Em,  G6,  Cm,  G6,  F6,  Faug, F+m, Dm,  G6,  G6,
Gaug, G+m, Cm,  F6,  Dm,  Dm,  F+m, Dm,  F6,  F6,  B-m, C+6, B-m, F6,  Dm,  G6,
G6,  G6,  Gaug, G+m, Cm,  Gaug, G6, Dm,  B-m, F6,  Faug, A6,  G6,  Gaug, G+m,
Cm,  F6,  Faug, F6,  Cm,  F6,  G6,  Gaug, Gaug, B6, Gaug, G6,  Gaug, Em,  Gaug,
Em,  A6,  F+m, B-m, F6,  Cm,  Gaug, Em,  A6,  Faug, B-m, B-m, Faug, F6,  G6,
G6,  F6,  Faug, F6,  Dm,  G6,  F6,  Dm,  F+m, Dm,  F+m, A6,  Faug, F6,  Faug, Dm,
Dm,  B-m, B-m, C+6, C+6, G+m, B6,  A6,  F+m, Faug, B-m, Dm,  B-m, C+6, B-m,
F+m, B6,  Gaug, Cm,  G+m, Cm,  F6,  F6,  B-m, Dm,  F6,  F6,  G6,  Dm,  G6,  G6,  Em,
A6,  G6,  Cm,  Cm,  G+m, B6,  G+m, C+6, C+6, C+6, Faug, B-m, Dm,  Dm,  G6,  Cm,
Gaug, Cm,  F6,  Cm,  G6,  Gaug, G6, F6,  Dm,  F6,  Faug, Faug, Faug, A6,  Em,
Em,  G6,  Dm,  Faug, F6,  B-m, F6,  Cm,  F6,  B-m, F+m, Dm,  G6,  F6,  F6,  Cm,  Cm,
Em,  G+m, Em,  A6,  Em,  A6,  F+m, B-m, B-m, B-m, F+m, B6,  A6,  Em,  G+m, B6,
B6,  Em,  G6,  Dm,  B-m, Dm,  Dm,  B-m, Dm,  Faug, Faug, F6,  Cm,  G6,  Gaug, B6,
G+m, Em,  G6,  G6,  Dm,  Faug, Faug, F6, Cm,  Gaug, G+m, Gaug, B6,  F+m, A6,
G6,  Em,  Cm,  F6,  Dm,  Dm,  Dm,  G6,  Em,  Em,  A6,  Em,  Gaug, Em,  Cm,  Cm,  Gaug,
G6,  G6,  Cm,  F6,  Dm,  Faug, A6,  Faug, A6,  Faug, F+m, F+m, B-m, C+6, G+m,
Em,  Gaug, G6,  Gaug, G6,  G6,  Dm,  G6,  Dm,  Dm,  F6,  B-m, F6,  G6,  Cm,  G+m,
Em,  G+m, B6,  G+m, Cm,  Cm,  F6,  Faug, Faug, Faug, F6, Dm,  G6,  Dm,  F+m,
Faug, Faug, B-m, C+6, G+m, C+6, Faug, F+m, B-m, Faug, Faug, A6,  G6,  Em,
Cm,  F6,  G6,  Cm.
```

Illustrations of icosahedral Hamiltonian cycles with symmetries

The figures below illustrate the Hamiltonian cycles involved. Quite generally, the Z_n symmetry acts by a shift by $12/n$ quints along the cycle and the orbits of chords consist of at most n chords of same type as the reader is encouraged to verify.
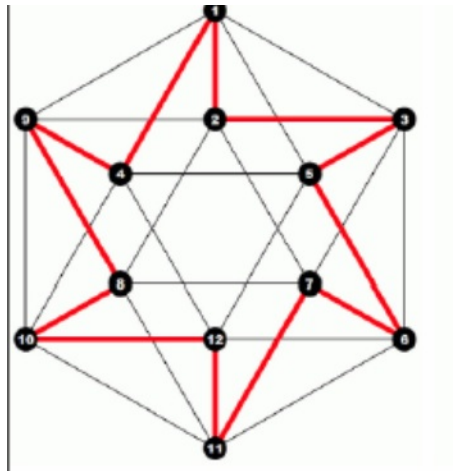
Figure 6.4: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 6-fold rotation symmetry acting shifts generated by a shift of 2 quints.
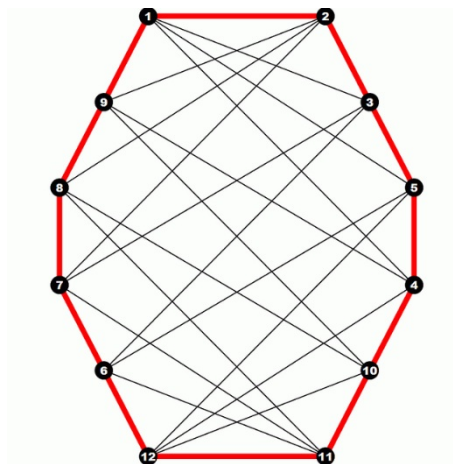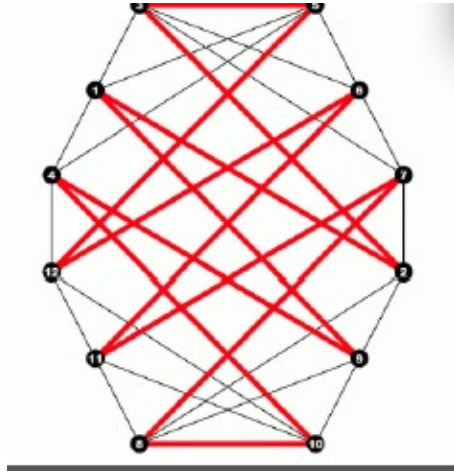

Figure 6.5: $(n_0, n_1, n_2) = (0, 16, 4)$ Hamiltonian cycle with 4 reflection symmetries generated by reflections in vertical and horizontal directions.

## 6.8 What could be the physical origin of Pythagorean scale?

I was contacted for a couple years ago by Hans Geesink and we had long discussions about consciousness and quantum biology. The discussion stimulated new ideas and this inspired me to write a chapter and article comparing our approaches (see `http://tinyurl.com/lwxdl7y`). Now Hans sent me two prepublications by him and D. K. F. Meijer.

The first preprint "Bio-Soliton Model that predicts Non-Thermal Electromagnetic Radiation Frequency Bands, that either Stabilize or Destabilize Life Conditions" is in arXiv [I45] (see `http://tinyurl.com/zz3ew33`). The abstract reads as:

Solitons, as self-reinforcing solitary waves, interact with complex biological phenomena such as cellular self-organisation. Soliton models are able to describe a spectrum of electromagnetism modalities that can be applied to understand the physical principles of biological ef-

Figure 6.6: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 4 reflection symmetries.
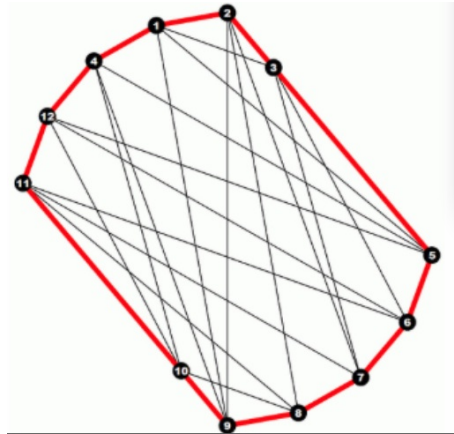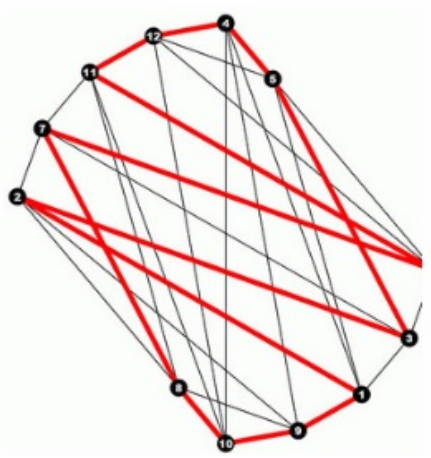

Figure 6.7: $(n_0, n_1, n_2) = (0, 16, 4)$ Hamiltonian cycle with 2-fold rotational symmetry realized as 6-quint shift along the cycle.

fects in living cells, as caused by electromagnetic radiation. A bio-soliton model is proposed, that enables to predict which eigen-frequencies of non-thermal electromagnetic waves are life-sustaining and which are, in contrast, detrimental for living cells. The particular effects are exerted by a range of electromagnetic wave frequencies of one-tenth of a Hertz till Peta Hertz, that show a pattern of twelve bands, if positioned on an acoustic frequency scale. The model was substantiated by a meta-analysis of 240 published papers of biological radiation experiments, in which a spectrum of non-thermal electromagnetic waves were exposed to living cells and intact organisms.

These data support the concept of coherent quantized electromagnetic states in living organisms and the theories of Davydov, Fröhlich and Pang. A spin-off strategy from our study is discussed in order to design bio-compatibility promoting semi-conducting materials and to counteract potential detrimental effects due to specific types of electromagnetic radiation produced by man-made electromagnetic technologies.

Second preprint "Phonon Guided Biology: Architecture of Life and Conscious Perception are mediated by Toroidal Coupling of Phonon, Photon and Electron Information Fluxes at Eigen-frequencies" is in Research Gate [I46] (see `http://tinyurl.com/j9rsyqd`). The

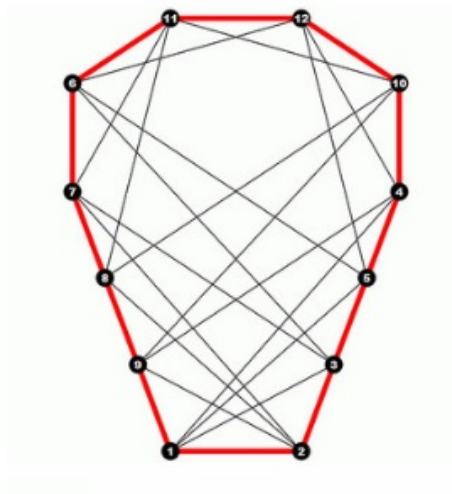**Figure 6.8:** $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold rotation symmetry.
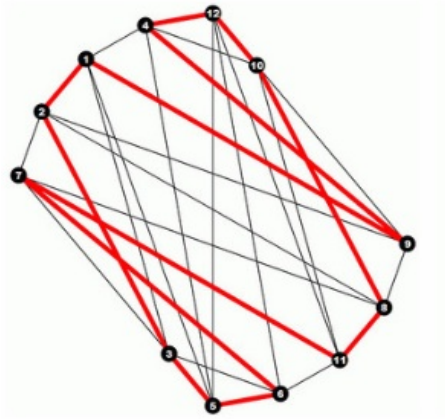
Figure 6.9: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold rotation symmetry.

abstract is following.

Recently a novel biological principle, revealing discrete life sustaining electromagnetic (EM) frequencies, was presented and shown to match with a range of frequencies emitted by clay-minerals as a candidate to catalyze RNA synthesis. The spectrum of frequency bands indicate that nature employs discrete eigen-frequencies that match with an acoustic reference scale, with frequency ratios of 1:2, and closely approximated by 2:3, 3:4, 3:5, 4:5 and higher partials. The present study shows that these patterns strikingly resemble eigen-frequencies of sound induced geometric patterns of the membrane vibration experiments of E. Chladni (1787), and matches with the mathematical calculations of W. Ritz (1909).

We postulate that the spectrum of EM frequencies detected, exert a phonon guided ordering effect on life cells, on the basis of induction of geometric wave patterns. In our brain a toroidal integration of phonon, photon and electron fluxes may guide information messengers such as Ca^{2+}-ions to induce coherent oscillations in cellular macromolecules. The integration of such multiple informational processes is proposed to be organized in a fractal 4-D toroidal geometry, that is proposed to be instrumental in conscious perception. Our finding of an "acoustic life principle" may reflect an aspect of the implicate order, as postulated by David Bohm.

Figure 6.10: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry realized as horizontal reflection
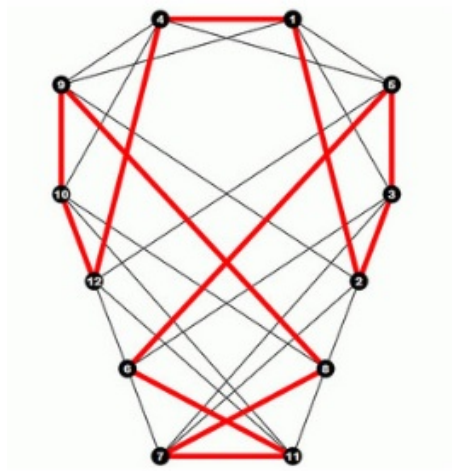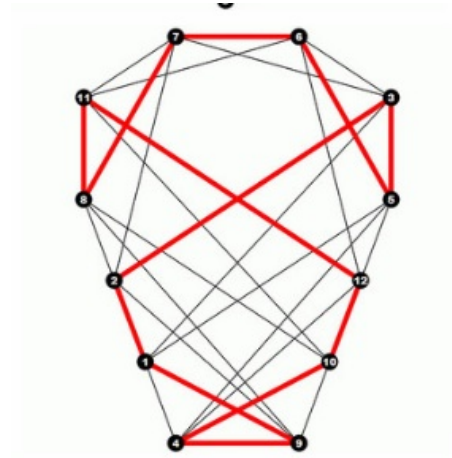

Figure 6.11: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.

A very concice and very partial summary about the articles would be following.

(a) 12-note scale seems to be realized in good approximation as frequency bands (rather than single frequencies) for a membrane like system with the geometry of square obeying four-order partical differential equation studied numerically by Ritz. Since the boundary conditions are periodic this system has effective torus topology. This is rather remarkable experimental fact and extremely interesting from TGD point of view.

(b) The papers also argue that also the octave hierarchy is realized. p-Adic length scale hierarchy indeed predicts that subset of powers of 2, and more generally of $\sqrt{2}$ defines a hierarchy of fundamental p-adic scales with p-adic prime p near to power of two.

In the following I will discuss first the condensed matter realization of 12-note scale and after that considder the significance and realization of 12-note scale from TGD point of view.

Figure 6.12: $(n_0, n_1, n_2) = (4, 8, 8)$ Hamiltonian cycle with 2-fold reflection symmetry.
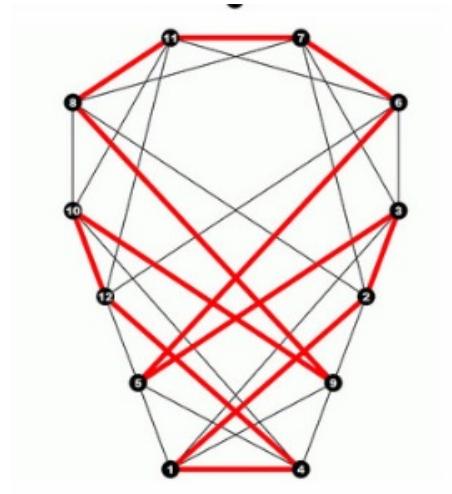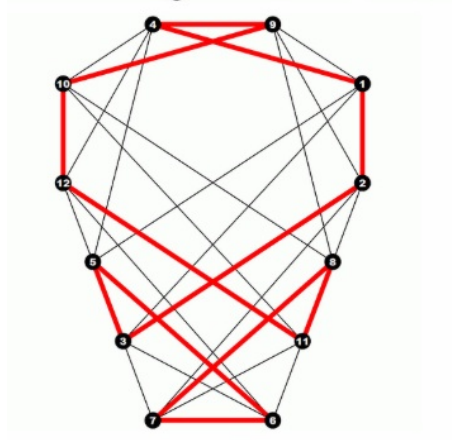

Figure 6.13: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.

6.8.1 Condensed matter realization of 12-note scale in terms of oscillations of square plate

The article discusses a condensed matter physics based realization of 12-note. Acoustic waves are seen as fundamental. Certainly the sound waves are important since they couple to electromagnetic waves. My feeling is however that they provide a secondary realization.

(a) The realization of 12-note system as 12 bands discussed in the articles is as eigen frequencies of deformations of square plate. Periodic boundary conditions imply that one can regard the system also as a torus. One has bands, not eigenfrequencies. I do not know whether one can pick up from bands frequencies, whose ratio to the fundamental would be rational and same as for Pythagorean scale. Since the system can be treated only numerically, it is difficult to answer this question.

(b) So called Chladni patterns (see "An Amazing Resonance Experiment" at `http://tinyurl.com/kcbmrzz`) are associated with vibrating thin square plate and correspond to the node lines of the deformation of the plate in direction orthogonal to the plate. As

Figure 6.14: $(n_0, n_1, n_2) = (2, 12, 6)$ Hamiltonian cycle with 2-fold reflection symmetry.

one adds very small particles at the plate and if the vibrational acceleration is smaller than the gravitational acceleration the particles get to the node lines and form Chladni pattern. Hence the presence of gravitation seems to be essential for the Chladni patterns to occur. These patterns make visible the structure of standing wave eigenmodes of the plate. It is also possible to have patterns assignable to the antinodes at which the deformation is maximum but vibrational acceleration vanishes as in the harmonic oscillator at the maximum value of the amplitude.

(c) The vibrations of square plate obey fourth order partial diff equation for the Chladni pattern having the general form

$$\partial_t^2 u = K(\nabla^2)^2 u \ . \tag{6.8.1}$$

Here u is the small deformation in direction orthonormal to the plate. The equation can be deduced from the theory of elasticity about which I do not know much. For standing wave solutions the time dependence is separable to trigonometric factor $sin(\omega t)$ or $cos(\omega t)$, and one obtains eigenvalue equation

$$K(\nabla^2)^2 u = -\omega^2 u \ . \tag{6.8.2}$$

(d) The natural basis for the modes is as products of 1-D modes $u_m(x)$ for string satisfying $\partial_x^2 u_m = 0$ at the ends of the string ($x = \{-1, 1\}$) this in both x and y directions. This must express the fact that energy and momentum do not flow out at boundaries.
The modes satisfy

$$\frac{d^4 u_m}{dx^4} = k_n^4 u_m \ . \tag{6.8.3}$$

Boundary conditions allow modes with both even and odd parity:

$$u_m = \frac{[cos(k_m)cosh(k_m x) + cosh(k_m)cos(k_n x)]}{cosh^2 k_m + cos^2(k_m)} \ ,$$

$$tan(k_m) + tanh(k_m) = 0 \ , \quad m \text{ even} \ .$$

$$u_m = \frac{[sin(k_m)sinh(k_m x) + sinh(k_m)sin(k_n x))]}{sinh^2 k_m + sin^2(k_m)}$$

$$tan(k_m) - tanh(k_m) = 0 \ , \quad m \text{ odd} \ . \tag{6.8.4}$$

(e) The 2-D modes are not products of 1-D modes but sums of products

$$w_{mn}^{\epsilon} = u_m(x)u_n(y) + \epsilon u_m(y)u_n(x) \ , \quad \epsilon = \pm 1 \ . \tag{6.8.5}$$

Modern physicist would notice classical entanglement between x and y degrees of free-dom. The first $\epsilon = 1$ mode is analogous symmetric two-boson state and second $\epsilon = -1$ mode to antisymmetric two-fermion state.

(f) The variational ansatz of Ritz was superposition of these modes (this variational method was actually discovered by Ritz). Ritz minimized the expectation value of the Hermitian operator $(\nabla^2)^2$ in the ground state and obtained an approximation for the frequencies which holds true with 1 per cent accuracy.

Unfortunately, 4-D geometry does not give rise to this kind of equations: time and space are not in democratic roles. TGD inspired vision would be different. The magnetic flux tubes and even strings could be the fundamental objects concerning biology and consciousness. The acoustic realization of the 12-note scale would be secondary one. Even genetic code would have fundamental realization at the level of dark nuclear physics [L29] and chemical realization of genetic code would be secondary realization.

6.8.2   Why 12-note scale?

Why I am convinced that 12-note scale should be so important?

(a) The mysterious fact about music experience is that frequencies whose ratios come as rationals are somehow special concerning music experience. People with absolute pitch prefer the Pythagorean scale with this property as aesthetically pleasing. Pythagorean scale is obtained by forming the 3^k multiples of fundamental and by dividing by a suitable power 2^m of 2 to get a frequency in the basic octave. This scale appears in TGD inspired model for music harmonies [L12] (see `http://tinyurl.com/yad4tqwl`), which as a byproduct led to a model of genetic code predicting correctly the numbers of DNA codons coding for given amino-acid. The appearance of powers of 2 and 3 suggest 3-adicity and 2-adicity. Furthermore, rationals correspond to the lowest evolutionary level defined by the hierarchy of algebraic extensions of rationals.

This gives excellent reasons to ask whether 12-note scale could be realized as some phys-ical system. One might hope that this system could be somehow universal. Geometric realization in terms of wave equation would be the best that one could have.

(b) The model of harmony is realized in terms of Hamilton cycles assignable to icosahedron and tetrahedron. Hamilton cycles at icosahedron are closed paths going through all 12 points of icosahedron and thus can define a geometric representation of the Pythagorean scale. The rule is that curve connects only nearest points of icosahedron and corresponds to scaling of frequency by 3/2 plus reduction to basic octave by dividing by a suitable power of 2. The triangles of the icosahedron define allowed 20 chords for given harmony and one obtains 256 basic harmonies characterized by the symmetries of the cycle: symmetry group can be cyclic group Z_6, Z_4 or Z_2 or reflection group Z_2 acting on icosahedron.

Bioharmonies are obtained by combining Z_6, Z_4 and Z_2 of either type. One obtains 20+20+20 =60 3-chords defining the bio-harmony. One must add tetrahedral harmony with 4 chords in order to obtain 64 chords. It turns out that it corresponds to genetic code under rather mild assumptions. DNA codons with 3 letters could correspond 3-chords with letter triplets mapped to 3-chords. Amino-acids would correspond to orbits of given codon at icosahedron under one of the symmetry groups involved.

6.8.3   How to realize 12-note scale at fundamental level universally?

How could one realize 12-note scale at the fundamental level - that is in terms of 4-D geometry? The realization should be also universal and its existence should not depend on special properties of physical system. Vibrating strings provide the simplest manner to realize 12-note scale. Harmonics do not however allow its realization. They are in higher octaves and define only the color of the note. There are actually two realizations.

The simplest realization relies on the analogy with piano.

(a) The string of piano corresponds to a magnetic flux tube/associated fermionic string and the frequency of the note would be determined by the length of the flux tube. The quantization for the length as certain rational multiples of p-adic length scale gives rise to the 12-note scale. Tensor network would be like piano with the flux tubes of the network with quantized lengths defining the strings of piano.

(b) Why the length of the flux tube defining the fundamental frequency would correspond to a frequency of Pythagorean scale? Could this be due to the preferred extremal property realizing SH and posing very strong conditions on allowed space-time surface and 3-surfaces at their ends at boundaries of causal diamonds? If so, 12-note scale would be part of fundamental physics!

The rational multiples $f(m,n) = (m/n)f_0$, $m = 0, 1, ..n - 1$, of the fundamental f_0 with $m/n \leq 2$ (single octave) are in a preferred position mathematically since the superpositions of waves with these frequencies can be represented as superpositions of the suitable harmonics of the scaled down fundamental $f_1 = f_0/n$. For Pythagorean scale $m/n = 3^k/2^l$ the new fundamental is some "inverted" octave $f_1 = f_0/2^{kmax}$ of the fundamental and the allowed harmonics are of form $m = 2^r 3^l$.

Second realization would be dynamical and based on the analogy with string instruments.

(a) String instruments allow to realize 12-note scale by varying the length of the vibrating string. The note of scale corresponds to the fundamental frequency for the portion of the shortened string, which is picked. Why the lengths of shortened strings should correspond to inverses of frequencies of 12-note scale? One should have powers of 3 divided by powers of 2 to get a frequency in fundamental octave. Could p-adic length scale hypothesis, which generalizes and length scales coming as powers of square roots of small primes help?

(b) Strings bring in mind magnetic flux tubes connecting partonic 2-surfaces. They behaving in good approximation like strings and are actually accompanied by genuine fermionic strings and corresponding string world sheets. Flux tubes play a fundamental role in living matter in TGD Universe. Flux tubes carrying dark matter identified as large $h_{eff} = n \times h$ phases would serve as space-time correlates for negentropic entanglement and gives rise to tensor nets with partonic 2-surfaces as nodes and flux tubes connecting them [L34]. Could magnetic flux tubes or associated fermionic strings provide the instruments using Pythagorean scale?

Partonic 2-surfaces and string world sheets dictate space-time surface by strong form of holography (SH) implied by strong form of general coordinate invariance. It is quite possible that not all configurations of partonic 2-surfaces and string world sheets allow SH that is realization as space-time surface: perhaps only the flux tubes with length corresponding to Pythagorean scale allow it. For p-adic counterparts of space-time surfaces the possibility of p-adic pseudo-constants (failure of strict determinism of field equations) makes this possible: the interpretation is as imagined p-adic space-time surface which cannot be realized as real space-time surface.

How these flux tubes could behave like strings of guitar? When my finger touching the guitar string it dividing it to two pieces. The analogy for this is the appearance of additional partonic 2-surface between the two existing ones so that one has two flux tubes connecting the original partonic two-surface to the new one. A change of the topology of 3-space would be involved with this stringy music!

More precisely, the flux tubes would be closed if they carry monopole magnetic flux: they would begin from "upper" wormhole throat of wormhole contact A (partonic 2-surface), go along "upper" space-time sheet to the throat of wormhole contact B go the "lower" space-time sheet through it, return to the "lower" throat of wormhole contact A and back to the "upper" throat. Shortening of the string would correspond to a formation of wormhole contact at some point of this flux tube structure splitting the flux tube to two pieces.

(c) Another realization could be in terms of the quantization of the distance between partonic 2-surfaces connected by flux tubes and associated strings in given p-adic length scale, which by p-adic length scale hypothesis would correspond to power of square root of 2 so that also octaves and possibly also half octaves would be obtained (note that half octave corresponds to tritonus, which was regarded by church as an invention of devil!). Also now the justification in terms of SH.

6.8.4 Could Chladni mechanism allow to realize morphogenesis?

Morphogenesis represents one of the basic unsolved problems of biology. Molecular biology and gene hypothesis have not allowed to understand what is involved. The probable reason is that biochemistry is local approach whereas morphogenesis is a non-local phenomenon. There have been attempts to understand morphogenesis using the catastrophe theory of Thom [A1]. Sheldrake has done highly intersting work with morphogenesis too. Robert Merrick's article harmonic theory of evolution (see `http://tinyurl.com/qda946l`) suggests a connection between the notion of harmony as expressed by 12-note scale and morphogenesis.

The basic building bricks of TGD vision about morphogenesis would be following.

(a) Macroscopic quantum coherence is to my view a necessary ingredient of morphogenesis and hierarchy of Planck constants allows to realize it. The notion of magnetic body (MB) is also necessary. MB would guide the morphogenesis. For instance, the replication of living system would be induced by that for MB. The fundamental dynamics takes place at the level of MB and biochemical level is only a shadow of this dynamics. "Topological light rays" ("massless extremals", MEs) is second key element. MB would use MEs to control visible living matter, in particular to guide morphogenesis. The challenge is to understand how MB achieves this.

(b) The notion of harmony assignable to various musical scales realized as Hamiltonian cycles at Platonic solids is central. The TGD based model for harmony [L12] was actually inspired by the book of Merrick's theory of music [?]. The model for harmonies assignable to 12-note scale led to a model for genetic code in terms of so called Hamiltonian cycles on icosahedron and tetra-hedron predicting correctly the numbers of DNA codons coding for given amino-acid and also predicted two additional amino-acids Pyl and Sec appearing in Nature.

(c) The fusion of real physics for sensory experience and various p-adic physics for cognition gives rise to adelic physics. In particular, one can speak about adelic variants of space-time surfaces and he notion of monadic geometry emerges. Geometric objects have discrete "spine" for which points have coordinate values in an algebraic extension of rationals for some preferred coordinate system dictated by the symmetries of the embedding space $M^4 \times CP_2$. Space-time surfaces are also locally continuous and smooth so that classical partial differential equations defining space-time surfaces as preferred extremals of Kähler action or its twistor lift make sense.

Platonic solids represents unique monadic geometries since they correspond to finite discrete subgroups of the 3-D rotation group giving rise to 3-dimensional structures as their geometric representations. Also planar polygons represent this kind of realizations and can be assigned to the inclusion hierarchy of von Neuman algebras knowns hyper-finite factors of type II_1 and very probably also to the analogous fractal hierarchy of sub-algebras of super-symplectic algebra isomorphic to the full algebra.

(d) The discrete points realizing monadic geometries could be accompanied by tensor networks having partonic 2-surfaces as notes connected by magnetic flux tubes serving as correlates for negentropic entanglement between the nodes at their ends would serve give rise to the emergence of proprioception - the experience about 3-space. The flux tubes would be analogous to strings of the music instruments with transverse oscillations defining the fundamental frequencies defining the notes of the scale. Tensor network could be regarded as music instrument having flux tubes as strings.

12-note scale could be by its special mathematical features and by preferred extremal condition fundamental from the point of view of morphogenesis. The lengths of flux tubes are quantized. One can imagine two options. The effective length of given flux tube can be varied as done in guitar or the tensor network would be like piano or harp: the lengths of flux tubes assignable to the tensor network would have quantized lengths coming as rational multiples of fundamental length in such a way that a representation of the 12-note system would be obtained.

The model of music harmony and 12-note scale would be assignable to icosahedron which would aslo define a very natural monadic geometry. This harmony would also related to genetic done. Monadic geometry could in turn emerge naturally in morphogenesis so that genetic code could after all lurk behind morphogonesis but being realized in terms of 3-chords rather than triplets of DNA nucleotides. Morphogenesis could be a realization of genetic code in terms of interfering fields.

How morphogenesis could then be realized in this picture?

(a) Chladni mechanism is a clever trick to make the nodal curves associated with standing waves visible. This mechanism could transcend to a basic mechanism of morphogenesis. The idea is very simple. Biomolecules could end up to the nodal surfaces for a standing waves 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.

(b) The objection is that TGD does not allow single-sheeted realizations of standing waves. 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 trigometric functions - say $sin(\omega t)sin(kz)\epsilon(x)$, $\omega = kc$. The force would vanish at nodal surfaces, which would thus define naturally the shape of a stationary structure defined by molecules.Now these surfaces would be zeros of $sin(kz)$ and $\epsilon(z)$.

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 time dependence and spatial dependence 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 the tensor network, where the flux tubes of MB indeed meet. Fractal structure with tensor networks with nodes of tensor networks can be assumed in TGD framework.

(c) 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.

6.9 Bio-catalysis, morphogenesis by generalized Chladni mechanism, and bio-harmonies

In the following I try to relate 3 different ideas inspired by TGD.

(a) The first idea is that bio-catalysis relies on the notion of magnetic body (MB) carrying
    dark matter: reconnections of U-shaped flux tubes giving rise to super-conducting flux
    tube pairs connecting two systems, and the reduction of their lengths as the value
    of $h_{eff}/h = n$ is reduced play a key role. The reduction of $h_{eff}/h = n$ for dark atom
    liberates also energy associated with hydrogen atom like states at flux tubes with energy
    scaling as $1/h_{eff}^2$. This energy could allow the reactants to overcome the potential wall
    making the otherwise very slow reaction fast [L35].

    This idea emerged from a model for hydrino atoms proposed by Randell Mills [D34]
    having scaled up binding energy spectrum manifesting itself as a radiation band in
    EUV range having no chemical origin. The simplest explanation TGD explanation is
    that the value of $h_{eff}/h = n$ is $n = 6$ for visible matter and that for hydrino like states
    it is $m = 1, 2, 3$. This would predict the scaling of the energy spectrum by $(n/m)^2$ and
    its occurrence would liberate the excess binding energy to be used by reacting molecules.

(b) Second idea is that generalized Chladni mechanism [L37] is behind morphogenesis and
    therefore very probably involved also with catalysis. Charged particles and even charged
    flux tubes would end up to the nodal surface of electric field to form biological structures.
    One could speak about dynamics of avoidance and the particles ending up to potential
    minima provide one example of this dynamics.

    In fact, there are strong mathematical and physical reasons to argue that the dynamics of
    space-time surface is dynamics of avoidance [L31]. The preferred extremals for the sum
    of Kähler action and volume term are extremals of both so that one can say that force
    density defined by Kähler action vanishes and the motion corresponds to a generalization
    of geodesic line to 4-D minimal surface.

(c) The third idea is that genetic code is realized as 3-chords of what I call bio-harmony
    and represented as dark photon triplets and "massless extremals" (MEs) or "topological
    light rays" [L12]. This gives also rise to a realization as sounds since living matter
    consists of electrets transforming light to sound and vice versa. The question is whether
    the sequence of 3-chords representing gene could provide a basic realization of Chladni
    mechanism so that morphogenesis could be regarded as "music of blood" (Greg Bear
    has written a fascinating scifi book with this title).

6.9.1 Catalysis and morphogenesis

I have ended up to a rather general mechanism of catalysis in terms of generalized Chladni
mechanism [L37]. The idea is that one has superposition of say em waves and charged
particles enter to the surfaces at which electric force vanish. If magnetic forces is parallel
to the surface, they state at the surface. If the interfering waves have same frequency the
situation is stationary. Also slowly varying frequency can be allowed if the frequency is small
as compared to the time scale of the re-organization of charged particles to the nodal surface
of electric field.

In TGD framework the superposition of fields is replaced with superposition of corresponding
classical forces on charged particles. MEs are carriers of the counterparts of classical fields
and one can have analogs of standing waves as MEs carrying the analog of plane wave having
fixed frequency. Charged particle in region of $H = M^4 \times CP_2$ containing disjoint union of
MEs of this kind touches all MEs and experiences the sum of the forces created by the fields
at MEs. Charged particles could be also replaced by magnetic flux tubes carrying charge
particles. Using pairs of MEs for which waves propagate in opposite directions one obtains
effective standing waves and one can form disjoint unions of these pairs in the same many to
obtain more complex nodal surfaces.

Biochemical reactions are central for morphogenesis at molecular level. The general TGD based vision is that MB containing dark matter controls biochemistry. This would explain why biochemical reactions can occur coherently in the scale of cell or even longer scales. One can even ask whether the fundamental dynamics is that of MBs and MEs representing TGD counterparts of radiation fields and whether MB in 4-D sense serves as a template for the biochemical self-organization patterns. The question is whether the generalized Chladni mechanism for MEs [K108] could play a role in bio-catalysis.

Conditions on 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.

What catalysis demands?

(a) 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.

(b) 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 [D34] suggests a solution [L35]. 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.

(c) 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.

(d) 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.

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 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→ 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.

6.9.2   The notion of bio-harmony and morphogenesis as music

For few years ago I constructed a model for harmony in music [L12] [K79]. The idea was
that Pythagorean 12-note scale is represented as closed non-self-intersecting curve at icosa-
hedron having 12 vertices and 20 face triangles with subsequent points of curve being nearest
neighbors such that the frequencies for them differ by a scaling factor 3/2. This gives slightly
more than 7 octaves giving rise to the discrepancy already well-known for Pythagoras. The
frequencies were projected to the basic octave by octave equivalence to get 12-note scale.

These closed curves at icosahedron related by icosahedral symmetry are equivalent and one
obtains finite number of non-equivalent curves known as Hamiltonian cycles. Only cycles
having symmetries were considered. Each would define a harmony with 20 basic 3-chords
assignable to the triangular faces of icosahedron. Hamiltonian cycles are classified by their
symmetries: symmetry group can be maximal Z_6, Z_4, or Z_2 which can correspond to π
rotation or reflection.

The connection with genetic code came as a total surprise.

(a) Icosahedron has 20 faces and this led to the question whether they could correspond to
the 20 amino-acids. The observation was that 60=20+20+20 DNAs could be interpreted
in terms of icosahedral harmonies corresponding to 3 Hamiltonian cycles with symmetry
groups Z_6, Z_4 and Z_2. This gives 256 different bio-harmonies.

(b) What about missing 4 DNAs? There are also two amino-acids (Pyl and Sec), which are
appear in Nature and are coded by a variant of genetic code. Should one add tetrahedron
in order to obtain the additional codons and amino-acids and two variants of the code.
Also the failure to obtain exactly 7 octaves can be used to argue that one must add

tetrahedron as glued to one side of icosahedron. This would give one additional note corresponding to the note going slightly out of the octave scale. The outcome is indeed two slightly different variants of the genetic code. What is so remarkable that the model predicts correctly the numbers of codons coding for a given amino-acid.

How to realize bioharmonies?

(a) The proposal was that genetic code is realized as sequences of 3-chords represented in terms of dark photons with frequency ratios determined by the given bio-harmony. Since dark photons can transform to ordinary photons identified as bio-photons, also interaction with visible matter would be possible. The transformation to ordinary sounds is also possible that the connection with music would be very concrete.

(b) The dark photons would couple to dark variants of genes proposed to be realized as dark proton sequences [L29]. Remarkably, also this realization of the genetic code predicts the numbers of codons coding for a given amino-acid correctly. If the notes of the 12-note scale correspond to the cyclotron frequencies assignable to the dark protons, the two realizations would be connected. For dark proton the cyclotron frequency in the endogenous magnetic field of .2 Gauss is 300 Hz so that the "music of blood" would be in the same frequency range as ordinary music. The notes of the scale would correspond to a spectrum of magnetic field strengths as indeed assumed for bio-photons. Large value of $h_{eff} = h_{gr}$ would guarantee that energies are in the range of bio-photon energies and are biologically effective.

(c) Musical harmonies would be central in biology and the essence of what it is to be living. The functioning organism is very literally like an orchestra. Various disorders would be analogous to dissonances. There are 256 different harmonies and same DNA sequence could correspond to any of these harmonies. Music is expression of emotions and generates emotions. The natural proposal is that these harmonies provide the molecular realization of emotions and basic building bricks of also our our emotions.

(d) This would give rise to a kind of resonance based communication and control system used by MB. For instance, the translation of mRNA sequence to amino-acid sequence would be like playing a piece of music. tRNAs attaching to given mRNA codon would correspond to the same 3-chord. Also amino-acids would correspond to dark DNA codons (dark protons in various states) and corresponding cyclotron frequencies.

This picture provides a different view about genetics. The reductionistic interpretation is that given gene corresponds to a given trait and enormous amount of work is done to deduce correlations between traits and genes. This picture has been challenged. It seems that the reductionism to single gene level simply does not make sense. If it would, it should be possible to predict given trait given gene corresponds: this kind of formula is extremely unfeasible. One must consider the entire genome.

The ability of the collection of genomes to play together to produce music of life would be essential. Disorders would be deviations from harmony and would be also caused by genetic mutations. Already earlier I ended up to a generalization of the notion of genome inspired by the notion of MB. The flux sheets of the MB would go through the DNA and could integrate the genomes of different cells to single coherent whole. One would have hierarchy: coherent gene expression in the scale of organism and even entire population would become possible using collective genome controlled by MB would become possible.

Here a connection with TGD inspired model of morphogenesis [L37] suggests itself strongly. Topological light rays (NEs) are correlates for communications between MB and biological body involving control by MB and sensory input from biological body and EEG is one example ab out these communications.

This inspires a model of morphogenesis based on generalized Chladni mechanism meaning that charged particles or even charged magnetic flux tubes are driven to the nodal surfaces of electric fields representing standing waves. The standing wave are represented as pairs of MEs with opposite direction of momentum (analogs of planewaves). The charged article experiences the sum of the forces assignable to various fields at various space-time sheets so

that effectively the fields superpose. Nodal surfaces would correspond to nodal surfaces of this effective field.

The 3-chord sequences could play a crucial in morphogenesis and morphostasis. Since the frequencies of the chord are in general different, the fields representing the members of the code cannot define static nodal surfaces. Hence given 3-chord could define a region of 3-space as union of 3 nodal surfaces. In the case of DNA they would correspond to the 3 letters of the codon. Note that dark codons themselves correspond to the states of dark proton mapped to frequency triplets and do not allow this kind of decomposition.

6.9.3 About Chladni mechanism, bio-harmonies, and genetic code for morphology

I have proposed that generalized Chladni mechanism plays a key role in morphogenesis and morphostasis [L37]. Since the nodal surfaces of field patterns define the shape of structures one can wonder whether Chladni mechanism realizes on 3-chords of bio-harmonies. Could morphogenesis express the music based on bioharmonies? On can consider this idea in more detail.

(a) Single ME allows only waves propagating with light velocity and standing waves are impossible. For a pair of MEs carrying analogs of plane waves with opposite spatial directions and same frequency, the nodes at which the em force experienced by charge particle vanishes, correspond to the vanishing of $sin(\omega t)sin(kz)$ at $z = n\pi/k$. Cladni surface is 1-D lattice formed by 2-D cross sections of ME.

(b) A region of M^4, where several ME pairs with the same frequency have a non-empty projection, represents an analog of hologram. Now the nodal surfaces correspond to the vanishing of the sum for the electric fields associated with MEs. For single ME there is one condition to be satisfied but for several (at least two) MEs meeting at same region of plane there are two conditions and they allow as a solution 1-D surface in the region where MEs meet. For more than 2 ME pairs, which are not in plane, the nodal surface consists of points.

If MEs are parallel with magnetic flux tubes the charged particles represented as wormhole contacts connecting ME and flux tube goes to the nodes $z = n\pi/k$. If there are 3 MEs (not in plane) for which the intersection or M^4 projections corresponds to a nodal surface of each then the nodal surface for all of them consists of single point in the intersection.

The localization to single point might be too strong a condition. Rather, 1-D localization of charges inside flux tubes form a network of flux tubes with nodes at the nodes for all flux tubes that meet might be enough. In this case the frequencies assignable to the flux tubes need not be identical. TGD based model for musical harmony relying on icosahedral and tetrahedral geometries leads also to model for genetic code and suggests strongly the realization of genetic code in terms of 3-chords. The notes of the chord would correspond to 3 different nodal surfaces assignable to DNA nucleotides for instance.

(c) With motivations coming from biology I have proposed that magnetic flux tubes and MEs parallel to them form lattice like structures with MEs and flux tubes defining the coordinate lines of a coordinate grid. For plane wave MEs with same frequency in these directions the nodal points are at the nodes of the grid and one obtains a lattice like structure. Also icosahedral quasicrystals can be considered.

There are good reasons to expect that also curvilinear MEs with the directions of wave vector and polarization vector depending on the position along ME. This would allow also quasi-lattices, which could be important in biology. Chladni mechanism for these structures could allow to catalyze chemical reaction in the nodes of the lattice and achieve the mysterious looking large scale coherence of biochemical reactions. Quasi-lattice could correspond also to the tissue formed by cells, to lipid layer of cell membrane, or to DNA or protein as 1-D lattice.

Consider now the possible connection between genetic code and the geometry of the 3-D lattice like structure.

(a) I have also proposed that through each DNA codon there goes 3 approximately orthogonal flux tubes - one tube per nucleotide - connecting it to some other molecules. One flux tube would be roughly parallel to DNA and two orthogonal to it. The molecules associated with the nodes could be other DNA nucleotides. There are many options to consider. The nucleotide of second DNA strand and the corresponding nucleotide in the DNA of second cell can be considered. The genomes of different cells could form a 3-D lattice with lattice points represented by DNAs and flux tube connections between corresponding DNA codon. The model for DNA-cell membrane system as topological quantum computer [K2] leads to ask whether DNA codons not involved with the coding of proteins could be connected with lipids of the lipid layer and define braids essential for topological quantum computation. Now the flux tube pair could be also associated with entire codon.

Could the number 3 for DNA nucleotides correspond to the dimension of the quasi-lattice involved? Could the flux tubes in three approximately orthogonal directions go through the three nucleotides and connect them to the corresponding DNA nucleotide in another cell? Could this correspondence preserve the linear order or can one imagine braiding but requiring that nucleotide is connected to its conjugate always as in DNA double strand?

This correspondence would give a profound geometric meaning for the number of letters of DNA codon. Only 1-D localization at the vertices of the flux tube is possible. The orientation of molecules entering to the node along 3 flux tubes (also essential for the catalyst action) could be interpreted as catalyst and the orientation of the catalyst and reacting molecules could be determined to a high degree by the interaction with em fields of the flux tube.

(b) The lattice constants for the flux tubes connecting nucleotides in different cells should be same but in the simplest picture they would be given by $d_i = a_i = c/\omega_i$. One should require $d = n_i a_i = n_i c/\omega_i$. If the frequencies are in rational ratios as for Pythagorean scale the integers can be chosen in this manner. The number n_i of nodes along ME between different cells proportional to ω_i would code for the frequency geometrically. The special emotional role of Pythagorean scale could reduce to a geometric condition, whose failure would tend to deform DNA!

(c) The possibility to have different frequencies for different flux tubes and the fact that the lattice constant defined by the wavelength is given by $a_i = n_i c/\omega$ means that the DNAs of different cells form an orchestra with music consisting of dark photons possibly being able to transform to dark phonons by piezo-electricity. The frequency scale should correspond to the inverse of the cellular distance. It is to be expected that also shorter scales corresponding to UV frequencies in bio-photon spectrum are involved.

To sum up, this picture would mean a long sought for direct connection between genes and the morphology of organism determined by the quasi-lattice like structure.

6.10   Logic, Fermions, And Language

The state basis for the fermionic Fock space has a natural interpretation as a Boolean algebra (fermion number =1/0↔ yes/no). In this manner ordinary Boolean algebra is extended to vector space spanned by fermionic states. When cognitive fermion pairs are used instead of fermions, fermion number conservation does not pose any constraints and full linear super-position of the Boolean algebra elements is possible. An interesting question is whether one could consider ordinary Boolean logic as some kind of limit for the complex quantum logic.

The simplest TGD based model for thinking systems leads to the result that thoughts correspond to quantum states in discrete spaces. The reason is that slightly non-deterministic

classical time evolution means a finite number of multi-furcations. These additional dynamical degrees of freedom correspond to N-element set labeling the different time evolutions associated with given initial values. This suggests that a suitably defined *binary* Hilbert space having Z_2 rather than complex numbers as a coefficient field could provide a simple quantum model for a thinking system. This raises the following question.

What would a quantum field theory in discrete space and with the field of complex numbers replaced with binary numbers Z_2 (0, 1/Yes, No) look like?

The answer is following.

(a) The state basis of the quantum field theory defined in N-element set is nothing but a Boolean algebra consisting of 2^N elements: all possible statements about the N elements interpreted as propositions! Bosons and fermions are one and the same thing and behave like fermions since occupation number can have only the values 0 and 1.

(b) The requirement that triangle equality for the inner product is satisfied, does not allow linear superposition and one must choose some orthogonal basis for the space. The absence of quantum superposition means that theory is completely classical. Thus it seems that Boolean QFT is completely classical and the transition from classical mechanics to quantum theory could be regarded as a transition from binary QFT to complex QFT or from a binary logic to complex logic.

(c) Quantization means construction of statements about statements: the simplest model for an abstraction process one can imagine! One can of course continue this quantization: second, third, etc., quantization is possible and this corresponds to a construction of statements about statements about..... Hence a direct connection with the ideas about genetic code emerges.

(d) Also the state basis in the Fock space of the ordinary fermions has interpretation as a Boolean algebra, all possible statements about some propositions (particle with a definite spin component is at point x).

6.10.1 The State Basis Of Fermionic Fock Space As Boolean Algebra

The state basis of a fermionic Fock space can be interpreted as a basis of a Boolean algebra. In quantum TGD all elementary particles are constructed using fermionic oscillators operators. This suggests that entire quantum field theory is actually a representation of Boolean algebra and N-fermion states have interpretation as statements about basic propositions labeled by the indices labeling fermionic oscillator operators. In particular, WCW spinor structure is constructed in terms of the fermionic oscillator operators for the second quantized spinor fields on space-time and this suggests a deep connection between spinor geometry and logic. Perhaps one could say that quantum logic is C-valued in the sense that all complex superpositions of a statement and its negation are possible.

In Boolean algebra one can select the maximum number of 2^{N-1} of statements consistent with given atomic statement (one bit fixed) as axioms. An interesting possibility is that only these statements are physically realized so that the number of states is reduced by a factor of one half. Amusingly, in the ordinary fermionic field theory the states created by a finite number of oscillator operators are the counterparts of the statements consistent with given atomic statement, their negations would correspond to a vacuum state obtained as an infinite product of all creation operators annihilated by creation operators. The states created by annihilation operators from this states are not allowed in QFT since they would have infinite energy.

One can identify the complex valued linear space of fermions as a generalization of Boolean algebra to complex Hilbert space. Cognitive fermion pairs could provide realization for this space as pairs of fermion and anti-fermion belonging to different space-time sheets and representing logical statement and its negation: the automatic presence of negation is rather

natural from the point of view of consciousness theory. The splitting of the wormhole contacts connecting the space-time sheets gives rise to annihilation process generating fermion and anti-fermion pair (fermionic quantum numbers reside on the boundary components of the split wormhole contact). In this manner one avoids problems related to fermion number conservation encountered otherwise in physical realization of the fermionic logic. Alternative possibility is to assume fixed number of fermions and associate truth values with the direction of spin.

6.10.2   Boolean Algebra As Boolean QFT

Boolean algebra $B(N)$ is generated by all possible yes/no statements about N propositions. It consists of sequences of N binary digits of form $(..., 1, 0, 0, .., 1)$ having value of 0 or 1. Addition is with respect to Z_2 so that $1 + 1 = 0$. Boolean algebra is Z_2 linear space and the elementwise multiplication of the binary digits in the string makes it algebra. $(0, 0, 0, ..)$ and $(1, 1, ...,)$ are zero and unit elements of the algebra.

Geometrically Boolean algebra $B(N)$ corresponds to all possible subsets of an N-element set. Sum corresponds to a symmetric difference (take the union of sets and throw away the common elements). Multiplication corresponds to the intersection of the sets. Entire set represents unit element and empty set zero. Empty set is not physically realizable, or equivalently, the zero element of the Boolean algebra does not correspond to a physical state in the Z_2 Hilbert space defined by the Boolean algebra.

Quantum field theory in N-element set formed by the basic propositions (analogous to 3-space in QFT) means associating to each element of the N-element set creation and annihilation operators and postulating standard commutation relations with them:

$$[a^\dagger(i), a(j)] = 1 \ .$$

One can also consider fermions that is anti-commutation relations but since -1=1 in Boolean algebra, they are equivalent with the bosonic commutation relations so that Boolean bosons and fermions are one and the same thing in the Boolean QFT.

The states of this QFT are constructed in the usual manner. The only difference is the occupation numbers are Z_2 valued and are either one or zero just as in the case of fermions. Thus Boolean particles are fermions always. Since N creation operators are involved one obtains a space generated by 2^N states. The proposition and its negation correspond to the states created by, say I oscillator operators and the dual of this state created by the remaining $N - I$ oscillators operators. Statement corresponds to I particles and its negation to I holes in the dual ground state containing all N oscillator operators.

Thus the state basis is nothing but the Boolean algebra associated with the N element set! Thus the state basis of Z_2 valued quantum field theory in the set of N propositions is nothing but the formation of all possible statements about these statements: a model for abstraction process. One can apply this process to the $2^N - 1$ element set and by continuing this process get a sequence of second quantizations as a sequence of abstractions.

The assumption of unrestricted linear superposition in Z_2 Hilbert space leads to difficulties with Schwartz and triangle inequalities. The physical interpretation of the theory requires that inner product satisfies Schwartz inequality

$$|(x, y)| \leq |x||y| \ .$$

Linear superposition allows states, say y, with zero norm since any superposition of even number of orthonormal states has zero norm in Z_2. The norm of the inner product of one of the basis states appearing in zero norm state, call it x, with the zero norm state y equals to one and is not smaller than the product of the norm of the basis state and state with vanishing norm: one obtains $1 < 0$, which does not make sense if inner product is interpreted as real number (as a Z_2 valued number one could perhaps say $1 = -1 < 0$). One ends up

to difficulties also with the triangle inequality: $|x + y| \leq |x| + |y|$ if x and y are zero norm states with single common element of orthonormal basis so that one has $|x + y| = 1$.

The only possible manner to save Schwartz and triangle inequalities is to assume that linear superposition is not allowed for Z_2 Hilbert space. This in turn means that situation is completely classical! If the set generating Boolean algebra consists of entire 3-space, this means that every state is gauge equivalent with an N-particle state of completely localized particles. This in turn implies that Boolean QFT should be more or less equivalent with classical mechanics and one could understand the transition from classical physics to quantum physics as the replacement of Z_2 with complex numbers C as the coefficient field of the state space.

One can change state basis by unitary transformations. Unitary matrices are obtained from orthogonal Z_2 valued unit vectors possessing entries equal to 1 or 0. Any unitary matrix corresponds to a matrix representing the permutation of 2^N elements of the basis of the Boolean algebra. Time development operator in this quantum field theory is always defined for a *finite* time interval only (the length of the "chronon" is fixed naturally in p-adic QFT) and represents a permutation of this basis. In particular, a nonlinear transformation of the oscillator operators in general occurs. All unitary transformations are permutations, which do *not* lead to state basis involving superpositions of the basic states. This is in accordance with the observation that Boolean QFT is completely classical.

6.10.3 Fermions, Zero Energy Ontology, And Boolean Cognition

Fermionic Fock state basis defines naturally a quantum version of Boolean algebra. In zero energy ontology predicting that physical states have vanishing net quantum numbers, positive and negative energy components of zero energy states with opposite fermion numbers define realizations of Boolean functions via time-like quantum entanglement. One can also consider an interpretation of zero energy states in terms of rules of form $A \rightarrow B$ with the instances of A and B represented as elements Fock state basis fixed by the diagonalization of the density matrix defined by $M-$-matrix. Hence Boolean consciousness would be basic aspect of zero energy states. Physical states would be more like memes than matter. Note also that the fundamental super-symmetric duality between bosonic degrees of freedom (size and shape of the 3-surface) and fermionic degrees of freedom would correspond to the sensory-cognitive duality.

This would explain why Boolean and temporal causalities are so closely related. Note that zero energy ontology is certainly consistent with the usual positive energy ontology if unitary process U associated with the quantum jump is more or less trivial in the degrees of freedom usually assigned with the material world. There are arguments suggesting that U is tensor product of of factoring S-matrices associated with 2-D integrable QFT theories [K25]: these are indeed almost trivial in momentum degrees of freedom. This would also imply that our geometric past is rather stable so that quantum jump of geometric past does not suddenly change your profession from that of musician to that of physicist.

6.10.4 Negentropic Entanglement, Fuzzy Logic, Quantum Groups, And Jones Inclusions

Matrix logic [A7] emerges naturally when one calculates expectation values of logical functions defined by the zero energy states with positive energy fermionic Fock states interpreted as inputs and corresponding negative energy states interpreted as outputs. Also the non-commutative version of the quantum logic, with spinor components representing amplitudes for truth values replaced with non-commutative operators, emerges naturally. The finite resolution of quantum measurement generalizes to a finite resolution of Boolean cognition and allows description in terms of Jones inclusions $\mathcal{N} \subset \mathcal{M}$ of infinite-dimensional Clifford algebras of the world of classical worlds (WCW) identifiable in terms of fermionic oscillator algebras. $\mathcal{N}$ defines the resolution in the sense that quantum measurement and conscious experience does not distinguish between states differing from each other by the action of $\mathcal{N}$.

The finite-dimensional quantum Clifford algebra $\mathcal{M}/\mathcal{N}$ creates the physical states modulo the resolution. This algebra is non-commutative which means that corresponding quantum spinors have non-commutative components. The non-commutativity codes for the that the spinor components are correlated: the quantized fractal dimension for quantum counterparts of 2-spinors satisfying $d = 2cos(\pi/n) \leq 2$ expresses this correlation as a reduction of effective dimension.

The moduli of spinor components however commute and have interpretation as eigenvalues of truth and false operators or probabilities that the statement is true/false. They have quantized spectrum having also interpretation as probabilities for truth values and this spectrum differs from the spectrum $\{1, 0\}$ for the ordinary logic so that fuzzy logic results from the finite resolution of Boolean cognition [K118].

6.10.5   Cognitive Codes And Fermions

p-Adic length scale hypothesis leads to the idea that each $p \simeq 2^k$, k integer, defines a hierarchy of cognitive codes with code word having duration given by the n-ary p-adic time scale $T(n, k)$ and number of bits given by any factor of k. Especially interesting codes are those for which the number of bits is prime factor or power of prime factor of k. $n = 2$ seems to be in special position in zero energy ontology. This is a strong quantitative prediction since the duration of both the code word and bit correspond to definite frequencies serving as signatures for the occurrence of commutations utilizing these codes.

If k is prime, the amount of information carried by the codon is maximal but there is no obvious manner to detect errors. If k is not prime there are several codes with various numbers of bits: information content is not maximal but it is possible to detect errors. For instance, $k = 252$ gives rise to code words for which the number of bits is $k_1 = 252, 126, 63$, $84, 42, 21_2, 9, 7, 6_2, 4, 3_2, 2$: the subscript $_2$ tells that there are two non-equivalent ways to get this number of bits. For instance, $126 = 42 \times 3$-bit codon can have 42 -bit parity codon: the bits of this codon would be products of three subsequent bits of 126-bit codon. This allows error detection by comparing the error codon for communicated codon and communicated error codon.

Mersenne primes are especially interesting as far as cognitive codes are considered the Mersenne prime M_{127} assignable to electron is of special interest since the corresponding time scale for CD is .1 seconds whereas the duration of bit corresponds to the time scale of 1 ms assignable to quark CDs.

Combinatorial Hierarchy as a hierarchy of "genetic codes"

The simplest model for abstraction process is based on the process in which one forms first all possible Boolean statements about N basic statements, 2^N altogether. If one drops one of the statements one has $M_N = 2^N - 1$ statements: M_N is Mersenne number. The motivation for the dropping of one statement might be that in set theoretical realization one of the statements corresponds to empty set and is not realizable. Alternatively, in the realization based on many-fermion states, vacuum state could correspond to this kind of state. One can form also statements about statements: the first level of abstraction. This leads to $M_{M_N} = 2^{M_N} - 1$ many-fermion states. Construction is especially intersting if the numbers $M(M_N)$ are primes, so called Mersenne primes. Indeed, in some cases one obtains hierarchies of Mersenne primes by repeating the construction as long as it works.

The so called Combinatorial Hierarchy, shown already earlier to provide an explanation for the numbers of the Genetic Code, emerges as the most notable hierarchy. The Combinatorial Hierarchy [A15] consists of the Mersenne numbers $2, M(1) = 3, 7 , 127, 2^{127} - 1, ..$ constructed using the rule $M(n + 1) = M_{M(n)} = 2^{M(n)} - 1$. The explicitly listed ones are known to be primes. Combinatorial Hierarchy emerges from a model of abstraction process as subsequent transitions from level to metalevel by forming Boolean statements about Boolean statements of level n and dropping one statement away and starting from $n = 2$ basic statements.

Combinatorial Hierarchy results also by constructing the sets of all subsets with empty set excluded starting from two element set.

The set of statements at level n can be given a structure of Finite Field $G(M(n), 1)$ if $M(n)$ is prime. The multiplicative groups $Z_{M(n)-1}$ form a nested hierarchy and the coset spaces Z_{k_n} $\equiv Z_{M(n+1)-1}/Z_{M(n)-1}$ are cyclic groups. Combinatorial Hierarchy based model of Genetic Code explains the number of DNA: s and amino-acids and the representation of words of the GC as triplets of 4 different codons. Amino-acids correspond to $k_{n=3} = 21$ axioms of a formal system defined by $n = 3$ level of Combinatorial Hierarchy having a unique embedding as the group $Z_{k_n} \subset Z_{M(n)-1} = Z_{126}$ and DNA: s correspond to the set $X_{N(DNA)} \subset Z_{M(n)-1}$ of $N(DNA) = (M(n) + 1)/2 = 64$ of statements consistent with given atomic statement at level n regarded as special cases of general theorems. GC corresponds to the mapping $x \to x^{k_{n-1}} = x^6$ in $Z_{M(n)-1}$ mapping DNA type statements to amino-acid type statements. The numbers of DNA: s coding single amino-acid are reproduced in a symmetry breaking mechanism involving the finite groups $Z_{p_{n-1}}$ and Z_{k_n} and symmetry breaking is in a well defined sense minimal. The infinite hierarchy of possible genetic codes suggests the possibility of an infinite hierarchy of increasingly complicated lifeforms or forms of intelligence.

Boolean mind and memetic code

The original proposal for the realization of Boolean mind was in terms of sequences cognitive neutrino pairs. These can be interpreted as wormhole contacts carrying neutrino and antineutrino at the light-like wormhole throats and would thus represent boson like entities. In the framework of the standard model the proposal looks of course completely non-sensical. TGD however predicts the existence of long range classical electro-weak fields, and one might imagine that inside neutrino- whose Compton length corresponds to length scale of cell- intermediate gauge bosons behave like massless fields. Although neutrinos could be important, the time scale of corresponding CD - about 10^4 years - suggests that cognitive neutrinos might be important in much longer time scale than the.1 second time scale assignable to the memetic code.

The recent view about TGD allows a much more general view. Zero energy ontology allows to interpret the fermionic parts of zero energy states as quantum superpositions of Boolean statements of form $a \to b$ with a and b represented in terms of positive and negative energy parts of the zero energy state. If one has negentropic entanglement this kind of state has interpretation as an abstraction - a "law of physics" - representing as a quantum superposition various instances of a more general law.

The simplest situation corresponds to a CD having only single positive energy fermion and negative energy fermion at its light-like boundaries. The fermion number or spin or isospin of the fermion could represent qubit. The hypothesis that memetic code corresponds to the next level of Combinatorial Hierarchy, when combined with p-adic length scale hypothesis, led to a prediction of order .1 seconds for the duration of the "wake-up" period of sub-self corresponding to the codeword of the memetic code. Since the CD assignable to electron has time scale.1 seconds and the CD assignable to u and d quarks has time scale 1/1.28 milliseconds there is a temptation to proposed that the quark-like sub-CDs of electronic CD give to a realization of memetic code word as a sequence of 126 quark like sub-CDs. u and d quarks would be assigned to the magnetic flux tubes connecting DNA and the lipids of the cell membrane in the model of DNA as topological quantum computer. Clearly, beautiful connection between new elementary particle physics, genetic code, nerve pulse activity, DNA as topological quantum computer, logical thought, and the basic time scales of speech are suggestive.

This codeword consists of 126 bits represented by quarks such that the two possible magnetization directions correspond to the two values of Boolean statement. This implies that the duration of single bit should 1/1260 seconds. The duration of the nerve pulse is slightly longer than this which might mean that the full memetic code is realized as membrane oscillations rather than nerve pulse patterns. Both hearing and vision have .1 second time scale as a fundamental time scale and sounds are indeed coded to membrane oscillations in ear.

One can consider also the realization of genetic code with six bits of the codon represented by various scaled up versions of quark CD coming as size powers of 2. In this case the ordering of the bits would come from the size of sub-CD whereas in previous example temporal ordering would define the ordering. It is not however clear whether the powers of two can be realized physically.

One can understand the number 126 as related to the total number of separately experienced frequencies in the interval $20 - 20.000$ Hz spanning 10 octaves. $10 \times 12 = 120$ is not far from 126: here 12 corresponds to 12 tones of basic music scale. Also speech has 10 Hz frequency as fundamental frequency. In visual primary cortex replicating triplets, 4-, 5- and 6-plets of spikes with highly regular intervals between spikes have been detected. The triplets are accompanied by ghost doublets. This would suggest a coding of some features of visual experience to reverberating mental images. The time scale for various patterns is .1 seconds. This could be seen as a support for the realization of some degenerate version of the memetic code as nerve pulse patterns.

The model for the memetic code encourages the following conclusions.

(a) Membrane oscillation/nerve pulse patterns correspond to temporal sequences of magnetization directions for quarks representing yes/no Boolean statements.

(b) The spin polarization of quarks is changed from the standard direction fixed by the spontaneous magnetization in the direction of axon by a ME moving parallel to axon, and inducing membrane oscillation or even a nerve pulse. Nerve pulses could correspond to a degenerate memetic code resulting by frequency coding for which the number of distinguishable code words is 64, and would thus naturally correspond to the reduction of the memetic code to the genetic code.

A very precise correspondence with the basic structures of the genetic code results. mRNA $\rightarrow$ protein translation corresponds to the translation of temporal sequences o magnetization directions to conscious cognitive experiences. Under very natural constraints the mapping to cognitive experiences is not one-to-one and the predicted degeneracy (2^{126} sequences correspond to ($2^{126} - 1)/63$ cognitive experiences) can be understood.

One might think that the full memetic code is an evolutionary newcomer and involved only with the logical thought: this would explain the completely exceptional characteristics of human brain. The full memetic code could be realized for certain regions of brain only. These regions certainly include auditory pathways responsible for the comprehension of speech [K41, K80, K83].

How nerve pulse patterns and membrane oscillations could be coded to Boolean statements?

The original proposal for the realization of the memetic code was based on the notion of cognitive neutrino pair. Zero energy ontology however disfavors this identification since the time scale assignable to CD of neutrino is of order 10^4 years. Therefore neutrinos would most naturally correspond to a time scale of consciousness much longer than the time scale of .1 seconds predicted to be present. If the proposed view about cell membrane is correct, classical weak fields should be important within the Compton length of any particle and therefore the interactions of neutrinos with Z^0 fields should be important as also the large chiral asymmetry in living matter suggests.

The realization of memetic codewords in terms of sub-CDs assignable to u and d quarks look much more attractive option since they have time scale of $1/1.28$ millisecond.

(a) The bit would correspond to quark existing in this kind of sub-CD. Memetic codon would correspond to electron's sub-CD containing a row of 127 quark sub-CDs. Standard physics interpretation could be as quantum fluctuation generating virtual pair of quark and negative energy antiquark. For non-standard values of $\hbar$ the durations of codewords and bits would be scaled up.

(b) The time-like row of quark sub-CDs resides in em (and possibly also Z^0) field associated with the cell membrane and having the direction of the axon. There is a time-like row of quark sub-CD at some points of axon with one sub-CD per millisecond time interval between sub-CDs. DNA as topological quantum computer hypothesis suggests that each lipid could correspond to quark sub-CD so that many-quark system would be in question. The minimization of the magnetic energy for a given sub-CD fixes the direction of spin and one has spontaneous magnetization in the case that the direction of magnetic field inside quark sub-CD does not change during the pulse.

(c) The time that it takes for a nerve pulse to traverse the point is slightly longer than millisecond. If the time which magnetic field has reversed direction is of order millisecond then the magnetic field experienced by quark can preserve its direction during the time interval that quark exists from the point of view of outsider. This is achieved if the temporal center of mass positions of the quark sub-CDs are given by $t_n = nz_0/v$, where z_0 is the distance between lipids containing quark sub-CD and the position of nerve pulse is given by $z = vt$, where v is the conduction velocity of nerve pulse. Unless this condition is satisfied, the direction of magnetic field changes during the time interval associated with sub-CD. In this case a superposition of bits identifiable as a qubit results.

(d) This means that nerve pulse sequence defines a (qu-)bit sequence with the direction of spin telling whether there was nerve pulse present in particular sub-CD. The presence/absence of nerve pulse corresponds to true/false statement in accordance with neuro science intuition.

Memetic code, and genetic code as a representation of phonemes?

The average duration of phonemes is about 140 ms, which is by a factor $\sqrt{2}$ longer than the duration.1 seconds of the memetic codon. Durations vary in the range 60-300 ms. Note that the 250-300 Hz rhythm associated with speech organs defines the pitch of speech but phonemes can be recognized even in the absence of the fundamental. The basic pitch of about 250 Hz implies that the number of memetic codons associated single single period is at most 2.

Phonemes can be classified by the vocal tract mechanism generating them and phonemes can be also recognized by their spectral decomposition.

(a) Formants [**?, ?**] correspond to vowels, approximants (say (r, l) and (j, w)), and nasals (m and n). Only few resonant frequencies are needed to characterize the formant. Lowest formant is below 1 kHz but higher formants above kHz and frequencies up to 3 kHz are possible. It is easy to understand that for vowels the frequency distribution does not depend on time for approximants and nasals it does.

(b) Fricatives (hiss, buzz). Fricatives lack the formant structure. Both correspond to a repeated time amplitude peak and frequency distribution involves wide range of frequencies with same intensity.

(c) Plosives (such as p, b and t, d) correspond to a single peak in the time domain and constant frequency distribution.

All sensory input might be transformed by a feedback circuit to sequences or notes/memetic codons represented as a modulation of the membrane voltage providing a universal cognitive/emotional representations. Also ordinary phonemes and notes would be represented in this manner.

Also other p-adic codes are possible. Phonemes, the number of which is 41 in American english, could correspond to a sub-code reducing to a genetic code with 64 codons. It is important to notice that the temporal distance between memetic codons does not matter. Other memetic codons could code for recognizable sound patterns not representing phonemes and could have meaning at some other levels of self hierarchy.

One can argue that the representations as "notes" and "phonemes" should carry roughly the same amount of information. For frequency representation as a sequence of "notes" 10 octaves

represents upper limit for the modulation frequencies. For high modulating frequencies the representation tends however to fail since slow modulation is not anymore in question. This would mean that the number of distinguishable "notes" is below $10 \times N$, where N is the maximum number of distinguishable frequencies inside octave. $N = 12$, the number of half notes in octave, would give 120 different "notes", which is not far from 127 and corresponds to M_7 allowing $2^7 - 1$ different codons making almost 7 bits with bit duration of 67 ms. Since the first codon in pulse-no pulse representation must be always pulse to tell that the codeword starts, this leaves 6 bits and genetic code. Codons can have varying but long enough pauses between them and the average duration .14 s of phonemes allows this. The association of genetic or memetic codons to characteristic spectrograms of phonemes as a function of time and frequency would result by cortical feedback.

Chapter 7

What Music Could Teach about Consciousness?

7.1 Introduction

Oliver Sacks have written marvellous books giving an overview about neurology not possible to obtain by reading highly specialized articles dealing with highly special problem and producing some statistical correlations and giving very little for anyone who tries to gain overall view.

These books are gems also for those trying to understand consciousness and allow to learn how much is already understood and how vast the variety of strange findings that should be explained by the theories of consciousness is. Sacks's books allow also to get idea about the limitations of neuroscience: it is far from clear that all the reported strange findings can be really explained in the framework of neuroscience. What makes these books so enjoyable is that Sacks communicates his message using stories. It is also heart warming to see Sacks's deep compassion towards his patients and the ability to see them as suffering humans.

Recently I have been reading his book "Musicophilia" [?] dealing with various aspects of music experience. Humans as a species indeed have a very special relation to music. But is it really genuine characteristic of human consciousness? One can even ask whether consciousness emerges only in higher species or whether it could be in some form a characteric of any living or even inanimate system? I am not the only quantum consciousness theorists forced to consider panpsychism in some form. In this framework one can ask whether music like aspects of conscious experience could be universal and only especially highly developed in humans?

7.1.1 Can One Do Without Music?

According to Sacks, some writers - for instance Pinker [?] - claim that we could quite well do without music. Most of us would disagree with Pinker on basis of personal experience.

(a) Left brain hemisphere dominates as far as functions of brain understood in the framework of neuroscience are considered. It is true, that brain hemispheres could be fighting for metabolic resources and power just as all other life forms and this could lead to suppression of those functions which left hemisphere can take care of.

(b) Musician's brain seems to be unique in the sense that its more democratic than average brain. First of all, neurologist can immediately identify musician's brain by visible changes in its anatomy. Corpus callosum connecting the two hemispheres is unusually thick so that left and right brain hemisphere are in much more democratic relationship than usually. Also planum temporale in the auditory area is asymmetric being bigger

at the right side. Most of us cannot do without music. Could it be that behind music is something which is vital element of being conscious?

(c) One can argue that the dominance of left hemisphere in adults reflects the fact left brain dominated consciousness is optimal for survival. Cognitive representations are abstractions and require much less bits than sensory representations, which are concrete and extremely detailed. The symbolic character of cognitive representations makes them also much more flexible. To understand what I mean consider the representation of a page of book using bit graphics to that using vector graphics file with letters identified as symbols allowing large number of representation in various fonts and pictures decomposed to basic elements. One might say that cognitive representations are for scientist and sensory representations for artist. But again: we cannot live without art!

(d) But why Nature would have built right hemisphere at all if it were useless? Could right brain have hitherto un-identified functions understandable only by widening the scope? EEG has been often often seen as a mere neural noise but it is now known that EEG codes for the contents of consciousness: could it be that EEG relates to the special functions of right hemisphere somehow? It seems useless to code information to EEG if it is not communicated somewhere. Where? And what would distinguish between the EEGs of right and left hemisphere?

(e) Interestingly, it is *right* brain hemisphere that dominates for children in fetus. Left brain also develops much more slowly suggesting the development of cognitive abilities characterizing brain hemisphere takes a longer time. Does left hemisphere continue cognitive differentiation from the level, where right hemisphere stopped? Or do both hemispheres have cognitive abilities potentially? These observations serve as important hints as one tries to understand what lies behind right-left dichotomy. How the left hemisphere differs from the right one. Left hemisphere cognizes: how cognition is realized at fundamental level?

On basis of these observations I disagree with Pinker.

7.1.2   Overall View Suggested By *Musicophilia*

In the sequel will I restrict the consideration to those stories of *Musicophilia*, which I find of special interest from the point of view of TGD inspired theory of consciousness. The outcome is a more precise formulation for the general TGD inspired vision about brain based on basic ideas of quantum TGD.

Zero Energy Ontology (ZEO) implies a new view about the relation between geometric and experienced time and allowing to generalize quantum measurement theory to a theory of consciousness.

Strong form of holography implies the analog of AdS/CFT duality between 2-D representation of physics based on string world sheets and partonic 2-surfaces and 4-D space-time representations. This duality is not tautology and this inspires the idea that these two representations correspond to two modes for consciousness motivating "Left brain talks, right brain sings" metaphor.

(a) Language and music could relate to two dual representations of conscious information - local and holistic, cognitive and sensory. Discretization of function/its Fourier transform as a collection of its values at discrete set values of time/frequencies would correspond local/holistic approximations of function. In principle any conscious entity - self- could utilize these two representational modes at appropriate quantum criticality.

(b) The holistic "musical consciousness" is assignable to right brain hemisphere and according to the stories of Sacks seems to characterized by episodal sensory memories. TGD based view about memories relies on ZEO: the memories would be mental images with sensory input from geometric past, genuine sensory experiences of time reversed sub-selves! This picture simplifies considerably and one can see all memories - sensory, cognitive, or emotional - as analogs of phantom pain, which would be also a sensory

memory and even more a genuine sensory experience. It is even possible that our biological bodies are used by two selves: right brain hemisphere sleeps when we are awake and vice versa. Even the experiences of epileptics about having double consciousness could be understood.

(c) A more concrete realization of "Left brain talks, right brain sings" metaphor relies on the assumption that "magneto-anatomy" is universal. Only the "magneto-physiology" characterized by the values of h_{eff} characterizing quantum criticality and defining a kind of intelligence quotient dictating the span of long term memory and planned action varies.

h_{eff} would differ for the magnetic bodies of various brain areas, and the spectrum of h_{eff} for right and left brain would differ and characterize their specializations. For instance, the value of h_{eff} would be large (small) for the cognitive areas of left (right) brain and small (large) for some higher sensory areas of right (left) brain. Magnetic bodies form a fractal hierarchy and one can characterize even individual cells and neurons by the value of h_{eff} associated with them. The spectrum for h_{eff} allows also to distinguish between members of the same species since it defines the skill profile. This obviously goes far beyond the genetic determinism.

7.2 Impressions Created By Stories

The following summary is only a rough sketch about stories of Musicophilia, a clumsy attempt to summarize what I see as especially interesting from my own point of view. My interests are selfish (or better to say, TGDeish): I try to abstract what is interesting from the point of view of quantum consciousness theory and I am eager to see whether these stories might help to develop a deeper vision about TGD inspired theory of consciousness. I strongly encourage the reader to read *Musicophilia* and also other books to get more balanced view: these books are rare gems.

7.2.1 Emergence Of Exceptional Music Abilities

Sacks deals with special music abilities. The exceptional musical talents are often - not always - accompanied by profound cognitive in-abilities and one speaks of idiot savants. Savant abilities involve memory feats suggesting that savants remember differently: one could speak of sensory memories.

Savants can also have exceptional mathematical talents such as ability to "see" the decomposition of integers to primes and the ability to perform complex algebraic operations to numbers. Some mathematicians possess these magic gifts: Ramanujan - certainly not a savant - is the classic example. There are also people having exceptional motor skills - consider only piano virtuosos and athletes who must have holistic control of their entire bodies.

These special gifts often emerge as one loses some cognitive abilities assignable to the left brain. Also sensory defects - say blindness at young age - can be accompanied by these abilities.

Also music training initiated at very early age can lead to the development of this exceptional talents. One can ask whether these sensory talents are necessarily accompanied by cognitive in-abilities and where they are associated with consciousness different from the standard wake-up consciousness.

(a) In music these talents include absolute pitch: person "sees" the pitch of heard or imagined note with an accuracy better than one quarter note and can associate with it note or even frequency. The process is completely spontaneous and involves no comparisons.

An analogy with the perception of visual colors comes in mind. Not only the ratios of frequencies must be rational in good accuracy in order to feel aesthetic but different keys sound different. One example mentioned by Sacks is a finnish scientist Olavi Sotavalta

able to tell the frequency of the sound produced by insect with an accuracy better than Hz.

Absolute pitch can be also a curse for a musician. Since the music piece transformed to different key is not the same piece anymore. Same effect in visual perception is achieved if the colors of painting would be shifted by scaling the frequency in the same manner as the transponation to different key scales the frequencies. This explains why classic compositions are in definite key: this matters for the composer with absolute pitch but for a person without absolute pitch like me this is of course of no significance.

The ability to name the note or tell even its frequency need not require anything outside standard neuroscience and can be explained as a learned association. One can of course ask what association is at the level of conscious experience.

(b) Absolute pitch is more general for musicians than average population and appears more often for musicians who have started at young age. Absolute ear is more general in cultures in which the pitch of speech is important (vietnamise, mandarin) suggesting that it can develop during early age.

Sacks tells stories about musical savants.

(a) Musical savant can have absolute sensory memory for music and reproduce the music piece in detail after hearing it just once: as if she would "see" the entire piece. In one case told by Sacks the memory of savant about read text was phonographic rather than photographic. Similar holistic sensory memory but with all the details present is sometimes associated with visual perception. This kind of holism is different from holism based on abstraction sacrificing the details.

Musical savant can be also highly sensitive to the harmony and the style of the composer and improvise music in this style. This might be understood assuming only that the person has sensory memory about the music and can literally hear it and improvise against this background. If cognition were involved a deep theoretical understanding of music would be required and this is typically lacking.

(b) There is a story about people suffering from a congenital disorder known as Williams syndrome and resulting in a strange mixture of intellectual strengths and weakness. Sacks calls these people hypermusical species. They are classified as intellectually retarded (IQ is around 60) but they have unusual command of language, are extremely social and friendly, and have a deep passion for music.

(c) Also ordinary persons can have sensory memories or hallucination like states as they fall asleep (hypnagogia) or wake-up (hypnopompia). These experiences seem to be associated with a loss or change of type of consciousness. Could left brain dominance/consciousness transform to right brain dominance/consciousness or vice versa? If so right brain would not be useless at all: we would spend one half of our life in the alternative mode of consciousness!

(d) Also visual and auditory hallucinations might have explanation in terms of right brain dominance. For instance, schizophrenics have hallucinations and sensory memories accompanied by cognitive impairing. Schizophrenic consciousness (as also that of children) has been proposed by Jaynes to correspond to bicameral consciousness, which would have preceded the modern left brain dominated cognitive consciousness.

Why the character of right and left brain consciousness would be so different: to my opinion neuroscience does not answer this question.

7.2.2   Phantom Fingers And The Problem Of Time

One fascinating story is about "phantom fingers". The brother of philosopher Wittgenstein was a concert pianist, who lost his second arm in World War I. He however experienced the fingers of his right hand as still existing and "played" with it to develop fingerings to music pieces. He experienced of receiving virtual sensory input from the fingers and also sent motor input to the stump as became clear from the movement of the stump.

The neuroscience explanation is that brain contains sensory maps of body parts and the sensory experience is localizable at this kind of representations in sensory cortex. This view has however an unsolved problem. Neurons or neural circuits in various sensory pathways should be somehow different - neurons for quale "red" should be different from those for note G or sensation of touch - but there seems to be no differences.

naïvely one could argue that maybe the sensory qualia are localized at the level of sensory receptors. Phantom leg is a standard objection against this idea. But could the naïve explanation be correct after all and force to dramatically modify our views about time?

As will be found, TGD based view about the relationship of geometric time and experienced time combined with ZEO indeed allows to consider a different explanation allowing also to understand the sensory memory feats of of idiot savants and providing a general explanation for right-left dichotomy and for why miraculous sensory abilities are often accompanied by cognitive inabilities.

7.2.3 When Music Suddenly Becomes A Passion

Sacks tells real life stories about various fascinating phenomena surrounding music experience: sudden musicophilia - the emergence of special musical talents and deep passion for music; epileptic seizures during which patient hears music with a strange feeling of familiarity; epilepsy induced by music; music imagery allowing to almost hear the imagined music (Beethoven who became deaf is a classic example in this respect); musical hallucinations; etc...

The sudden emergence of musicophilia suggests that right brain consciousness ceases to be inhibited in wake-up state and becomes a dominating part of conscious experience and that sensory memories characteristic for it appear too. This would suggests that right hemisphere is specialized to produce sensory memories.

The dejavu type experiences are of special interest from the point of view of TGD inspired theory of consciousness since they might give a way to test the vision about the relationship between two times and ZEO based view about memory.

7.2.4 Music And Neurological Defects

Sacks tells how music has helped his patients to cope with various brain defects classifiable as sensory, motor, cognitive, emotional, etc... Some examples suggest that music is not at all so useless outcome of evolution as Pinker argues and that musical right brain consciousness can come in rescue when left brain suffers damage.

(a) The defects considered are often those of left hemisphere. Say those of frontotemporal regions leading to semantic dementia (`http://tinyurl.com/zscxotc`), non-fluent aphasia, and changes in social behavior and conduct such as poor impulse controls.

(b) (Non-fluent) aphasia is motor defect and due to the damage of Broca's area (`http://tinyurl.com/yb8f7fal`) located in promotor area in the left hemisphere and responsible for the production of speech. The victim looses the ability to produce speech although he remembers the meanings of the words. The patient can however to learn to communicate fluently by singing. Singing as a mode of expression is naturally associated with the right brain and one can say that right brain hemisphere comes in rescue.

(c) Person can also suffer from fluent aphasia, kind of mirror image of aphasia. Person can produce but t not understand speech speech - in other words cannot assign meaning to the words or sentences that she hears. Fluent aphasia as a receptive defect associated with the damage to the Wernicke's areas in left hemisphere (`http://tinyurl.com/yb8zp5rp`). From neuroscience perspective it is natural to consider the possibility that the patient does not understand what she hears but understands what she says or vice versa. Sacks talks also about "semantic aphasia": I am not quite sure whether he means that the words that the person produces have no meaning to her: this would suggest

damage of both Broca and Wernicke areas. What is however remarkable that that the patient can learn to understand communications by singing: right brain again!

(d) As opposed to aphasia, amnesia is a defect of right hemisphere. The victim loses completely all episodal memories and becomes a person without past and future: life story can reduce to few seconds and the persons experiences waking up from sleep or re-incarnating again and again and the world is new in every wake-up. Cognitive abilities are not lost and the patient recalls the meanings of words. Sacks tells a moving story about how a victim of amnesia with help of her loving life companion and music gradually manage to rebuild meaning to his life.

(e) In some cases the damage to the frontal areas leads to emotional flatness. Person becomes inert, flat, and indifferent -as Sacks expresses it - and loses ability to initiate actions. Sacks tells about a case in which patient seemed to gain back his emotions while singing: impossible by the damage to the frontal lobes if neuroscience view is correct. Episodal memories seem to be characteristic for right brain consciousness. Could temporary right brain consciousness stimulated by singing allow to have episodal memories with emotional content? Could this be an emotional analog of phantom leg.

7.3   TGD Inspired Theory Of Consciousness Very Briefly

The believer in quantum consciousness of course wonders whether these strange findings could be understood in terms of his or her pet theory. First one must try to identify the questions that one must answer if one wants to understand the findings about music and brain described so elegantly by Sacks. My proposal for the list of correct questions if following.

(a) What are the quantum physical correlates of mental image? How mental images are born and die? What features are as mental images? What their binding to sensory percepts does mean physically?

(b) What is the relationship between geometric time of physicists and the experienced time. What memories are?

(c) Do right- and left brain consciousness differ in some fundamental manner and how this is possible taking into account the similar looking neuronal structure? These possibly existing fundamentally different modes of consciousness should have correlates, which belong outside the neuroscience and perhaps even outside the standard physics.

What are these correlates and how do they relate to EEG? Note that EEG is a poorly understood aspect of neuroscience which until hitherto has been regarded as neural noise but is now know to correlate with contents of consciousness and with the state of brain. The strange effects of ELF em fields on vertebrate were indeed the starting point of the TGD based approach to brain. Bio-photons have been known for long time and are now taken seriously and there might be a relationship.

I can answer these questions only on my own behalf and to do it I must introduce the basic notions and ideas of TGD inspired theory of consciousness. I will not go into details here because I have done this so many times and just suggest that the reading of some basic stuff about TGD inspired theory of consciousness. Suffice it to list just the basic ideas and notions.

7.3.1   Basic Ideas Of TGD Inspired Theory Of Consciousness

(a) ZEO and causal diamonds (CDs) and hierarchy of Planck constants assignable to quantum criticality are basic notions. Number theoretic vision is also central. In particular, adelic physics fusing real physics and various p-adic physics as correlates for cognition is also basic building brick.

(b) Consciousness theory is generalization of quantum measurement theory constructed to solve the basic problems of ordinary quantum measurement theory: observer becomes self described by physics rather than being outsider of the physical world. Weak form of Negentropy Maximization Principle (NMP) [K59] defines the basic variational principle of consciousness and state that the negentropy gain in state function reduction is maximal.

(c) The notion of observe as an outsider to the physical world is replaced by that of self. Self corresponds to a state function reduction sequence to the same boundary of CD. In standard quantum measurement theory this sequence does not change the state but in TGD framework the state at the opposite boundary of CD and even opposite boundary changes. This gives rise to the experience flow of time having the increases of the temporal distance between the tips of CD as a geometric correlate. Self dies as the first reduction to the opposite boundary takes place and re-incarnates at the opposite boundary as its time reversal. Negentropy Maximization Principle forces it to occur sooner or later.

Self hierarchy is a basic notion in TGD inspired theory of consciousness. Self experiences sub-selves as mental images. The continual birth and death of mental images supports this view if one accepts the idea about hierarchy. One can also consider identification for what the change of the arrow of time means for mental image. The time inversion of mental images about external world generates the mental image at opposite boundary of CD and this suggests interpretation as memory - something so simple that I discovered it only when trying to understand phantom leg.

(d) TGD physics is number theoretically universal. This means that real physics is generalized to adelic physics. Besides real number based physics also p-adic physics assignable to p-adic number fields and their algebraic extensions are introduced and identified as physical correlates of cognition: kind of mind stuff of Descartes besides res extensa. Field equations make sense also in p-adic number fields and one can define what preferred extremal of Kähler action mean in p-adic context.

One can speak also about intersection of realities and p-adicities defined by a particular extension of rational physics. Space-time surfaces are characterized by parameters and if these parameters belong to this extension one can interpreted space-time surfaces either as real or p-adic: the algebra is formally the same. One can algebraically continue the parameters from the extension of rationals to reals and extensions of p-adic numbers and obtains what might be called fundamental sensory and cognitive representations. One can say that fermions localized at string world sheets define the quantum correlates for Boolean cognition and p-adic space-time sheets its space-time correlates.

(e) MBs carrying dark matter identified as $h_{eff} = n \times h$ phases of ordinary matter define quantum correlates for selves. Magnetic body (MB) has hierarchical onion-like structure and it communicates with biological body using dark photons propagating along magnetic flux tubes. EEG and its fractal generalization make both communication from/control of biological body to/by MB. Dark matter hierarchy can be reduced to quantum criticality and this in turn has deep roots in the adelic physics.

MB is and ideal place for the realization of the two basic representation based on pulses *resp.* frequencies behind "Left brain talks, right brain sings" metaphor. 4-D field representations could be realized in terms of massless extremals and pulse representations in terms of supra currents assignable with magnetic flux tubes carrying fermionic strings.

The completion of organism-environment double to MB-organism-environment triple would be the extension of the ontology of neuroscience needed. Neuroscience alone would not be enough to understand the strange aspects of brain consciousness.

7.3.2 Hierarchy Of Quantum Criticalities And Strong Form Of Holography

The hierarchy of quantum criticalities reduces to strong form of holography in turn implied by strong form of General Coordinate Invariance (GCI).

(a) Strong form of holography states that the information about quantum aspects of physics is coded by second quantized induced spinor fields localized at string world sheets and intersecting partonic 2-surfaces at discrete point sets. Collections of string world sheets and partonic 2-surfaces (briefly 2-surfaces) dictate space-time surfaces identified as preferred extremals of so called Kähler action having vanishing Noether charges in a sub-algebra of so called super-symplectic algebra. These conditions effectively eliminate degrees of freedom so that instead of 3-D holograms one has 2-D holograms.

(b) The possibility to code space-time surfaces by appropriate boundary conditions at string world sheets (they carry vanishing classical W fields and possibly also Z^0 fields) means that one can reduce to world of classical worlds to a reduced WCW consisting of the collections of these 2-surfaces. This obviously defines the counterpart of AdS/CFT correspondence. Instead of equivalence of QFT at the $n-1$-D Minkowski space defining boundary of AdS^n with string theory in the interior of of 10-D $AdS^n \times S^{10-n}$ one has something which is very near to ordinary holography: the stringy physics at 2-surfaces is dual to the classical physics in the interior of 4-D space-time surface in $M^4 \times CP_2$.

(c) This duality is not a tautology! All collections of 2-surfaces need not allow a continuation to a preferred extremal of Kähler action. Continuability implies strong correlations between the 2-surfaces so that one cannot take any collections of 2-surfaces and continue it to preferred extremal.

This is true in real sector. In p-adic sectors the situation is different because p-adic differential equations allow integration constants which have vanishing derivative but are piecewise continuous depending on finite number of pinary digits of the coordinates. This freedom suggests that the continuation to p-adic 4-surface is always possible.

The interpretation would be obvious in consciousness theory. Strong form of holography in the direction $2-D \to 4-D$ corresponds to imagination. Space-time surface can be imagined by continuing the 2-D surfaces to 4-D preferred extremals in p-adic sectors and the imagined space-time surface is not unique. In the real sector this imagination need not be possible in real sector. Imagination is unrealistic!

7.3.3   Selves, Their Time Reversals, And Memories

The notion of self provided by ZEO predicts that selves have time reversals. Could this allow to understand the strange findings about idiot savants?

In this framework the idea about memory recall as communication with the brain of geometric past (time reflection for signals propagating to past) can be formulated more precisely. Memory recall quite generally corresponds to a temporary falling asleep/death of sub-self (mental image) followed by immediate re-incarnation in geometric past and giving rise to mental image located in past.

I have proposed variants of this mechanism such as time like entanglement and emission of signal from the brain of the geometric past back. Time-like entanglement does not seem to be necessary for having sensory memory and signals to geometric future would correspond to a further re-incarnation of sub-self with the original arrow of time. This is possible but does not seem necessary.

Association with the Sacks's stories stimulates fascinating questions.

(a) Is memory recall this kind of re-incarnation of sub-self (mental image) in the geometric past? This kind of experience would be just like ordinary experience having both sensory, motor, cognitive, and emotional aspects. Could the sensory memories associated with right brain consciousness explain the memory feats of the idiot savants?

For instance, the ability to re-experience the music piece heard once would make possible to repeat it by playing together with the second self in past. Combined with absolute pitch this would give powerful music abilities.

Sacks tells also about epileptic seizures in which one hears music and experiences "double consciousness". Could mental images in right and left hemisphere be simultaneously awake and create this doubling of consciousness?

(b) Could the pain in phantom leg be sensory memory that is genuine sensory experience associated with the leg, which still exists in the geometric past? Could all memories be actually conscious experiences of time reversed sub-selves? Could Wittgenstein's brother's phantom fingers exist in the geometric past before World War I and would he "play" piano with the hand of geometric past?

(c) Could the patient who had lost emotions and seemed to get it back - not possible according to neuroscience - while singing have emotional counterpart of phantom leg sensations so that he had genuine emotional mental images from the time time before accident? These memories would be analogous to the sensory memories of idiot savants allowing their memory feats and to the sensory memories created by the stimulation of temporal lobes. Why sensory memories are so rare has a simple explanation: their interference with sensory input from recent moment could have disastrous effects. Most memories are non-sensory sine they can be distinguished from the sensory input.

(d) Could the sub-selves (mental images) associated with right brain be time reversed with respect to the left brain sub-selves? naïvely left brain dominance means that right brain "sleeps"- or lives in geometric past, remembers in the scale of entire hemisphere. Could it be that when left hemisphere is awake and "remembers geometric future" (precognizes, plans, predicts), right hemisphere is also awake but remembers geometric past. Do the time directions of right and left selves change during sleep? Are we living two lives? Is the right hemisphere the "Ka" of ancient Egyptians?

(e) The feeling that the music heard during during the epileptic seizure is familiar brings in mind dejavu experience. For instance, one can imagine that a cognitive representation about the experience was formed as the original experience occurred and still exists in the geometric "now". Could this create the sensation of familiarity.

(f) Sacks tells about a patent with amnesia with time span of autobiographical memory measured in seconds but having usual cognitive abilities assignable to left hemisphere. The simplest explanation is that the region of right brain responsible for autobiographical memories was damaged and the value of h_{eff} associated with the corresponding magnetic body was reduced dramatically.

7.3.4 Hallucinations From The Point Of View Of ZEO

7.3.5 Hallucinations From The Point Of View Of ZEO

Sacks tells also about music hallucinations and emphasizes that is not clear these experiences can be always regarded as hallucinations. The following TGD inspired considerations are not specific to music hallucinations.

(a) If one accepts that the feedback from brain or MB to sensory organs as virtual sensory input is possible then imagination differs from hallucinations only in that the virtual sensory input stops before it reaches the sensory organ.

On the other hand, imagery as a completion of string world sheets and partonic 2-surfaces to - in general non-unique - 4-D surface could be possible in p-adic sectors (p-adic pseudo-constants) whereas in real sector it is possible only partially in the general case. This applies also to virtual sensory inputs: they can be imagined but not necessarily realized.

The two definitions are consistent if the impossibility of complete continuation to real sector corresponds to the impossibility of the virtual sensory input to reach the sensory organ.

(b) The possibility of time reversal for mental images makes possible episodal memories as genuine mental images in geometric past. One cannot speak of hallucinations now, and even talking about memory is somewhat misleading since the event happens for the first time with respect to subjective time. It would be better to talk about multi-time experiences.

The experiences in which person hears music could be therefore genuine episodal memories/real experiences. Dreams could have both the hallucinatory and sensory memory aspect. My own dreams are often localized to my childhood and youth but cannot be regarded as experiences about real events - the interpretation as time reversed imagery could be considered.

(c) I have considered the possibility that some experiences induced by psychedelics - such as experiences of meeting representatives of some exotic life forms - could be real [K101, K107]. The objection that finite light velocity makes these encounters impossible can be circumvented in ZEO since signals can propagate to geometric past and reflect back in time direction. Essentially seeing in time direction would be in question.

From consciousness theory perspective this could mean simple time reversal of subself so that the sensory mental images are in geometric past. Mechanism wold be same as in the case of long term memory/genuine experience except that the sensory mental image represents representative of distance civilization rather than something generated in own brain. Even in the case of music "hallucinations" it is not clear whether the mental image can be localized in the own brain in past! If the process is a sequence in which the sub-self dies and reincarnates several times it can involve also classical communication and could give rise to memories, which are not sensory ones.

One can argue that the size of the CD assignable with human as conscious entity poses strong limitations on the distance of the civilization. The naïve first guess is that the size scale of this CD corresponds to the human light life - less than 100 light years typically. This assumption is however un-necessarily strong. The size scale of personal CD could be considerably longer: in this case however the sensory mental images about body and environment would not be near the boundary of CD but in its interior. The largest value of h_{eff} in the personal hierarchy of sub-selves defines the size of personal CD and at the same time the span of long term memory serving as a kind of IQ. The higher this IQ, the higher the probability of this kind of communications would be.

There are still many unanswered fundamental questions about CDs possibly relevant for the considerations above. Can one assume that space-time surfaces can continue outside the boundaries of CD so that CD could be seen as spotlight of consciousness? Or does CD define its sub-Universe in the sense that it is nothing outside it or that it is impossible to say anything about the situation outside it? How CDs of various size scales interact and can they overlap?

7.4   Two Modes Of Of Consciousness

In the following the idea about two modes of consciousness basically reducing to strong form of holography is developed in more detail.

7.4.1   Conscious Holograms And Two Kinds Of Fundamental Representations

The idea about brain as hologram was introduced in neuroscience long time ago by Karl Prigram [?] (`http://tinyurl.com/ydyv6ohr`) and there is considerable support for it although it is also clear that at the higher levels of the evolutionary hierarchy brain functions can be localized. Also living matter can be seen as a hologram in the sense that DNA contains the information about the entire organism. I introduced for long time ago the notion of conscious hologram [K15].

Strong form of holography generalizes this notion to a basic law of quantum physics and since consciousness theory reduces to quantum measurement theory in ZEO, of consciousness. The generalized of AdS/CFT realizing strong form of holography is not a tautology since the collections of 2-surfaces do not always define a realizable imagery. This suggests

that dual representations give rise to two different fundamental representations of conscious information.

The first representation is in terms of collections of 2-surfaces replacing a naïve discretization of space-time surface by co-dimension 2 discretization dynamical in the sense that physical state itself defines its discretization at both quantum and classical level. String world sheet discretization is a generalization of 4-D discretization in terms of world lines reducing to 3-D discretization using discrete points.

(a) Finite measurement resolution is a key notion of quantum TGD. One realization is in terms of string world sheets. At the level of "world of classical worlds" (WCW) its is realized as discretization of general coordinate invariant parameters characterizing the 2-surfaces [K117].

This allows to avoid problems related to general coordinate invariance and symmetries that plagued the earlier proposal based on cognitive maps of discrete points sets of real space-time surfaces to p-adic ones or vice versa.

There is no local correspondence between real and p-adic space-time surface by a common points of embedding space in the algebraic extension of rationals as suggested in the earlier proposal [K120]: the p-adic-real connection is global. Real and p-adic preferred extremals share 2-surfaces with parameters in algebraic extension of rationals identifiable as either real or p-adic numbers.

(b) The existence of 4-D representation is guaranteed by strong form of holography if additional correlations between 2-surfaces hold true. For generic 2-surfaces continuation is possbile in p-adic sectors but is not unique and can be interpreted in terms of imaginery.

(c) Cognitive representations would naturally correspond to this 2-D representation since the reduction of information would be huge. Since the continuation to p-adic space-time surface for obvious reasons is not unique, conceptualization abstracting out the common aspects of the 4-D representations is necessary and forces the development of cognition and abstraction to see what the correlations between 2-surfaces guaranteeing realizable imagery are. Abstraction allows symbolic representation and imagination.

(d) The fundamental representation would be in terms of fermionic strings connecting partonic 2-surfaces, which can have arbitrarily large size (h_{eff} hierarchy). Sound is a phenomenon which is always associated with the relative motion of particles rather than single particle and in this sense differs from elementary particles. The oscillations of these strings could define sound as a fundamental phenomenon, and fermionic strings could be highly analogous to strings of music instrument.

(e) At the light-like partonic orbits defining the "lines" of generalized Feynman diagrams (or rather generalized twistor diagrams) the signature of the induced metric changes from Euclidian to Minkowskian. These light-like 3-surfaces correspond to boundaries of physical objects and the ends of strings at them define fermion lines in twistor diagrams [K109]. At partonic 2-surfaces at the boundaries of CDs the discretization consists of a collection points in accordance with naïve expectations.

Second representation would be in terms of 4-D surfaces themselves and corresponds to the sensory representations in real context. 4-D real representation is much more detailed, concrete, and holistic. In some cases the concreteness of the representation makes it superior. Consider only the miraculous feats of mathematician Ramajunan or physicist Tesla, who could see his thoughts. This representation cannot of course not complete and by the huge super-symplectic symmetries the representation should involve only very general characteristics. This representation would be naturally realized at the level of field body (massless extremals and magnetic body).

(a) The flux tubes of the MB carrying dark fermions realized at fermionic string world sheets would be part of the 4-D representation. Magnetic flux tubes are indeed in a key role in TGD inspired theory of consciousness and of living matter.

(b) Massless extremals (MEs or topological light rays) accompanying magnetic flux tubes and having also tube-like structure are extremals of Kähler action (very probably also preferred ones) represent a propagation of arbitrary radiation pulse to either direction but the superposition of pulses propagating to opposite directions is impossible. The shape of the pulse is not changed during propagation, the signal is precisely targeted, and it propagates with maximal signal velocity. Classic analog of laser beam is in question.

(c) Cyclotron frequencies, which are typically determined by lengths of magnetic flux tubes and by the values of magnetic fields at them, would be a natural parameters capturing gross geometric features of space-time surface. Note that also Kähler magnetic field is a geometric notion in TGD framework since classical gauge fields are geometrized in terms of sub-manifold geometry.

Also the scale of CD determined by the temporal distance between its tips defines a natural resonance frequency spectrum.

7.4.2   How Nerve Pulses And EEG Could Relate To 2-D And 4-D Representations?

How nerve pulses and EEG relate to the 2-D and 4-D fundamental representations? The answer is not straightforward. The description of neuroscience is not based on many-sheeted space-time having fractal hierarchy of space-time sheets, and there are many layers of approximations involved. It also seems that neuroscience misses an important element related to MB - the "motor actions" of MB (hierarchy of them) and MEs, in particular braiding of flux tubes identifiable as braid strands and are accompanied by strings.

(a) Resonance frequencies of EEG realized using MEs parallel to flux tubes could relate to frequency representation serving as a correlate for large scale quantum coherence. MB would coordinate the behavior of brain in this manner. alpha band and kHz synchrony would be examples of this.

(b) Neuroscience does not provide direct analog of 2-D representation responsible for cognitive memories. In TGD based model for DNA as topological quantum computer [K2, K114] it is assumed that nucleotides or codons are connected by flux tubes to the lipids of the internal lipid layer of the nuclear or even cell membrane. Same can hold true for microtubules and axonal membrane. Also connections between lipid layers and connections of outer lipid layers to lipid layers of other cell membranes are possible.

(c) Axonal microtubules are very natural as far as cognitive memory representations are considered. The propagation of nerve pulse induces flow of the 2-D liquid defined by lipids and induces braiding of the flux tubes connecting axonal membrane to microtubules. One has two braidings: time-like braiding analogous to that generated by dancers on the floor and space-like braiding generated if dancers feet are connected to a wall (now DNA strand). Space-like braiding stores time-like braiding to memory. The 2-D representation would be naturally associated with the braid strands idealized as strings. These effectively 2-D braid representations would form a fractal hierarchy and be basic aspect of biology.

(d) The value of h_{eff} for the magnetic body part associated with a given brain area defines how long the span of long term memory and planned action for the brain region in question is and can be used to explain also the difference between right and left hemispheres as also difference between individuals without any additional assumptions. Quite generally, the spectrum of h_{eff} would explain the skill profile of individual.

7.4.3   How The Two Representations Could Be Realized At The Level Of MB?

How the two representations could be realized at MB - ME complexes?

(a) Effective 2-D representation could involve supra currents propagating along the flux tubes of MB. Supra current is of course practical higher level notion idealizing fermions and Cooper pairs with point like objects. At basic level one has pairs of fermions at different partonic 2-surfaces connected by strings. The string connecting the partonic 2-surfaces of the members of Cooper pair and its oscillations would correspond to the fundamental level.

A possible realization of effectively 2-D representation in terms of fermion currents or supra currents is discussed in [K78] [L22, L19]. The discussion was inspired by the observation that SmB_6 behaves in "schizophrenic" manner in external magnetic field: it is topological insulator but conducts current in scales of order 10^{-4} m and conduction velocity is million times higher than expected [L22].

In de Haas-van Alphen effect (`http://tinyurl.com/ych7b9n8`) the magnetization depends periodically as function on the inverse value of the external magnetic field. The effect leads to an explanation of the paradoxical phenomenon. Magnetic flux tubes become carrier of dark electron currents at quantum criticality defined as value of magnetic field at which a new cyclotron orbit emerges at the surface of flux tube with fixed thickness. This flux tube must correspond to electron energy which is very near to the Fermi energy. This indeed requires quantum criticality.

If electron density (and thus Fermi energy) is kept constant, quantum criticality is realized only for discrete values of magnetic field strength allowing the generation of quantum critical cyclotron orbit carrying dark electrons (say). If electron density can vary and magnetic field strength is fixed, then certain values of electron density allow quantum criticality and dark electron current along flux tube. The variation of electron density could be the natural control variable in the case of nerve pulses. Part of electron current would leak out to MB as dark current.

(b) Frequency representation could be realized in terms classical em fields (MEs) assignable to EEG and its variants and having as quantum counterparts dark photons assignable to flux tubes. EEG resonance frequencies should correspond to cyclotron frequencies. Flux tube thickness determining the value of magnetic field is at criticality must be such that the cyclotron frequencies correspond to generalized Josephson frequencies in order to make possible the communication of the variations of membrane potential to the MB. In both cases quantum criticality making possible the presence of dark matter at flux tubes is necessary and makes possibly transformation of electrons to dark matter phase with $h_{eff}/n = n$.

7.4.4 What The Specialization Of The Brain Hemisphere To 2-D Or 4-D Representation Could Mean?

"Right brain signs, left brain talks" metaphor should have concrete content and the 2-D and 4-D representations could could provide this content. The challenge is to understand how this specialization might be realized.

The specialization to a particular representation cannot take place at the level of neuro-anatomy. The specialization should therefore occur at the level of MB.

(a) Could the magneto-anatomies of the left- and right MBs differ? Or is the magneto-anatomy universal and differentiation leads to different magneto-physiologies. The latter option looks more feasible. Differentiation would select the available quantum criticalities in turn selecting which representation is used. This option is certainly the most flexible one.

(b) Also the values of h_{eff} involved characterizing the size of MB matter: the larger the value of MB, the higher the magnetic IQ. This would suggests that magnetic bodies are present but the time scale of corresponding long term memories and planned actions depends on the value of h_{eff}. The growth of magnetic body would be intellectual development.

(c) In left hemisphere only cognitive areas (including frontal lobes) could have access go MB with large h_{eff} or access to it (ability to generate the needed quantum criticality) making possible long term cognitive memories. In right hemisphere only sensory areas could have access MB with large h_{eff}.

(d) The universality of magneto-anatomy is also consistent with the enormous flexibility of brain. For instance, for patients with very bad epileptic seizures brain hemispherectomy (http://tinyurl.com/ycszpb5k) can be the only possible treatment. Usually this operation is carried out at age below four years since at this age brain is still developing and at higher age complications appear (I do not know whether there exists detailed data about the character of these complications). Surprisingly, the operation has no apparent effect on personality or memory (http://tinyurl.com/nppk9vc)! In particular, entire left or right hemisphere can be removed.

(e) The most flexible and still metabolically feasible (by $E = h_{eff}f$ large h_{eff} photons are metabolically very costly!) option is that the magneto-anatomy of all cells is same and that the character of quantum criticality available determines, which option can be used. The specialization would be at the level of magneto-physiology fixing what control knobs are available and large h_{eff} photons would be generated only when needed.

This option would be minimun option conforming with "right brain sings, left brain talks" metaphor. Even if the access is possible at both sides, metabolic economy would favor specialization meaning that left hemisphere develops cognitive long term memories and skills and right hemisphere their sensory counterparts. The observation that he damage for the left hemisphere causes cognitive defects can be understood: right brain hemisphere comes in rescue but it has generated only long term sensory memories with large h_{eff} whereas cognitive memories are short term memories and cognitive skills are much weaker. Also the loss of autobiographical memory in the damage of right hemisphere can be understood if right brain is specialized to produce this kind of episodal memories.

This option also allows to understand the magic mathematical skills if these skills are associated with some region of the right hemisphere. The skill in question would be more analogous to sensory perception rather than cognition. For instance, a possible explanation for the miraculous ability to "see" the decomposition of an integer to primes is that it is a visual representation for the dark phase transition in which a phase characterized by $h_{eff}/h = n_1 n_2$ transforms to a phase characterized by $h_{eff}/h = n_i$, $i = 1$ or 2.

7.4.5 Fractal Hierarchy Of Binary Structures And Realization Of Two Kinds Of Representations

Many basic structures of living matter serving as basic units of consciousness have binary structure and this has already earlier led to the idea that one has fractal hierarchy of binary structures analogous to pairs of brain hemispheres. It seems natural to assume that pulse and frequency representations are realized and the right-left asymmetry suggests that second member of pair produces frequency representation and second member the pulse representation.

Twin primes are pairs $(k, k+2)$ of primes and seems to be of special importance. As **Table 7.1** below demonstrates, there is large number of these pairs in biologically relevant length scales and they might correspond to twin structure forming a fractal hierarchy especially interesting from the point of view of consciousness. The members of first few twin primes are of form $n \pm 1$ for $n = 4, 6, 12, 18, 30, 42, 60, 72, 102, 108, 138, 150, 180, 192, 198, 228, 240, 270, 282, ...$

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

In the following only few examples are considered.

(a) DNA double strand has binary structure: one strand is active and second one passive as far as transcription is considered. There are also portions for which the two strands

$(k, k+2)$	$(137, 139)$	$(149, 151)$	$(167, 169 = 13^2)$	$(179, 181)$
$L_e(k)$	.78 A	5 nm	2.5μm	.16 mm
$(k, k+2)$	$(191, 193)$,	$(197, 199)$		
$L_e(k)$	1 cm	8 cm		

Table 7.1: Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair $(167, 13^2 = 169)$ although $k = 169$ is not prime. The two largest scales could relate to structures appearing in brain. Note that the primes $k = 151, 157, 163, 167$ correspond to Gaussian Mersennes. The appearance of so many Gaussian Mersennes in the length scale interval between cell membrane thickness and the size of cell nucleus is a number theoretical miracle.

are identical: these correspond to palindromic sequences of DNA. These palindromes serve as control units initiating transcription of gene.

An analogous symmetric structure in brain is pineal gland, which Descartes identified as seat of soul. One might think that MB controls gene expression through the palindromes and MB of the entire brain via the pineal gland. There are also other glands performing hormone control, and they could also serve as lower level relay stations controlling brain hemispheres rather than entire brain.

(b) Nuclear and cell membranes consist of two lipid layers and correspond to *primary* p-adic length scales $k = 149$ and $k = 151$ (both integers are primes): the latter corresponds to Gaussian Mersenne. I have proposed that this double layer has the structure of generalized Josephson junction [K80]. Similar Josephson junction structure could be associated with DNA double strand. The generalized Josephson frequencies would give rise to EEG in terms of large h_{eff} dark photons with energies in visible and UV range characterizing bio-photons.

Frequency modulation of generalized Josephson frequencies by nerve pulse patterns would assign to the nerve pulse representation at axons the frequency representation communicated to the MB. This leads to ask whether the Josephson currents between brain hemispheres possibly running through corpus callosum define give rise to an analog of EEG at low frequencies? This Josephson junction would be of special importance for the music consciousness.

(c) Twin primes could define binary pairs forming both kinds of sensory representations. The pair (179,181) corresponds to primary p-adic scales (.16-.32) mm perhaps assignable to epithelial sheets, which are double cell layers appearing in skin. The pair (191,193) corresponds to primary scales (1.0,2.0) cm perhaps assignable to the basic structural units of cortex. The pair (197,199) corresponds to primary length scales (9, 18) cm naturally assignable to brain hemispheres.

(d) There are also several highly interesting primary p-adic length scales associated with twin primes and Gaussian Mersennes possibly having relevance as size scales of structures relevant for biosphere but these will not be discussed here.

The *secondary* p-adic time scales associated with Gaussian Mersennes and twin primes $(k, k+2)$ might be interesting from the point of view of memory long.

(a) Consider first Gaussian Mersennes. For $k = 127$ associated with electron the secondary time scale is .1 seconds defining the fundamental biorhythm and this time scale defines the duration of sensory mental image. For $k = 151$ associated with Gaussian Mersenne the secondary time cale is by a factor $2^{151-127} = 2^{24}$ longer and roughly 1.6×10^6 seconds, about 18 days. For $k = 157$ the time scale is 64 times longer - 10^8 seconds, roughly 3 years. For $k = 163$ the time scale is 64 times longer and about 200 years. Could these time scales define preferred size scales for MBs and time scales of long term memory? Note that the scales is of order Earth circumference already for $k = 127$.

(b) The twin pair $(137, 139)$ could correspond to time scales 3.2 sec and 6.4 sec perhaps assignable to short term memory. The twin pair $(149, 151)$ would correspond to time scales of 9 days and 18 days.

7.4.6 Absolute Pitch

Absolute pitch can be seen as right brain aspect of consciousness. Sensory memories are involved and I have already discussed the TGD based model for them. Sensory memories allow to literally hear the piece of music repeatedly and build associations to note, piano key, or even to frequency.

That rational frequency ratios (in Pythagorean scale coming as powers $(3/2)^k$ reduced to the lowest octave by octave equivalence are preferred might relate to the number theoretic vision about evolution as emergence of higher dimensional algebraic extensions of rationals. The lowest level would correspond to rational numbers.

Absolute scale does not only mean that the ratios of frequencies that a person with absolute pitch prefers are rational. It means also that there is indeed absolute scale and music in other scales is different and in some cases even non-recognizable as same music piece.

Interestingly, the range of visible frequencies is one octave suggesting that there might be a deep connection between music and vision. Sacks tells that already Newton considered the possibility that the 8 notes correspond to some colors of light. TGD inspired mode geometric model for harmony [K79] [L16, L12] leads to analogous correspondence.

(a) I have considered this connection in detail in the geometric model of harmony providing also a model of genetic code [K79]. The first observation is that 12-note scale has as many notes as there are vertices at icosahedron, one of the Platonic solids. Second observation is that icosahedron has 20 triangles as faces and that also the number of amino-acids is 20.

This inspires the idea that given harmony corresponds to so called Hamiltonian cycle, which is a closed (by octave equivalence) non-self-intersecting curve connecting neighboring vertices at icosahedron and going through all vertices. Single step between neighboring points of the curve correspond to single quint (scaling of frequency by factor 3/2): the idea is that notes differing by quint are 3-adically near to each other. Each Hamiltonian cycle defines one particular harmony with 3-chords defined by the 20 triangles. There are 17 different harmonies and 11 of them have symmetries.

(b) The surprise is that one can understand the degeneracies of the genetic code defined as numbers of DNAs coding for given amino-acid for 60 DNAs in terms of the symmetries of Hamiltonian cycles. 4 DNAs are however lacking. There is also second problem: 12 quints corresponds to slightly more than 7 octaves so that projection to the same octave gives 13 rather than 12 notes with two notes very near to each other: this problem was familiar already for Pythagoras.

The handling of these problem requires addition of tetrahedron bringing in also 4 additional DNAs and 2 additional amino-acids known to be coded in some circumstances by DNA in all organisms (Pyl and Sec). One obtains actually two slightly different genetic codes, and can ask whether the two DNA strands speak different dialects of the same language.

(c) The model maps genetic codons consisting of 3 nucleotides to triangles to 3-chords and the allowed 64 chords define what I call bio-harmony. 256 different bioharmonies consistent with genetic code are predicted. These harmonies have as buildingbricks harmonies consisting of 20 allowed 3-chords.

(d) The model leads to the proposal that the fundamental realization of the genetic code could be in terms of dark photons with frequencies, which could be in the range of audible frequencies. Also the representation in terms of dark photons is suggestive and since living matter is piezoelectric it could allow to transform dark phonons to dark photons and vice versa.

If the last step of this argument is accepted, the problem of understanding absolute scale reduces to the physical identification of the special dark cyclotron frequency - call it f_0. It could correspond to note C (say). Neuroscientist would explain this special frequency as a resonance frequency of some neural circuit - for instance, thalamocortical resonance frequency around 40 Hz is assumed to result in this manner. In TGD framework the presence of MB changes the situation.

(a) The first step is to accept that the identification of gravitational Planck constant $\hbar_{gr} = GMm/v_0$ with $\hbar_{eff} = n \times \hbar$ [K71, **?**] (M and m are masses connected by magnetic flux tube mediating the gravitational interaction and v_0 is velocity parameter [K93, **?**, K71]). This fixes the value of $h_{eff}/h = n$ and implies that the spectrum of cyclotron energies does not depend on the mass of charged particle and depending on the magnetic field strength only. Bio-photon energy spectrum corresponds to the spectrum of magnetic field strengths. The condition that the energy spectrum is in the scale of bio-photon energies belonging to the range of excitations energies of biomolecules (visible and UV range) fixes the value of n if the value of magnetic field and mass of charged particle is fixed to.

(b) An interesting - perhaps too science fictive - possibility giving a justification for 12-note scale at fundamental level would be that the octave spanned by visible photon energies corresponds to 12-note scale realized as powers of 3/2 modulo 2 for this magnetic field strength, call it B_0. In this case different ions would correspond to scaled variants of basic spectrum with scaling factor given the ratio $q_0 A_i/q_i A_0$ of mass numbers, where A_0 is the mass number of the reference ion and q_0 is its charge, say H^+. One would obtain preferred keys related by these scalings. This is of course only one possibility.

Some bio-molecular transition energy fixes the basic frequency and therefore the value of B_0 and perhaps also other frequencies. DNA absorbs UV light at wavelength of 260 nm and energy 4.8 eV: the highest energy of visible photon energy is around 3.2 eV and correspond to wavelength of 390 nm. The ratio of this energies is 3/2 - one quint! Maybe this is not a pure accident.

$B_0 = .2$ Gauss is suggested as the preferred value of endogenous magnetic field by the original observations that ELF em fields have quantal looking effects on verterbrate brain [K70, K35]. If this value is accepted, one can deduce the value of $h_{eff}/h = n$ for reference ion. The optimal choice is to take the reference ion as H^+ since the masses are in a good approximation integer multiples of proton so that the values of h_{eff} are approximately $n_i(ion) = A_i \times n_i(proton)$ and thus integer valued. For $B_0 = .2$ Gauss proton cyclotron frequency is 300 Hz. Ion frequencies are in EEG spectrum. The higher powers of 3/2 give higher octaves and frequencies in audible range. 10 actaves would give audible range.

(c) The two kinds of representations are possible if the quantum criticality condition for cyclotron resonance in case of frequency representation or for the generation of electronic supra currents in the case of pulse representation is satisfied. This would fix the value of the magnetic field strength B_0 for H^+.

Chapter 8

Is Non-associative Physics and Language Possible only in Many-Sheeted Space-time?

8.1 Introduction

In Thinking Allowed Original (see `https://www.facebook.com/groups/thinkallowed/`) there was very interesting link added by Ulla about the possibility of non-associative quantum mechanics (see `http://phys.org/news/2015-12-physicists-unusual-quantum-mechanics.html#jCp`).

Also I have been forced to consider this possibility.

(a) The 8-D embedding space of TGD has octonionic tangent space structure and octonions are non-associative. Octonionic quantum theory however has serious mathematical difficulties since the operators of Hilbert space are by definition associative. The representation of say octonionic multiplication table by matrices is possible but is not faithful since it misses the associativity. More concretely, so called associators associated with triplets of representation matrices vanish. One should somehow transcend the standard quantum theory if one wants non-associative physics.

(b) Associativity seems to be fundamental in quantum theory as we understand it recently. Associativity is a fundamental and highly non-trivial constraint on the correlation functions of conformal field theories. It could be however broken in weak sense: as a matter of fact, Drinfeld's associator emerges in conformal field theory context. In TGD framework classical physics is an exact part of quantum theory so that quantum classical correspondence suggests that associativity could play a highly non-trivial role in classical TGD. The conjecture is that associativity requirement fixes the dynamics of space-time sheets - preferred extremals of Kähler action - more or less uniquely. One can endow the tangent space of 8-D imbedding $H = M^4 \times CP_2$ space at given point with octonionic structure: the 8 tangent vectors of the tangent space basis obey octonionic multiplication table.

Space-time realized as n-D surface in 8-D H must be either associative or co-associative: this depending on whether the tangent space basis or normal space basis is associative. The maximal dimension of space-time surface is predicted to be the observed dimension $D = 4$ and tangent space or normal space allows a quaternionic basis.

(c) There are also other conjectures [K109] about what the preferred extremals of Kähler action defining space-time surfaces are.

    i. A very general conjecture states that strong form of holography allows to determine space-time surfaces from the knowledge of partonic 2-surfaces and 2-D string world sheets.

ii. Second conjecture involves quaternion analyticity and generalization of complex structure to quaternionic structure involving generalization of Cauchy-Riemann conditions.

iii. $M^8 - M^4 \times CP_2$ duality stating that space-time surfaces can be regarded as surfaces in either M^8 or $M^4 \times CP_2$ is a further conjecture.

iv. Twistorial considerations select $M^4 \times CP_2$ as a completely unique choice since M^4 and CP_2 are the only spaces allowing twistor space with Kähler structure. The conjecture is that preferred extremals can be identified as base spaces of 6-D sub-manifolds of the product $CP_3 \times SU(3)/U(1) \times U(1)$ of twistor spaces associated with M^4 and CP_2 having the property that it makes sense to speak about induced twistor structure.

The "super(optimistic)" conjecture is that all these conjectures are equivalent.

The motivation for what follows emerged from the observation that language is an essentially non-associative structure as the necessity to parse linguistic expressions essential also for computation using the hierarchy of brackets makes obvious. Hilbert space operators are however associative so that non-associative quantum physics does not seem plausible without an extension of what one means with physics. Associativity of the classical physics at the level of *single* space-time sheet in the sense that tangent or normal spaces of space-time sheets are associative as sub-spaces of the octonionic tangent space of 8-D embedding space $M^4 \times CP_2$ is one of the key conjectures of TGD.

But what about many-sheeted space-time? The sheets of the many-sheeted space-time form hierarchies labelled by p-adic primes and values of Planck constants $h_{eff} = n \times h$. Could these hierarchies provide space-time correlates for the parsing hierarchies of language and music, which in TGD framework can be seen as kind of dual for the spoken language? For instance, could the braided flux tubes inside larger braided flux tubes inside... realize the parsing hierarchies of language, in particular topological quantum computer programs? And could the great differences between organisms at very different levels of evolution but having very similar genomes be understood in terms of widely different numbers of levels in the parsing hierarchy of braided flux tubes- that is in terms of magnetic bodies as indeed proposed. If the intronic portions of DNA connected by magnetic flux tubes to the lipids of lipid layers of nuclear and cellular membranes make them topological quantum computers, the parsing hierarchy could be realized at the level of braided magnetic bodies of DNA.

Fortunately the mathematics needed to describe the breaking of associativity at fundamental level seems to exist. The hierarchy of braid group algebras forming an operad combined with the notions of quasi-bialgebra and quasi-Hopf algebra discovered by Drinfeld are highly suggestive concerning the realization of weak breaking of associativity. With good luck this breaking of associativity is all that is needed. With not so good luck this breaking of associativity takes place already at the level of single space-time sheets and something else is needed in many-sheeted space-time.

8.2 Is Non-associative Physics Possible In Many-sheeted Space-time?

The key question in the sequel is whether non-associative physics could emerge in TGD via *many-sheeted* space-time as an outcome of many-sheetedness and therefore distinguishing TGD from GRT and various QFTs.

8.2.1 What Does Non-associativity Mean?

To answer this question one must first understand what non-associativity could mean.

(a) In non-associative situation brackets matter. $A(BC)$ is different from $(AB)C$. Here AB need not be restricted to a product or sum: it can be anything depending on A and B.

From schooldays or at least from the first year calculus course one recalls the algorithm: when calculating the expression involving brackets one first finds the innermost brackets and calculates what is inside them, then proceed to the next innermost brackets, etc... In computer programs the realization of the command sequences involving brackets is called parsing and compilers perform it. Parsing involves decomposition of program to modules calling modules calling.... Quite generally, the analysis of linguistic expressions involves parsing. Bells start to ring as one realizes that parsings form a hierarchy as also do the space-time sheets!

(b) More concretely, there is hierarchy of brackets and there is also a hierarchy of space-time sheets labelled by p-adic primes and perhaps also by Planck constants $h_{eff} = n \times h$. B and C inside brackets form (BC), something analogous to a bound state or chemical compound. In TGD this something could correspond to a "glueing" space-time sheets B and C at the same larger space-time sheet. More concretely, (BC) could correspond to braided pair of flux tubes B and C inside larger flux tube, whose presence is expressed as brackets (..). As one forms $A(BC)$ one puts flux tube A and flux tube (BC) containing braided flux tubes B and C inside larger flux tube. For $(AB)C$ flux one puts tube (AB) containing braided flux tubes A and B and tube C inside larger flux tube. The outcomes are obviously different.

(c) Non-associativity in this sense would be a key signature of many-sheeted space-time. It could show itself in say molecular chemistry, where putting on same sheet could mean formation of chemical compound AB from A and B. Another highly interesting possibility is hierarchy of braids formed from flux tubes: braids can form braids, which in turn can form braids,... Flux tubes inside flux tubes inside... Maybe this more refined breaking of associativity could underly the possible non-associativity of biochemistry: biomolecules looking exactly the same would differ in subtle manner.

(d) What about quantum theory level? Non-associativity at the level of quantum theory could correspond to the breaking of associativity for the correlation functions of n fields if the fields are not associated with the same space-time sheet but to space-time sheets labelled by different p-adic primes. At QFT limit of TGD giving standard model and GRT the sheets are lumped together to single piece of Minkowski space and all physical effects making possible non-associativity in the proposed sense are lost. Language would be thus possible only in TGD Universe!

8.2.2 Language And Many-sheeted Physics?

Non-associativity is an essentially linguistic phenomenon and relates therefore to cognition. p-Adic physics labelled by p-adic primes fusing with real physics to form adelic physics are identified as the physics of cognition in TGD framework.

(a) Could many-sheeted space-time of TGD provides the geometric realization of language like structures? Could sentences and more complex structures have many-sheeted space-time structures as geometrical correlates? p-Adic physics as physics of cognition would suggest that p-adic primes label the sheets in the parsing hierarchy. Could bio-chemistry with the hierarchy of magnetic flux tubes added, realize the parsing hierarchies?

(b) DNA is a language and might provide a key example about parsing hierarchy. The mystery is that human DNA and DNAs of most simplest creatures do not differ much. Our cousins have almost identical DNA with us. Why do we differ so much? Could the number of parsing levels be the reason- p-adic primes labelling space-time sheets? Could our DNA language be much more structured than that of our cousins. At the level of concrete language the linguistic expressions of our cousin are indeed simple signals rather than extremely complex sentences of old-fashioned German professor forming a single lecture each. Could these parsing hierarchies realize themselves as braiding hierarchies of magnetic flux tubes physically and - more abstractly - as analos of parsing hierarchies for social structures. Indeed, I have proposed that the presence of collective

levels of consciousness having the hierarchy of magnetic bodies as a space-time correlates distinguishes us from our cousins so that this explanation is consistent with more quantitative one relying on language.

(c) I have also proposed that intronic portion of DNA is crucial for understanding why we differ so much from our cousins [K2, K114]. How does this view relate to the above proposal? In the simplest model for DNA as topological quantum computer introns would be connected by flux tubes to the lipids of nuclear and cell membranes. This would make possible topological quantum computations with the braiding of flux tubes defining the topological quantum computer program.

Ordinary computer programs rely on computer language. Same should be true about quantum computer programs realized as braidings. Now the hierarchical structure of parsings would correspond to that of braidings: one would have braids, braids of braids, etc... This kind of structure is also directly visible as the multiply coiled structure of DNA. The braids beginning from the intronic portion of DNA would form braided flux tubes inside larger braided flux tubes inside.... defining the parsing of the topological quantum computer program. The higher the number of parsing levels, the higher the position in the evolutionary hierarchy. Each braiding would define one particular fundamental program module and taking this kind of braided flux tubes and braiding them would give a program calling these programs as sub-programs.

(d) The phonemes of language have no meaning to us (at our level of self hierarchy) but the words formed by phonemes and involving at basic level the braiding of "phoneme flux tubes" would have. Sentences and their substructures would in turn involve braiding of "word flux tubes". Spoken language would correspond to temporal sequences of braidings of flux tubes at various hierarchy levels.

(e) The difference between us and our cousins (or other organisms) would not be at the level of visible DNA but at the level of magnetic body. Magnetic bodies would serve as correlates also for social structures and associated collective levels of consciousness. The degree of braiding would define the level in the evolutionary hierarchy. This is of course the basic vision of TGD inspired quantum biology and quantum bio-chemistry in which the double formed by organism and environment is completed to a triple by adding the magnetic body.

8.2.3   What About The Hierarchy Of Planck Constants?

p-Adic hierarchy is not the only hierarchy in TGD Universe: there is also the hierarchy of Planck constants $h_{eff} = n \times h$ giving rise to a hierarchy of intelligences. What is the relationship between these hierarchies?

(a) I have proposed that speech and music are fundamental aspects of conscious intelligence and that DNA realizes what I call bio-harmonies in quite concrete sense [L12] [K79]: DNA codons would correspond to 3-chords. DNA would both talk and sing. Both language and music are highly structured. Could the relation of h_{eff} hierarchy to language be same as the relation of music to speech?

(b) Are both musical and linguistic parsing hierarchies present? Are they somehow dual? What does parsing mean for music? How musical heard sounds could give rise to the analog of braided strands? Depending on the situation we hear music both as separate notes and as chords as separate notes fuse in our mind to a larger unit like phonemes fuse to a word. Could chords played by single instrument correspond to braidings of flux tubes at the same level? Could the duality between linguistic and musical intelligence (analogous to that between function and its Fourier transform) be very concrete and detailed and reflect itself also as the possibility to interpret DNA codons both as three letter words and as 3-chords [L12]?

8.3 Braiding Hierarchy Mathematically

More precise formulation of the braided flux tube hierarchy leads naturally to the notions of braid group and operad that I have considered earlier. They have a close relationship with quantum groups - more precisely, bialgebras and Hopf algebras and their generalizations quasi-bialgebras and quasi-Hopf algebras, which in turn allow to characterize what might be called minimal breaking of associativity in terms of Drinfeld associator. These notions are already familiar from conformal field theories and string theories them so that there are good hopes that no completely new mathematics is not needed.

It must be made clear that I am not a mathematician and the following is just a modest attempt to understand what the problem is. I try to identify the algebraic structure possibly allowing to realize the big vision and gather some results about these structures from Wikipedia: I confess that I do not understand the formulas at the deeper level and my goal is to find their physical interpretation in TGD framework.

8.3.1 How To Represent The Hierarchy Of Braids?

Before going to web to see how modern mathematics could help in the problem, try first to formulate the situation more concretely. One must consider a more detailed representation for braids and for their hierarchy.

Consider first rough physical geometric view about braids of braids represented in terms of flux tubes.

(a) Braid strands have two ends: one can label them as "lower" and "upper". Flux tubes can be labelled by p-adic prime p and $h_{eff} = n \times h$. Magnetic flux tubes can carry monopole flux and this could be crucial for the breaking of associativity - at least it is so in the proposed model (see `http://tinyurl.com/y7oom5kh`). The possibility of apparent magnetic monopoles in TGD framework indeed involves many-sheetedness in an essential manner: monopole flux flows from space-time sheet to another one through wormhole contact. This can be taken as one possible hint about the concrete physics involved.

(b) One can get more precise picture by using formulas. One has labelling of flux tubes by primes p and Planck constants h_{eff}: to be short call this label $a, b, c, ...$ Since the values of p and h_{eff} are graded one could also speak of grading. The states for given value of a assignable to braid strands are labelled by the quantum states $A, B, ...$ associated with them and analogous to algebra elements. One must however consider all possible situations so that has operators $A_a, B_a, ...$ analogous to algebra elements of a graded algebra about which Clifford algebras and super-algebras are familiar examples.

(c) Consider now the physical interpretation for the breaking of associativity. For ordinary associative algebra one considers $A(BC) = (AB)C$. This condition as such make sense if $A(BC)$ and $(AB)C$ are inside same flux tube and perhaps also that the strands A, B, C are not braids. In the general case one must must add the labels a, b, c, d and a, b_1, c_1, d_1 and one obtains $((A_d B_d)_c)C_b)_a$ and $(A_{b_1}(B_{d_1} C_{d_1}))_{c_1})_a$. Obviously, these two states need not identical unless one has $a = b = c = d = b_1 = c_1 = d_1$, which is also possible and means that all strands are at the same flux tube labelled by a. The challenge is to combine various almost copies of algebraic structure defined by braidings and labelled by $a, b, ..$ to larger algebraic structure and formulate the breaking of associativity for this structure.

8.3.2 Braid Groups As Coverings Of Permutation Groups

Consider next the definition of braid group.

(a) The notion of braiding can be algebraized using the notion of braid group B_n of n strands, which is covering of the permutation group S_n. For ordinary permutations

generating permutations are exchanges of P_i two neighboring elements in the ordered set $(a_1, ..., a_n)$: $(a_i, a_{i+1}) \rightarrow (a_{i+1}, a_i)$. Obviously one has P_i^2 so that permutation is analogous to reflection. For braid group permutation is replaced to twisting of neighboring braid strand. It looks like permutation if one looks at the ends of strands only. If one looks entire strands, there is no reason to have $P_i^2 = 1$ except possibly for the representation of braid group. For arbitrarily large n that one has $P_i^n \neq 1$. 2-D braid group B_n can be represented as a homotopies of 2-D plane with n punctures identifiable as ends of braid strands defined by their non-intersecting orbits.

(b) At the level of quantum description one must allow quantum superpositions of different braidings and must describe the quantum state of braid as wave function in braid group: one has element of group algebra of braid group. To each element of braid group one can assign unitary matrix representing the braiding and this unitary matrix would define a "topological time evolution" defined by braiding transforming the initial state at the lower end of braid to the state at upper end of braid. Hence it seems that braid group algebra is the proper mathematical notion. One has quantum superposition of topological time evolutions: something rather abstract.

8.3.3   Braid Having Braids As Strands

Many-sheeted space-time makes possible fractal hierarchy of braids. Braid group in above sense would act on flux tubes at the same space-time sheets or space-time of QFT and GRT. Braids can have as strands braids so that there is hierarchy of braiding levels. The hierarchy of coilings of DNA provides a simple example (very simple having not much to do with the hierarchy of braidings for flux tubes).

(a) Suppose that one has only two levels in the hierarchy. One has n braid strands/flux tubes altogether and there are k larger flux tubes containing n_i, $i = 1, .., k$ flux tubes so that one has $\sum_{i=1}^{k} n_i = n$. One can imagine a coloring of the braid strands inside given flux tube characterizing it. Only braid strands inside same flux tube - with the same color - can be braided. The full braid group B_n braiding freely all n braid strands is restricted to a subgbroup $B_{n_1} \times .... \times B_{n_2}$. This group can be regarded as subgroup of B_n so that permutations of B_{n_i} have a well-defined outcome, which seems however to be trivial classically. In quantum situation the exchange of the factors B_{n_i} however corresponds to braiding and for non-trivial quantum deformations its action is non-trivial. One has braided commutativity instead of commutativity.

(b) Besides this there are braidings for the k braids of braids and this gives braid group B_k acting at upper level of hierarchy. Clearly the higher level braids b_i, $i = 1, ..., k$ and lower level braids b_{ij}, $j = 1, ..., n_i$ form a two-levelled entity. The braid groups B_k and B_{n_i} form an algebraic entity such that B_k acts by permuting the entities. Same holds true for the braid group algebras. This structure generalizes to an entire hierarchy of braid groups and their group algebras.

The hierarchy of braid group algebras seems to closely relate to a very general notion known as operad (see `http://tinyurl.com/yavyhcsk`). The key motivation of the operad theory is to model the computational trees resulting from parsing. The action of permutations/braidings on the basic objects is central notion and one indeed has hierarchy of symmetric groups/braid groups such that the symmetric/braid group at $n + 1$:th level permutes/braids the objects at n:th level. Now the objects would be braids whose strands are braided. The braids can be strands of higher level braids and these strands can be braided. The action of braidings extends to that on braid group algebras defining candidates for wave functions.

8.4   General Formulation For The Breaking Of Associativity In The Case Of Operads

The formulas characterizing weak form of associativity by Drinfeld and others look rather mysterious without understanding of their origins. This understanding emerges from very simple but general basic arguments. Instead of studying given algebra one transcends to a higher abstraction level and studies - not the results of algebraic expressions - but the very process how the algebraic expression is evaluated and what kind of rules one can pose on it. The rules can be abstracted to what is called algebraic coherence.

The evaluation process - parsing - starts from inner most brackets and proceeds outwards so that eventually all brackets have disappeared and one has the value for the expression. This process can be regarded as a tree which starts from n inputs which are algebra elements, in the recent case they could be braid group algebra elements.

For instance, $(AB)C$ corresponds to an tree in which A, B, C are the branches. As one comes downwards, A and B fuse in the upper node and AB and C in the lower node. One manner to see this is as particle reaction proceeding backwards in time. For $A(BC)$ B and C fuse to BC in the upper node and A and BC at the lower node. Associativity says that the two trees give the same result. "Braided associativity" would say that these trees give results differing by an isomorphism just as braided commutativity says that AB and BA give results differing by isomorphism.

One can formulate this more concretely by denoting algebra decomposition $A \otimes B \in V \otimes V \to AB \in V$ by θ. In associativity condition one has 3 inputs so that 3-linear map $V \otimes V \otimes V \to V$ is in question. $(AB)C$ corresponds to $\theta \circ (\theta, 1)$ applied to $(A \otimes B \otimes C)$. Indeed, $(\theta, 1)$ gives $(AB, C) \in V \otimes V$. Second step $\theta\circ$ applied to this gives $(AB)C$. In the same manner, $A(BC)$ corresponds to $(\theta \circ (1, \theta)$ and associativity condition can be expressed as

$$\theta \circ (\theta, 1) = \theta \circ (1, \theta) \ \ .$$

An important delicacy should be mentioned. Although operations can be non-associative, the composition of operations is assumed to be associative. One can imagine obtaining $((ab)c)d$ either by $\theta \circ (\theta, 1) \circ (\theta, 1, 1))$ or by $(\theta \circ (\theta, 1)) \circ (\theta, 1, 1))$. The condition that these expressions are identical is completely analogous to the associativity for the composition of functions $f \circ (g \circ h) = (f \circ g) \circ h$ and this axiom looks obvious becomes one is used to *define $f \circ g$* using this formula (starting from rightmost brackets). One could however imagine starting the evaluation of the composition of operators also from leftmost brackets. This makes sense if the composition can be done without the substitution of the value of argument.

8.4.1   How Associativity Could Be Broken?

How to obtain the breaking of associativity? The first thing is to get some idea about what (weak) breaking of associativity could mean.

Breaking of associativity at the level of algebras

Basic examples about breaking of associativity might help in the attempts to understand how many-sheetedness could induce the breaking of associativity. The intuitive feeling is that the effect is not large and disappears at QFT limit of TGD.

In the case of algebras one has bilinear map $V \otimes V \to V$. Now this map is from $V \otimes V \to V \otimes V$ so that the two situations need not have much common. Despite this one can look the situation in the case of algebras.

Lie-algebras and Jordan algebras represent key examples about non-associative algebras. Associative algebras, Lie-algebras, and Jordan algebras can be unified by weakning the associativity condition $A(BC) = (AB)C$ to a condition obtained by cyclically symmetrizing this condition to get the condition

$$A(BC) + B(CA) + C(AB) = (AB)C + (BC)A + (CA)B$$

plus the condition

$$(A^2 B)A = A^2(BA)$$

defining together with commutativity condition $AB = BA$ Jordan algebra (`http://tinyurl.com/y8n9ol9p`). Note that Jordan algebra with multiplication $A \cdot B$ is realized in terms of associative algebra product as $A \cdot B = (AB + BA)/2$. A good guess is that the non-associative Malcev algebra formed by imaginary octonions with product $xy - yx$ satisfies these conditions.

Could the analog of the condition $A(BC) + B(CA) + C(AB) = (AB)C + (BC)A + (CA)B$ make sense also for the braiding group algebra assignable to quantum states of braids? The condition would say that cyclic symmetrization by superposing different braiding topologies gives a quantum state, which is in well-defined sense associative. Cyclic symmetry looks attractive because it plays also a key role in twistor Grassmannian approach.

Bi-algebras and Hopf algebras

One must start from bi-algebra $(B, \nabla, \eta, \Delta, \epsilon)$. One has product ∇ and co-product Δ analogous to replication of algebra element: particle physicists has tendency to see it as "time reversal" of product analogous to particle decay as reversal of particle fusion. The key idea is that co-multiplication is algebra homomorphism for multiplication and multiplication algebra homomorphism for co-multiplication. This leads to four commutative diagrams essentially expressing this property (see `http://tinyurl.com/y897z3es`).

Instead of giving the general definitions it is easier to consider concrete example of bi-algebra defined by group algebra. Bi-algebra has product $\nabla : H \otimes H \to H$ and co-product $\Delta : H \to H \otimes H$, which intuitively corresponds to inverse or time reversal of product. In the case of group algebra this holds true in very precise sense since one has $\Delta(g) = g \otimes g$: Δ is clearly analogous to replication. Besides this one has map $\epsilon : H \to K$ assigning to the algebra element a scalar and inverse map taking the unit 1 of the field to unit element of H, called also 1 in the following. For group algebra one has $\epsilon(g) = 1$. Bi-algebras are associative and co-associative. Commutativity is however only braided commutativity.

Hopf algebra $(H, \nabla, \eta, \Delta, \epsilon, S)$ is special case of bi-algebra and often loosely called quantum group. The additional building brick is algebra anti-homomorphism $S : H \to H$ known as antipode. S is analogous to mapping element of h to its inverse (it need not exist always). For group algebra one indeed has $S(g) = g^{-1}$. Besides the four commuting diagrams for bi-algebra one has commutative diagrams $\nabla(S, 1)\Delta = \eta\epsilon$ and $\nabla(1, S)\Delta = \eta\epsilon$, where ϵ is co-unit. The right hand side gives a scalar depending on h multiplied by unit element of H. For group algebra this gives unit at both sides. In the general case the situation $\Delta(h) = h \otimes h$ is true for group like element only and one has more complex formula $\Delta(h) = \sum_i a_i \otimes b_i$. One also defines primitive elements as elements satisfying $\Delta(h) = h \otimes 1 + 1 \otimes h$. Also Hopf algebras are associative and co-associative.

Quasi-bialgebras and quasi-Hopf algebras

Quasi-bi-algebras giving as special case quasi-Hopf algebras were discovered by Russian mathematician Drinfeld (for technical definition, which does not say much to non-specialist see `http://tinyurl.com/y7b6lpop` and `http://tinyurl.com/y89cs5oy`). They are non-associative or associative modulo isomophrism.

Consider first quasi-bi-algebra $(B, \Delta, \epsilon, \Phi, l, r)$. Δ and ϵ are as for bi-algebra. Besides this one has invertible elements Φ (Drinfeld associator) and r, l called right and lef unit constraints. The conditions satisfied are following

- $$(1 \otimes \Delta) \circ \Delta(a) = \Phi[((\Delta \otimes 1) \circ \Delta(a)]\Phi^{-1} \ .$$

  For $\Phi = 1 \otimes 1 \otimes 1$ one obtains associativity.

- $$[(1 \otimes 1 \times \Delta)(\Phi)][(\Delta \otimes 1 \otimes 1)(\Phi)] = (1 \otimes \Phi)[1 \otimes \Delta \otimes 1)(\Phi)(\Phi \otimes 1) \ .$$

- $$(\epsilon \otimes 1)(\Delta(a)) = l^{-1}al \ , \quad (1 \otimes \epsilon)(\Delta(a)) = r^{-1}ar \ .$$

- $$1 \otimes \epsilon \otimes 1)(\Phi) = 1 \otimes 1 \ .$$

These mysterious looking conditions express the fact that Drinfeld associator is a bialgebra co-cycle.

Quasi-bialgebra is braided if it has universal R-matrix which is invertible element in $B \otimes B$ such that the following conditions hold true.

$$(\Delta^{op})(a) = R\Delta(a)R^{-1} \ . \tag{8.4.1}$$

Note that for group algebra with $\Delta g = g \otimes g$ one has $\Delta^{op} = \Delta$ so that R must commute with Δ. Whether this forces R to be trivial is unclear to me. Certainly there are also other homomorphisms. A good candidate for a non-symmetric co-product is $\Delta g = g \times h(g)$ where h is a homomorpism of the braid group. This requires the replacement $S(g) \to S(h^{-1}g)$ in order to obtain unitarity for $\nabla(1, S)\Delta$ loop removing the braiding.

$$(1 \otimes \Delta)(R) = \Phi_{231}^{-1} R_{13} \Phi_{213} R_{12} \Phi_{213}^{-1} \ . \tag{8.4.2}$$

$$(\Delta \otimes 1)(R) = \Phi_{321}^{-1} R_{13} \Phi_{213}^{-1} R_{23} \Phi_{123} \ . \tag{8.4.3}$$

This and second condition imply for trivial R that also Φ is trivial.

For $\Phi = 1 \otimes 1 \otimes 1$ the conditions reduces to those for ordinary braiding. The universal R-matrix satisfies the non-associative version of Yang-Baxter equation

$$R_{12} \Phi_{321} R_{13} (\Phi_{132})^{-1} R_{23} \Phi_{123} = \Phi_{321} R_{23} (\Phi_{231})^{-1} R_{13} \Phi_{213} R_{12} \ . \tag{8.4.4}$$

Quasi-Hopf algebra is a special case of quasi-bialgebra. Also now one has product ∇, co-product Δ, antipode S not present in bialgebra, and maps ϵ and η. Besides this one has two special elements α and β of H such that the conditions $\nabla(S, \alpha) \cdot \Delta = \alpha$ and $\nabla(1, \beta S) \cdot \Delta = \alpha$. To my understanding these conditions generalize the conditions $\nabla(S, 1)\Delta = \eta\epsilon$ and $\nabla(1, S)\Delta = \eta\epsilon$.

Associativity holds but only modulo a morphism in the same way as commutativity becomes braided commutativity in the case of quantum groups. The braided commutativity is characterized by R-matrix. The morphism defining "braided associativity" is characterized by the product $\Phi = \sum_i X_i \otimes Y_i \otimes Z_i$ acting on triple tensor product $V \otimes V \otimes V$ and satisfying certain algebraic conditions. Φ has "inverse" $\Phi^{-1} = \sum_i P_i \otimes Q_i \otimes R_i$ The conditions $(1, \beta S, \alpha)\Phi = 1$ and $(S, \alpha, \beta S)\Phi = 1$. Here the action of S is that of algebra anti-homomorphism rather than algebra multiplication.

Drinfeld associator, which is a non-abelian bi-algebra 3-cocycle satisfying conditions analogous to the condition for weakened associativity holding true for Lie and Jordan algebras. These quasi-Hopf algebras are known in conformal field theory context and appear in Knizhnik-Zamolodchikov equations so that a lot of mathematical knowhow exists. According to Wikipedia, quasi-Hopf algebras are associated with finite-D irreps of quantum affine algebras in terms of F-matrices used to factorize R-matrix. The representations give rise to solutions of Quantum Yang-Baxter equation. The generalization of conformal invariance in TGD framework strongly suggests the relevance of Quasi-Hopf algebras in the realization of non-associativity in TGD framework.

Drinfeld double

Drinfeld double provides a concrete example about breaking of associativity. It can be formulated for finite groups as well as discrete groups. Drinfeld's approach is essentially algebraic: one works at the level of group algebra. In TGD framework the approach is geometric: algebraic constructs should emerge naturally from geometry. Braiding operations should induce algebras.

The basic notions involved are following.

1. One begins from a trivial tensor product of Hopf algebras and modified. In trivial case algebra product is tensor product of products, co-product is tensor product of co-products, antipode is tensor product of antipodes, map ϵ is product of the maps from the factors of the tensor product and delta maps unit element of field K to a product of unit elements. Drinfeld double represents a non-trivial tensor product of Hopf algebras.

2. One application of Drinfeld double construction is tensor product of group algebra and its dual. One can also interpret it as tensor product of braids as non-closed paths and closed braids (knots) as closed paths: in TGD framework this interpretation is suggestive and will be discussed later.

3. Drinfeld double allows breaking of associativity. It can be broken by introducing 3-cocycle (see http://tinyurl.com/y9vcsmyg) of group cohomology (see http://tinyurl.com/y755gd36). In the recent case group cohomology relies on homomorphism of group braid G to abelian group $U(1)$. n-cocycle is a map $G^n \to U(1)$ satisfying the condition that its derivation vanishes $d_n f = 0$. $d_n \circ d_{n-1} = 0$ holds true identically.

The explicit definition of n-cocycle is in additive notion for U(1) product (usually multiplicative notation is used is) given by to illustrate that d_n acts like exterior derivative.

$$(d_n f)(g_1, g_2, g_n, g_{n+1}) = g_1 f(g_1, ...g_n) - f(g_1 g_2, g_2, ..., g_{n+1}) + f(g_1, g_2 g_3, ..., g_{n+1})$$
$$- ... + (-1)^n f(g_1, g_2...g_n g_{n+1}) + (-1)^{n+1} f(g_1, g_2...g_n) \ .$$

$$(8.4.5)$$

This formula is easy to translate to multiplicative notion. The fact that group cohomology is universal concept strongly suggests that 3 co-cycle can be introduced quite generally to break associativity in the sense that different associations differ only by isomorphism.

The construction of quantum double of Hopf algebras is discussed in detail at http://tinyurl.com/ybbvjaw5. Here however non-associative option is not discussed. In http://tinyurl.com/ya8n98o5 one finds explicit formula for Drinfeld double for the Drinfeld double formed by group algebra and its dual. Just to give some idea what is involved the following gives the formula for the product:

$$(h, y) \circ (g, x) = \frac{\omega(h, g, x)\omega(hgx((hg)^{-1}, h, g)}{\omega(h, gx(g)^{-1}, h, g)}(hg, x) \ .$$

$$(8.4.6)$$

Without background it does not tell much. What is essential however that the starting point is algebraic. The product is non-vanishing only between (g, x) and (h, gxg^{-1}). For gauge group like structure one would have x instead of $g^{-1}xg^{-1}$. ω is 3-cocycle: it it is non-trivial one as associativity modulo isomorphism.

I do not have any detailed understanding of quasi-Hopf algebras but to me they seem to provide a very promising approach in attempts to understand the character of non-associativity associated with the braiding hierarchy. The algebraic construction of Drinfeld double does not seem interesting from TGD point of view but the idea that group cocycle is behind the breaking of associativity is attractive. Also the generalization of construction of Drinfeld double to code what happens in braiding geometrically is attractive. One of the many difficult challenges is to understand the role of the varying parameters p, h_{eff}, q at the level of braid group algebras and their projective representations characterized by quantum phase q.

8.4.2 Construction Of Quantum Braid Algebra In TGD Framework

It seems that there is no hope that naïve application of existing formulas makes sense. The variety of different variants of quantum algebras is huge and one should have huge mathematical knowledge and understanding in order to find the correct option if it exists at all. Therefore I bravely take the approach of physicists. I try to identify the physical picture and then look whether I can identify the algebraic structure satisfying the axioms of Hopf algebra. In the following I first list various inputs which help to identify constraints on the algebraic structure, which should be simple if it is to be fundamental.

Trying to map out the situation

Usually physicists have enough trouble when dealing with single algebraic structure: say group and its representations. Unfortunately, this does not seem to be possible now. It seems that one must deal with entire collection of algebraic structures defined by braid groups B_n with varying value of n forming a hierarchy in which braid groups act on lower level braid groups.

1. What is clear that the algebraic operation $(A \otimes B) \to AB$ is somehow related to the braiding of flux tubes or fermionic strings connecting partonic 2-surfaces. One can also consider strings connecting the ends of light-like 3-surfaces so that one has both space-like and time-like braiding. One has flux tubes inside flux tubes.

   The challenge is to identify the natural algebra. It seems best to work with the braiding operations themselves - analogs of linguistic expressions - than the states to which they act. Braiding operations form discrete group, braid group. One must deal with the quantum superpositions of braidings so that one has wave functions in braid group identifiable as elements of discrete group algebra of braid group B_n. One can multiply group algebra elements and include the group algebra of B_m to that of B_n m a factor of n so that the desired product structure is obtained. The group algebras associated with various braid numbers can be organized to operad.

   The operad formed by the braid group algebras has the desired hierarchical structure, and braid group algebra is one of the basic structures and quantum groups can be assigned with its projective representations.

2. For a given flux tube (and perhaps also for the fermionic string(s) assigned with it) one has degrees of freedom due different values of the quantum deformation parameter q for which roots of unity define preferred values in TGD framework. In TGD framework also hierarchy $h_{eff}/h = n$ of Planck constants brings in additional complexity. Also the p-adic prime p is expected to characterize the situation: preferred p-adic primes can be interpreted as so called ramified primes in the adelic vision about quantum TGD [K117] unifying real and various p-adic physics to a coherent whole. This brings in new elements. It is still unclear how closely n and $q = exp(i2\pi/m)$ are related and whether one might have $m = n$. Also the relationship of p to n is not well-understood. For instance, could p divide n.

3. Geometrically the association of braid strands means that they belong to the same flux tube. Moving the brackets in expression to transform say $(A(BC))$ to $((AB)C)$ means that strands are transferred from flux tube another one. Hence the breaking of associativity should take place at all hierarchy levels except the lowest one for which flux tube contains single irreducible braid strand - fermion line.

   The general mechanism for a weak breaking of associativity is describable in terms of Drinfeld's associator for quasi-bialgebras and known in some cases explicitly - in particular, shown by Drinfeld to exists when the number field used is rational numbers - is the first guess for the mechanism of the breaking of associativity. Drinfeld's associator is determined completely by group cohomology, which encourages to think that it can be used as such as as a multiplier in the definition of product in suitable tensor product algebra. How the Drinfeld's associator depends on the p,n, and q is the basic question.

4. Besides the geometric action of braidings it is important to understand how the braidings act on the fundamental fermions. An attractive idea is that the representation is as holonomies

defined by the induced weak gauge potentials as non-integrable phase factors at the boundaries of string world sheets defining fermion lines. The vanishing of electroweak gauge fields at them implies that the non-Abelian part of holonomy is pure gauge as in topological gauge field theories for which the classical solutions have vanishing gauge field. The em part of the induce spinor curvature is however non-vanishing unless one poses the vanishing of electromagnetic field at the boundaries of string world sheets as boundary condition. This seems un-necessary. The outcome would be non-trivial holonomy and restriction to a particular representation of quantum group with quantum phase q coming as root of unity means conditions on the boundaries of string world sheets. Quantum phase would make itself visible also classically as properties of string world sheets which together with partonic 2-surfaces determined space-time surface by strong form of holography. An interesting question relates to the possibility of non-commutative statistics: it should come from the weak part of induced connection which is pure gauge and seems possible as it is possible also in topological QFTs based on Chern-Simons action.

Hints about the details of the braid structure

Concerning the details of the braid structure one has also strong hints.

1. There two are two basic types of braids: I have called them time-like and space-like braids. Time-like (or rather light-like) braids are associated with the 3-D light-like orbits of partonic 2-surfaces at which the signature of the induced metric changes signature from Minkowskian to Euclidian. Braid strands correspond to fermionic lines identifiable as parts of boundaries of string world sheets. Space-like braids are associated with the space-like 3-surfaces at the ends of causal diamond (CD). Also they consist of fermionic lines. These braids could be called fundamental.

   If these braids are associated with magnetic flux tubes carrying monopole flux, the flux tubes are closed. Typically they connect wormhole throats at first space-time sheet, go to the second space-time sheet and return. Hence two-sheeted objects are in question. The braids in question can closed to knots and could correspond to closed loops assigned with the Drinfeld quantum double. The tensor product of the groupoid algebra associated with time-like braids and group algebra associated with space-like braids is highly suggestive as the analog of Drinfeld double.

   Also magnetic flux tubes and light-like orbits of partonic 2-surfaces can become braided and one obtains the hierarchies of braids.

2. Since strong world sheets and partonic 2-surfaces have co-dimension 2 as sub-manifolds of space-time surface they can also get braided and knotted and give rise to 2-braids and 2-knots. This is something totally new. The unknotting of ordinary knots would take place via reconnections and the reconnections could correspond to the basic vertices for 2-knots analogous to the crossing of the plane projections of ordinary knot. Reconnections actually correspond to string vertices. A fascinating mathematical challenge is to generalize existing theories so that they apply to 2-braids and 2-knots.

3. Dance metaphor emerged in the model for DNA-lipid membrane system as topological quantum computer [K2, K114]. Dancers whose feet are connected to wall by threads define time-like braiding and also space-like braiding through the resulting entanglement of threads. The assumption was that DNA codons or nucleotides are connected by space-like flux tubes to the lipids of lipid layer of cell membrane or nuclear membrane.

   If they carry monopolo flux they make closed loops at the structure formed by two space-time sheets. The lipid layer of cell membrane is 2-dimensional and can be in liquid crystal state. The 2-D liquid flow of lipids induces braiding of both space-like braids if the DNA end is fixed and of time-like braids. This leads to the dance metaphor: the liquid flow is stored at space-time level to the topology of space-time as a space-like braiding of flux tubes induced by it. Space-like braiding would be like written text. Time-like braiding would be like spoken language.

4. If the space-like braids are closed, they form knots and the flow caused at the second end of braid by liquid flow must be compensated at the parallel flux tube by its reversal since braid strands cannot be cut. The isotopy equivalence class of knot remains unchanged since knots get gg^{-1} piece which can be deformed away. Second interpretation is that the braid X transforms to gXg^{-1}. This kind of transformation appears also in Drinfeld construction. This suggests that the purely algebraic tensor product of braid algebra and its dual corresponds in TGD framework semi-direct tensor product of the groupoid of time-like braids and space-like braids associated with closed knots. The semi-direct tensor product would define the fundamental topological interaction between braids.

5. One can also consider sequence of n tensor factors each consisting of time-like and space-like braids. This require a generalization of the product of two tensor factors to $2n$ tensor factors. Dance metaphor suggests that a kind of chain reaction occurs.

What the structure of the algebra could be?

With this background one can try to guess what the structure of the algebra in question is. Certainly the algebra is semi-direct product of above defined braid group algebras. The multiplication rule would have purely geometric interpretation.

1. The multiplication rule inspired by dance metaphor for 2 tensor factors would be

$$(a_1, a_2) \circ (b_1, b_2) = (a_1 a_2 b_1 a_2^{-1}, a_2 b_2) \ . \tag{8.4.7}$$

Here a_1, b_1 correspond label elements of time-like braid groupoid and a_2, b_2 the elements of braid group associated with the space-like braid. This would replace the trivial product rule $(a_1, a_2)(b_1 g) = (a_1 b_1, a_2 b_2)$ for the trivial tensor product. The structure is same as for Poincare group as semi-direct product of Lorentz group and translation group: $(\Lambda_1, T_1)(\Lambda_2, T_2) = (\Lambda_1 \Lambda_2, T_1 + \Lambda_1(T_2))$.

It is easy to check that this product is associative. One can however add exactly the same 3-cocycle factor

$$(h, y) \circ (g, x) = \frac{\omega(h, g, x)\omega(hgx((hg)^{-1}, h, g)}{\omega(h, gx(g)^{-1}, h, g)}(hg, x) \ . \tag{8.4.8}$$

Here (h, y) corresponds to (a_1, a_2) and (g, x) to (b_1, b_2). This should give breaking of non-associativity and third group cohomology of braid group B_n would characterize the non-equivalent associators.

2. The product rule generalizes to n factors. This generalization could be relevant for the understanding of braid hierarchy.

$$(a_1, a_2, ...a_n) \circ (b_1, b_2, ...b_n) \equiv (c_1, ..., c_n) \ , \tag{8.4.9}$$

where one has

$$
\begin{aligned}
&c_n = a_n b_n \ , &&c_{n-1} = a_{n-1} Ad_{a_n}(b_{n-1}) \ , &&c_{n-2} = a_{n-2} Ad_{a_{n-1}a_n}(b_{n-2}) \ , \\
&c_{n-3} = a_{n-3} Ad_{a_{n-2}a_{n-1}a_n}(b_{n-3}) \ \ ,.... &&&&c_1 = a_1 Ad_{a_2.....a_n}(b_1) \ . \\
&Ad_x(y) = xyx^{-1} \ .
\end{aligned}
$$

$$\tag{8.4.10}$$

In this case a good guess for the breaking of associativity is that the associator is defined in terms of n-cocyle in group cohomology.

What is remarkable that this formula guarantees without any further assumptions the condition

$$\nabla_{1\otimes2}(\Delta_1(a),\Delta_2(b)) = \nabla_1(\Delta_1(a))\nabla_2(\Delta_2(b)) = \sum_{(a)} a_1 a_2 \sum_{(b)} b_1 b_2 \ ,$$

$$\Delta_1(a) = \sum_{(a)} a_1 \otimes a_2 \quad , \quad \Delta_2(b) = \sum_{(b)} b_1 \otimes b_2$$

(8.4.11)

as a little calculation shows. For group algebra one has $\Delta(a) = g \otimes g$. $\nabla_{1\otimes2}$ refers to the product defined above.

3. The formula for $\Delta_{1\otimes2}$ is also needed. The simplest guess is that it corresponds to replication for both factors. This would mean $\Delta^{op} = \Delta$: non-symmetric form guaranteeing non-trivial braiding is however desirable. A candidate satisfying this condition in $n = 2$ case is asymmetric replication:

$$\Delta_{1\otimes2}(bab^{-1},b) \otimes (a,b)$$
$$\Delta^{op}_{1\otimes2}(a,b) \otimes (bab^{-1},b) \ .$$

(8.4.12)

4. In $n = 2$ case the formula for antipode would read as

$$S(a_1,a_2) = (a_2^{-1}a_1^{-1}a_2, a_2^{-1})$$

(8.4.13)

instead of $S(a_1,a_2) = (a_1^{-1},a_2^{-1})$. Again the semi-direct structure would be involved. One can check that the formula

$$\nabla_{1\otimes2}(1,S)\Delta_{1\otimes2} = 1 \otimes 1$$

(8.4.14)

holds true.

8.4.3 Should One Quantize Complex Numbers?

The TGD inspired proposal for the concrete realization of quantum groups might help in attempts to understand the situation. The approach relies on what might be regarded as quantization of complex numbers appearing as matrix elements of ordinary matrices.

1. Quantum matrices are obtained by replacing complex number valued of matrix elements of ordinary matrices with operators. They are are products of hermitian non-negative matrix P analogous to modulus of complex number and unitary matrix S analogous to its phase. One can also consider the condition $[P,S] = iS$ inspired by the idea that radial momentum and phase angle define analog of phase space.

2. The notions of eigenvalue and eigenstate are generalized. Hermitian operator or equivalently the spectrum of its eigenvalues replaces real number. The condition that eigenvalue problem generalizes, demands that the symmetric functions formed from the elements of quantum matrix commute and can be diagonalized simultaneously. The commutativity of symmetric functions holds also for unitary matrices. These conditions is highly non-trivial, and consistent with quantum group conditions if quantum phases are roots of unity. In this framework also Planck constant is replaced by a hermitian operator having $h_{eff} = n \times h$ as its spectrum. Also $q = exp(in2\pi/m)$ generalizes to a unitary operator with these eigenvalues.

3. This leads to a possible concrete representation of quantum group in TGD framework allowing to realize the hierarchy of inclusions of hyperfinite factors obtained by repeatedly replacing the operators appearing as matrix elements with quantum matrices.

4. This procedure can be repeated. One might speak of a fractal quantization. At the first step one obtains what might be called 1-hermitian operators with eigenvalues replaced with hermitian operators. For 1-unitary matrices eigenvalues, which are phases are replaced with unitary operators. At the next step one considers what might be called 2-hermitian and 2-unitary operators. An abstraction hierarchy in which instance (localization to a point as member of class) is replaced with wave function in the class. This hierarchy is analogous to that formed by infinite primes and by the sheets of the many-sheeted space-time. Also braids of braids of ... form this kind of abstraction hierarchy as also the parsing hierarchy for linguistic expressions.

I have proposed that generalized Feynman diagrams or rather - TGD analogs of twistor diagrams - should have interpretation as sequences of arithmetic operators with each vertex representing product or co-product and having interpretation as time reversal of the product operation.

1. The arithmetic operations could be induced by the algebraic operations for Yangian algebra [A6] [B10, B8, B9] assignable to the super-symplectic algebra. I have also proposed that there TGD allows a very powerful symmetry generalizing the duality symmetry of old-fashioned string models relating s- and t-channel exchanges. This symmetry would state that one can freely move the ends of the propagator lines around the diagrams and that one can remove loops by transforming the loop to tadpole and snipping it away. This symmetry would allow to consider only tree diagrams as shortest representations for computations: this would reduce enormously the calculational complexity. The TGD view about coupling constant evolution allows still to have discrete coupling constant evolution induced by the spectrum of critical values of Kähler coupling strength: an attractive conjecture is that the critical values can be expressed in terms of zeros of Riemann zeta [L21].

2. One can represent the tree representing a sequence of computations in algebra as an analog of twistor diagram and the proposed symmetry implies associativity since moving the line ends induces motion of brackets. If co-algebra operations are allowed also loops become possible and can be eliminated by this symmetry provided the loop acts as identity transformation. This would suggest strong form of associativity at the level of single sheet and weaker form at the level of many-sheeted space-time. One could however still hope that loops can be cancelled so that one would still have only tree diagrams in the simplest description. One would have however sum over amplitudes with different association structures.

3. Co-product could be associated with the basic vertices of TGD, which correspond to a fusion of light-like parton orbits along their ends having no counterpart in super-string models (tensor product vertex) or the decay of light-like parton orbit analogous to a splitting of closed string (direct sum vertex). For the direct sum vertex one has direct sum (unlike string models): one can say that the particle propagates along two path in the sense of superposition as photons in double slit experiment. For the tensor product vertex $D(g) = \Delta(g) = g \times g$ is the first guess. $D(g) = (1, S)\Delta(g) = g \otimes Sg$ or $D(g) = Sg \otimes g$ or their sum suitably normalized is natural second guess. Unitarity allows only the latter option since $\nabla\Delta$ does not conserve probability for probability amplitudes unlike $\nabla(1, S)\Delta$ although it does so for probability distributions. For the direct sum vertex $\Delta(g) = 1 \otimes g \oplus g \otimes 1$ suitably normalized is the natural first guess.

4. Co-product Δ might allow interpretation as annihilation vertex in particle physics context. Co-product might also allow interpretation in terms of replication - at least at the level of topological dynamics of braiding. The possible application of co-product to the replication occurring biology assumed to be induce by replication of magnetic flux tubes in TGD based vision is highly suggestive idea. Is the identification of co-product as replication consistent with its identification as particle annihilation?

   Second question relates to the antipode S, which is anti-homomorphism and brings in mind time reversal. Could one interpret also S as an operation, which should be included to the braid group algebra in the same way as the inclusion of complex conjugation to the algebra of complex numbers produces quaternions? Could one interpret the identity $\nabla(1 \otimes S)\Delta(g) = \eta\epsilon(g) = 1$ by saying that the annihilation to $g \otimes S(g)$ followed by fusion produces braid wave function concentrated on trivial braiding and destroying the information associated with braiding completely. The fusion would produce non-braided particle rather than destroying particles altogether.

5. The condition that loop involving product and annihilation does not affect braid group wave function would require that it takes g to g. For the standard realization of co-product Δ of group algebra $g \to g \otimes g \to g^2$ so that this is not the case. The condition defining Δ is not easy to modify since one loses homomorphism property of Δ. The repetitions of loops would give sequence of powers g^{2n}. For wave function $\sum D(g)g$ this would give the sequence $\sum D(g)g \to \sum D(g)g^2 \to .... \to \sum D(g)g^{2n}$: since given group element has typically several roots one expects that eventually the wave function becomes concentrated to unity with coefficient $\sum D(g)$! For wave functions one has $\sum D(g) = 0$ if they are orthogonal to $D(g) = constant$ as is natural to require. Almost all wave functions would approach to zero so that unitary would be lost. For probability distributions the evolution would make sense since the normalization condition would be respected.

   Also the irreversible behaviour looks strange from particle physics perspective unless $D(g)$ is concentrated on identity so that braiding is trivial. Topological dissipation might take care that this is the case. For elementary particles partonic 2-surfaces carry in the first approximation only single fermion so that braid group would be trivial. Braiding effects become interesting only for strand number larger than 2. The situations in which partonic surface carries large number of fermion lines would be more interesting. Anyonic systems to which TGD based model assigns large h_{eff} and parton surfaces of nanoscopic size could represent a condensed matter example of this situation.

6. Does the behavior of Δ force to regard generalized Feynman diagrams representing computations with different numbers of self-energy loops non-equivalent and to sum over self-energy loops in the construction of scattering amplitudes? The time evolution implied by topological self energy loops is not unitary which suggest that one must perform the sum. There are hopes that the sum converges since the contributions approaches to $\sum D(g) = 0$. This does not however look elegant and is in conflict with the general vision.

   Particle physics intuition tells that in pair annihilation second line has opposite time direction. Should one therefore identify annihilation $g \to g \otimes S(g)$. Antiparticles would differ from particles by conjugation in braid group. The self energy loop would give trivial braiding with coefficient $\sum D(g)D(g^{-1}) = \sum D(g)D(g)^* = 1$ so that unitarity would be respected and higher self energy loops would be trivial. The conservation of fermion number at fundamental level could also prevent the decays $g \to g \otimes g$.

   One could also take biological replication as a guide line.

1. In biological scales replication by $g \to g \otimes g$ vertex might not be prevented by fermion number conservation but probability conservation favors $g \to g \otimes Sg$. Braid replication might be perhaps said to provide replicas of information: whether this conforms with no-cloning theorem remains to be seen. Braid replication followed by fusion means topological dissipation by a loss of braiding and loss of information. Could the fusion of reproduction cells corresponds to product and that replication to co-product possibly involving the action of S one the second line. Fusion followed by replication would lead to a loss of braiding: for

$g \to g \otimes g$ perhaps making sense in probabilistic description gradually and for $g \to g \otimes Sg$ instantaneously: a reset for memory? Could these mechanisms serve as basic mechanisms of evolution?

2. There might be also a connection with the p-adic length scale hypothesis. The naïve expectation is that $g \to g^2$ in fusion followed by Δ means the increase of the length of braid by factor 2 - kind of ageing? Could the appearance of powers of two for the length of braid relate to the p-adic length scale hypothesis stating that primes p near powers of 2 are of special importance?

To summarize, the proposed framework gives hopes about description of braids of braids of .... Abstraction would mean transition from classical to quantum: from localized state to a de-localized one: from configuration space to the space of complex valued wave functions in configuration space. Now the configuration space would involve different braidings and corresponding evolutions, and various values of p, h_{eff} and q. If this general framework is to be useful it should be able to tell how the braiding matrices depend on p and h_{eff}: note that p and h_{eff} would be fixed only at the highest abstraction level - the largest flux tubes. This indeterminacy could be interpreted in terms of finite measurement resolution and inclusions of HFFs should help to describe the situation. Indeterminacy could also be interpreted in terms of abstraction in a way similar to the interpretation of negentropically entangled state as a rule for which the state pairs in the superposition represent instances of the rule.

Part III

Quantum Model for EEG and Nerve Pulse

Chapter 9

Dark Matter Hierarchy and Hierarchy of EEGs

9.1 Introduction

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

Also long range weak forces play a key role. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and Z^0 fields are proportional to each other whereas for standard ground state classical Z^0 fields are very weak. This leads to a correct prediction for the frequencies of peak sensitivity for photoreceptors - something highly non-trivial remembering that also the large parity breaking effects in living matter find a natural explanation. It must be however emphasizef that there is also alternative model of Josephson junctions which seems to provide a better explanation for the role of protons in metabolism. Second quantitative key observation was that for electrons and quarks the time scales of causal diamonds correspond to fundamental biorhythms assignable to central nervous system.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity. A fractal hierarchy of EEGs and its generalizations identified in terms of Josephson radiation is predicted with levels labeled by p-adic length scales and the value of $\hbar$ at various levels of dark matter hierarchy: the recent view about the generalization of the notion of embedding space realizing this hierarchy is discussed in the Appendix. Cell membrane would represent only one level in this hierarchy. The analogs of EEG would exist for various organs, organelles and even cell. Also the possibility of ZEG, WEG and QEG corresponding to Z^0 bosons, W bosons, and gluons must be considered.

9.1.1 Background Ideas

Zero energy ontology

Zero energy ontology meant a breakthrough in the understanding of TGD and TGD inspired theory of consciousness and biology.

In zero energy ontology the S-matrix is generalized to M-matrix defining entanglement coefficients between positive and negative energy parts of zero energy states [K25]. M-matrix has interpretation as a "complex square root" of density matrix and thus provides a unification of thermodynamics and quantum theory. S-matrix is analogous to the phase of Schrödinger amplitude multiplying positive and real square root of density matrix analogous to the modulus of Schrödinger amplitude.

The notion of finite measurement resolution realized in terms of inclusions of von Neumann algebras allows to demonstrate that the irreducible components of M-matrix are unique and

possesses huge symmetries in the sense that the hermitian elements of included factor $\mathcal{N} \subset \mathcal{M}$ defining the measurement resolution act as symmetries of M-matrix, which suggests a connection with integrable quantum field theories.

Zero energy ontology is consistent with the ordinary positive energy ontology when the time scale T characterizing CD is long as compared to the time scale of observations. For shorter times scales however creation of matter from vacuum having in standard QFT framework interpretation as quantum fluctuations becomes possible and this process might occurs routinely in living matter unless the values of Planck constant assignable to CDs are very large. Also CDs can be created in quantum jump and a possible interpretation for a creation of CD is in terms of embedding space correlates of selves and of directed attention generating mental images. This interpretation leads to a model explaining how the arrow of psychological time emerges and why the contents of sensory experience are in so narrow time interval. The unexpected prediction is that zero energy ontology assigns to elementary particles macroscopic times scales. In particular, the time scales assignable to electron, d, and u quarks correspond to the frequencies 10 Hz (fundamental biorhythm), 1280 Hz (kHz cortical synchrony), and 160 Hz (cerebellar synchrony).

Systematic mistake in the identification of p-adic lengths scales above electron length scale

Before going to the topic it should be confessed that the identification of p-adic length scales and times above that defined by electron has been plagued by a systematic error appearing in all writings before 2014. This mistake deserves some comments.

1. The wrong identification was $L(151) \simeq 10$ nm implying wrong identification of other scales above $L(127)$ since I have calculated them by scaling $L(151)$ by an appropriate power of two. What I have denoted by $L(151)$ is actually obtained by scaling the Compton length $L_e(127) = \hbar/m_e$ by $2^{(151-127)/2}$ and therefore electrons Compton scale if it would correspond to $k = 151$. Since the mass of electron from p-adic mass calculations is given by $m_e = \sqrt{5 + X}\hbar/L(127)$, the correct identification of $L(151)$ would be

$$L(151) = 2^{(151-127)/2}L(127) = 2^{(151-127)/2}L_e(151)/\sqrt{5+X} = 10/\sqrt{5+X} \ \ nm \ , \ \ 0 \leq X \leq 1 \ .$$

Here X denotes the unknown second order contribution of form $X = n/M_{127}$, n integer, to the electron mass, and in the first approximation one can take $X = 0$ - the approximation is excellent unless n is very large. In the sequel I will try to use the shorthand $L_e(k) = \sqrt{5}L(k)$ but cannot guarantee that the subscript "e" is always present when needed: it is rather difficult to identify all places where the earlier erratic definition appears. I can only apologise for possible confusions.

2. This mistake has no fatal consequences for TGD inspired quantum biology. Its detection however provides a further support for the speculated central role of electron in living matter. Since the scales obtained by scaling the electron Compton scale seem to be important biologically (scaled up Comton scale $\sqrt{5}L(151)$ corresponds to cell membrane thickness), the conclusion is that electrons - or perhaps their Cooper pairs - play a fundamental role in living matter. The correct value of $L(151)$ is $L(151) = 4.5$ nm, which is slightly below the p-adic length scale $L_e(149) = 5$ nm assigned with the lipid layer of cell membrane.

3. I have also assigned to electron the time scale $T = .1$ seconds defining a fundamental biorhythm as a secondary p-adic time scale $T_2(127) = \sqrt{M_{127}}T(127)$. The correct assignment of $T = .1$ seconds is as the secondary Compton time $T_{2,e}(127) = \sqrt{M_{127}}T_e(127)$ of electron: secondary p-adic time scale is $T_2(127) = \sqrt{M_{127}}T(127)$ and corresponds to $T_{2,e}(127)/\sqrt{5} = .045$ seconds and to $f(127) = 22.4$ Hz.

p-Adic length scale hypothesis and biology

The basic implication of zero energy ontology is the formula $T_2(k) = T(k) \simeq 2^{k/2}L(k)/c = L(2,k)/c$ for the secondary p-adic time scale for $p \simeq 2^k$. This would be the analog of $E = hf$ in quantum

mechanics and together hierarchy of Planck constants would imply a direct connection between elementary particle physics and macroscopic physics. Especially important this connection would be in macroscopic quantum systems, say for Bose Einstein condensates of Cooper pairs, whose signature the rhythms with $T(k)$ as period would be. The presence of this kind of rhythms might even allow to deduce the existence of Bose-Einstein condensates of hitherto unknown particles.

Unfortunately, the mistake in the identification of the p-adic length scales above electron scale forces to modify the definition of $T(k)$ by introducing a $\sqrt{5+X}$ factor so that it becomes the secondary Compton time scale of electron in the p-adic length scale considered. Writing this explicitly, one has $T_e(k) \equiv T_{2,e}(k) = 2^{k-127}T_{2,e}(127) \equiv 2^{k-127}T_e(127)$. Apologies for a loose notation replacing subscript "2, e" with "e".

1. For electron secondary Compton time equal to $T_e(k) = .1$ seconds defines the fundamental $f_e = 10$ Hz bio-rhythm appearing as a peak frequency in alpha band. This could be seen as a direct evidence for a Bose-Einstein condensate of Cooper pairs of high T_c super-conductivity. That transition to "creative" states of mind involving transition to resonance in alpha band might be seen as evidence for formation of large BE condensates of electron Cooper pairs.

2. TGD based model for atomic nucleus [L4] predicts that nucleons are connected by flux tubes having at their ends light quarks and anti-quarks with masses not too far from electron mass. The corresponding p-adic frequencies $f_q = 2^k f_e$ could serve as a biological signature of exotic quarks connecting nucleons to nuclear strings. $k_q = 118$ suggested by nuclear string model would give $f_q = 2^{18}f_e = 26.2$ Hz. Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and f_q is not too far from 27.3 Hz Schumann resonance and the cyclotron frequency $f_c(^{11}B^+) = 27.3$ Hz for $B = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain.

3. For a given $T_e(k)$ the harmonics of the fundamental frequency $f = 1/T(k)$ are predicted as special time scales. Also resonance like phenomena might present. In the case of cyclotron frequencies they would favor values of magnetic field for which the resonance condition is achieved. The magnetic field which in case of electron gives cyclotron frequency equal to 10 Hz is $B_e \simeq 3.03$ nT. For ion with charge Z and mass number A the magnetic field would be $B_I = \frac{A}{Z}(m_p/m_e)B_e$. The $B = .2$ Gauss magnetic field explaining the findings about effects of ELF em fields on vertebrate brain is near to B_I for ions with f_c alpha band. Hence the value of B could be understood in terms of resonance with electronic B-E condensate.

4. The hierarchy of Planck constants predicts additional time scales $T_e(k)$. The prediction depends on the strength of the additional assumptions made. One could have scales of form $nT(k)$. Integers n could correspond to ruler and compass integers expressible as products of first powers of Fermat primes and power of 2. There are only four known Fermat primes so that one has $n = 2^n \prod_i F_i$, $F_i \in \{3, 5, 17, 257, 2^{16} + 1\}$. In the first approximation only 3- and 5- and 17-multiples of 2-adic length scales would result besides 2-adic length scales.

5. Mersenne primes are expected to define the most important fundamental p-adic time scales. The list of real and Gaussian (complex) Mersennes M_n possibly relevant for biology is given by n=89, 107, 113*, 127, 151*, 157*, 163*, 167* (* tells that Gaussian Mersenne is in question).

$$
\begin{array}{lllll}
n & 89 & 107 & 113 & 127 \\
f_e/Hz & 2.7 \times 10^{12} & 1.0 \times 10^7 & 1.6 \times 10^5 & 10 \\
n & 151 & 157 & 163 & 167 \\
T & 19.4\ d & 3.40\ y & 218.0\ y & 3.49 \times 10^3\ y
\end{array}
\tag{9.1.1}
$$

Mersenne hypothesis

The scale of the Josephson frequencies assignable to a given neuron is determined by the value 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.

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exists a stronger correlation between hierarchies of p-adic length scales and Planck constants. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four p-adic length scales $L_e(k)$ with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm). Of course, $L(k) = L_e(k)/\sqrt{5}$ also are in biologically interesting length scale range. The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$. The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$.

This proposal will be referred to as Mersenne hypothesis and it leads to strong predictions about EEG since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to given value of $\hbar$ a fixed size scale having interpretations as size scale of body part or magnetic body.

DNA and topological quantum computation

The model of DNA as topological quantum computer led to a dramatic progress in the understanding of how magnetic body interacts with the biological body. The model which looks the most plausible one relies on two specific ideas.

1. Sharing of labor means conjugate DNA would do TQC and DNA would "print" the outcome of TQC in terms of RNA yielding amino-acids in the case of exons. RNA could result in the case of introns. The experience about computers and the general vision provided by TGD suggests that introns could express the outcome of TQC also electromagnetically in terms of standardized field patterns. Also speech would be a form of gene expression. The quantum states braid would entangle with characteristic gene expressions.

2. The manipulation of braid strands transversal to DNA must take place at 2-D surface. The ends of the space-like braid are dancers whose dancing pattern defines the time-like braid, the running of classical TQC program. Space-like braid represents memory storage and TQC program is automatically written to memory during the TQC. The inner membrane of the nuclear envelope and cell membrane with entire endoplasmic reticulum included are good candidates for dancing halls. The 2-surfaces containing the ends of the hydrophobic ends of lipids could be the parquets and lipids the dancers. This picture seems to make sense.

One ends up to the model also in top-down way.

1. Darwinian selection for which 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.

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.

4. Fluid flow must 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.

5. The topology of the braid traversing cell membrane cannot not 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.

6. There are several problems related to the details of the realization. How nucleotides A,T,C,G are coded to strand color and what this color corresponds to? One can imagine several possibilities [K114] and the vision about DNA as topological quantum computer [K2] suggests that genetic code is indeed represented in several way. One of them predicts that wormhole contacts carrying quark and anti-quark at their ends appear in all length scales in TGD Universe. How to split the braid strands in a controlled way? High T_c super conductivity provides the 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. How magnetic flux tubes can be cut without breaking the conservation of the magnetic flux? The notion of wormhole magnetic field saves the situation now: after the splitting the flux returns back along the second space-time sheet of wormhole magnetic field. The model inspires several testable hypothesis about DNA itself: in particular, the notion of anomalous em charge of DNA leads to several predictions of this kind. Also new mechanisms of catalytic action based on phase transitions reducing the value of Planck constant emerge.

Summary of basic ideas leading to the model of EEG

The concrete realization of this vision is based on several ideas that I have developed during last five years.

1. The vision about dark matter as a hierarchy of phases partially labeled by the value of Planck constant led to the model of DNA as topological quantum computer [K2]. In this model magnetic flux tubes connecting DNA nucleotides with the lipids of the cell membrane define strands of the braids defining topological quantum computations. The braid strand corresponds to so called wormhole flux tube and has quark and antiquark at its ends. u and d quarks and their antiquarks could code for four DNA nucleotides in this model. The braid strand corresponds to so called wormhole flux tube and has quark and antiquark at its ends. u and d quarks and their antiquarks could code for four DNA nucleotides in this model. There are also other options. In particular, the states of dark proton are in one-one correspondence with DNA, RNA, amino-acids and possibly also tRNA, and vertebrate genetic code is realized as a natural mapping between DNA and amino-acid like states [L4, K42]. This coding would map entire dark DNA codons to dark amino-acids, and one cannot reduce the code words to separate letters since quarks are quantum entangled.

2. Zero energy ontology assigns to elementary particles so called causal diamonds (CDs). For u and d quarks and electron the Compton time time scales are (6.5,.78, 100) ms respectively, and correspond to fundamental biorhythms. As already noticed, secondary electron Compton time corresponds to 10 Hz fundamental biorhythm defining also the fundamental

frequency of speech organs,.78 ms to kHz cortical synchrony [**?**]. and 160 Hz to cerebellar synchrony [**?**]. Elementary particles therefore seem to be directly associated with neural activity, language, and presumably also hearing. One outcome was the modification of the earlier model of memetic code involving the notion of cognitive neutrino pair by replacing the sequence of cognitive neutrino pairs with that of quark sub-CDs within electron CD. Nerve pulses could induce the magnetization direction of quark coding for bit but there are also other possibilities. The detailed implications for the model of nerve pulse [K80] remain to be disentangled.

3. The understanding of the Negentropy Maximization Principle [K59] and the role of negentropic entanglement in living matter together with the vision about life as something in the intersection of real and p-adic worlds was a dramatic step forward. In particular, space-like and time-like negentropic entanglement become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.

The model of sensory receptor

One can think of two alternative models for sensory receptor. The first model for sensory receptor identifies cell membrane as almost vacuum extremal.

1. It has been clear from the beginning that the nearly vacuum extremals of Kähler action could play key role key role in living systems. The reason is their criticality making them ideal systems for sensory perception. These extremals carry classical em and Z^0 fields related to each other by a constant factor and this could explain the large parity breaking effects characterizing living matter. The assumption that cell membranes are nearly vacuum extremals and that nuclei can feed their Z^0 charges to this kind of space-time sheets (not true for atomic electrons) in living matter leads to a modification of the model for the cell membrane as Josephson junction [K80]. Also a model of photoreceptors explaining the frequencies of peak sensitivity as ionic Josephson frequencies and allowing the dual identifications Josephson radiation as bio-photons (energies) [I34] and EEG radiation (frequencies) emerge since the values of Planck constant can be very large.

2. The value of the Weinberg angle in this phase is fixed to $sin^2(\theta_W) = .0295$, whereas in standard phase the value is given by $sin^2(\theta_W) = .23$. This assumption of course might be criticized and is probably unrealistic. It can be given up if the effective cell membrane potential depends on the receptor of particular ion. Also the argument behind the conclusion about Weinberg angle is rather weak being based on rather ad hoc identification of the energies of photons with peak sensitivity as generalized Josephson energies assignable to specific dark ions.

Second model identifies cell membrane as far from vacuum extremal and is supported by the findings of Pollack about water as a fourth phase of water. This model forces generalization of Josephson junction so that Josephson energy as increment of Coulombic energy is replaced with its sum with the difference of cyclotron energies defining the TGD counterpart of the chemical potential in the thermodynamical model which in Zero Energy Ontology is replaced with its "square root". This model is also consistent with the TGD views about metabolism and bio-photons and also provides a mechanism for the generation of nerve pulse.

In microscopic description one must consider transmembrane proteins as Josephson junctions and one could argue that they can be either near to vacuum extremals or far from vacuum extremals but that both states are are not possible.

The ensuing general model of how cell membrane acts as a sensory receptor has unexpected implications for the entire TGD inspired view about biology.

1. DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.

2. Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.

3. (Generalized) Josephson frequencies or assignable to biologically important ions are in one-one correspondence with the qualia and (generalized) Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic way in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both bio-photons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.

4. At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action this analogy can be justified so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

9.1.2 Vision About Eeg

The general model for EEG relies on the idea that EEG frequencies correspond to Josephson frequencies defined by membrane potentials and provide cognitive and one might also say emotional representation of the sensory input at the magnetic body in terms of cyclotron transitions. The perturbations of the membrane potentials caused by spikes, neurotransmitters affecting alertness reducing the magnitude of the resting potential induced frequency modulations of the membrane potentials and one can say that the cell is like a singing whale with evoked potentials and nerve pulse patterns coded to the varying frequency. Song is expression of this singing but also speech involves frequency modulation as one learns by playing slowly recorded spoken language.

The scale of the frequency assignable to a given neuron is determined by the value 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 μm) 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.

An essential assumption is that cell membrane corresponds to almost vacuum extremal so that classical Z^0 field proportional to em field is present and leads to the replacement of ionic charges with effective charges much larger than ionic charges so that that membrane voltage corresponds to a photon energy in visible or UV range and the energies of biologically most important ions span half octave.

Armed with this picture one ends upd with a rather detailed quantitative model for EEG. In this chapter this model is applied in more detail. Features, synchronization, stochastic resonance, temporal codings, and what I have used to called scaling will be discussed.

9.1.3   Fractal Hierarchy Of Generalizations Of Eeg

EEG is replaced with a fractal hierarchy of generalizations of EEG corresponding to various values of Planck constants involved and to what kind of part of living system the magnetic body in question corresponds.

1. There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions in magnetic field $B_{end} = .2$ Gauss and its $1/\hbar$ scaled counterparts, and to the Josephson frequencies f_J associated with Josephson junctions assigned with cell membranes. If Josephson radiation modulates cyclotron radiation also the frqequencies $mf_J \pm nf_c$ appear in the spectrum.

2. In standard model $f_J = ZeV/\hbar$ would determined by the membrane potential and would correspond to energy in infrared. This sounds completely reasonable. TGD however suggests that cell membrane as a critical system correspond to an almost vacuum extremal. This predicts classical Z^0 field proportional to em field to which nuclei and neutrinos are assumed to couple. This would explain chiral selection in living matter and predict correctly the frequencies of peak sensitivity for photoreceptors as Josephson frequencies assignable to the biologically most important ions. The effective couplings of ions to membrane potential are modified and the Josephson frequencies correspond to energies in visible and UV range. Bio-photons and EEG could be seen as manifestations of one and same thing: Josephson radiation with a large value of Planck constant with energies of bio-photons and frequencies of EEG.

3. An important point is that the ions involved must behave like bosons. For cyclotron condensates either Cooper pairs of ordinary fermionic ions or exotic ions chemically similar to their standard counterparts obtained from neutral bosonic atom by making one or more neutral color flux tubes connecting nucleons charged. For Josephson radiation only the latter option works. TGD based nuclear physics indeed predicts this kind of nuclei and there is experimental evidence for their existence [L4]. [L4].

4. For cyclotron frequencies the extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but non-vanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands while Josephson radiation would propagate along flux tubes parallel to the cell membrane. Far from biological body one expects both kinds of flux quanta to fuse to form larger ones so that one has parallel space-time sheets carrying cyclotron *resp.* Josephson radiation. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

5. Josephson frequencies are assignable to the cell membrane and would naturally correspond to the communication of sensory data to the magnetic body. This would suggest that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via gene expression. This picture might be too naive. Josephson radiation would induce transitions between cyclotron states should generate sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as time reversal of sensory perception allowed by zero energy ontology would mean that same mechanisms are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

6. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. Note that for 5 Hz Josephson frequency

and membrane potential and for $V = . - 70$ mV corresponding to the resting potential of neuron one obtains $r = (0.96, 1.20, 1.34, 1.01) \times 2^{47}$ for almost vacuum extremals. For Ca^{++} ion r is very near to a power of 2.

9.1.4 Basic Aspects Of Eeg

Consider now how one could understand basic characteristics of EEG during wake-up and sleep in this framework.

1. For small amplitudes and for the lowest harmonics this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites.

2. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

3. In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. The simplest explanation is that the value of Planck constant increases by a factor 2 in a phase transition having interpretation as a leakage of cell membrane space-time sheet between the pages of Big Book defined by the generalized embedding space. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. This stage could correspond to a value of Planck constant which is 4 times its value in wake-up state.

The generalization of the model for EEG hierarchy to the case of ZEGs is straightforward and Josephson frequency spectrum is the same. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

9.1.5 The Effects Of ELFEM Fields On Brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains were crucial for the development of the model of EEG. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and its generalizations. These effects therefore serve as a killer test for the scenario and are still only partially understood.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around 10^{-7} V/m and second corresponds to the range $1 - 10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

1. Cyclotron frqeuencies led to the vision about cyclotron condensates of biologically important ions and their Cooper pairs at the flux quanta of dark magnetic field with so large Planck constant that the energies of cyclotron photons are above thermal threshold. The model for EEG and bio-photons in terms of Josephson radiation from cell membrane which is almost vacuum extremal allows to make this model more quantitative.

2. The temperature window has one interpretation in terms of a competion of almost vacuum extremal property of cell membrane possible above some critical temperature and high T_c super-conductivity possible below some critical temperature.

3. The amplitude window 10^{-7} V/m follows from a quantized form of Faraday law whose existence is supported by the fact that space-time sheets are analogs of Bohr orbits in exact sene. The quantisation condition relates the amplitude of electric field to Planck constant

and frequency. For the value $r = \hbar/\hbar_0 = 2^{47}$ of Planck constant required by 5 Hz Josephson frequency the 10^{-7} V/m amplitude is predicted correctly.

4. The amplitude window around 1-10 V/m (EEG amplitudes are in the range 5-10 V/m) follows if the values of Planck constant in the range $10^7 r - 10^8 r$ can be justified. A possible justification is based on the observation that for $r_1 = 10^8 r$ the Compton wave length of intermediate gauge bosons corresponds to $k = 163$ defining Gaussian Mersenne and wavelength nearly that corresponding to 2 eV energy, which also corresponds to bio-photon energies assignable to 50 mV subcritical membrane potential. 1-10 V/m interval corresponds roughly to the range of bio-photon energies. Electron's Compton length corresponds for $r_1 = 10^8 r$ to 28 cm, which defines the size scale of brain. One might hope that these findings could allow to build an internally consistent story about what happens.

9.1.6 Generalized EEG and Consciousness

If the Josephson radiation for a particular primary sensory organ and corresponding sensory pathway propagates to a specific part of the magnetic body along flux quanta it for sensory qualia. Similar interpretation applies to motor action interpreted formally as sensory perception in reversed time direction. Note that the resting potential for the cell membrane is considerably higher for motor neurons than for sensory receptor neurons. The assumption that Josephson radiation induces cyclotron transitions leads to a general interpretation of the generalized EEG in terms of spectroscopy of consciousness.

1. The primary qualia are coded by quantum numbers of quark pairs (or pairs of them) assignable to the ends of the flux tubes connecting DNA nucleotide and lipids. Sensory input generates the Josephson radiation and induces the primary qualia at the level of sensory receptor. Josephson radiation can also regenerate primary qualia or mental images in one-one correspondence with the primary qualia along the entire sensory pathway. Josephson radiation can transform to either bio-photons or EEG photons.

2. At the magnetic body Josephson radiation induces cyclotron transitions if resonance conditions are satisfied which implies that the communication of sensory data is optimal for special values of cell membrane resting potential for a fixed value of the magnetic field which of course can also vary. The value of resting potential critical for the generation of nerve pulse is the best candidate in this respect.

3. Also cyclotron transitions could correspond to some kind sensory qualia. "General feeling of existence" possibly accompanying all sensory qualia shared by the magnetic body is one possible identification for the quale involved. The quantum entanglement between this kind of mental image and the mental image representing the primary quale is natural candidate for the experience.

9.1.7 Vision About Biological Evolution And Evolution Of Brain

The proposed model for EEG, the idea that Gaussian Mersennes (four of them are in the range 10 nm-2.5 micrometers) define p-adic length scales allowing exotic variants of color and electro-weak physics with light intermediate gauge bosons at space-time sheets near vacuum extremals, and the assumption that the preferred values of Planck constant are such that they relate these p-adic scales to each other leads to a detailed quantitative vision about evolution of life as emergence of longer scales belonging to this hierarchy and as special case also to a vision about evolution of cell, nervous system, EEG, and long term memory. The model predicts a hierarchy of preferred size scales for various sub-systems of organisms and corresponding time scales identifiable in terms of bio-rhythms and memory span.

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` [L11].

9.2 What Is EEG Made Of?

The usual classification of EEG frequencies by EEG bands is more or less a convention and the definitions of various bands vary in frustratingly wide ranges. In a more ambitious approach bands should be replaced with some substructures identified on basis of their physical origin and function. In the proposed framework this is possible. This identification of substructures of course applies only to that part of EEG from which evoked potentials, noise, and possible other contributions are subtracted.

9.2.1 Basic Ingredients For Dark Hierarchy Of EEGs

The dark hierarchy of Josephson junctions with fixed size characterized by a p-adic length scale most naturally assignable to a member of twin prime pair defining a fractal hierarchy of EEG like spectra assignable to various parts of organism is the basic element of the model of generalized EEG. In the following only ordinary EEG is considered.

The path to recent view

The most obvious guess is that Josephson radiation is used for communications from cell membrane to magnetic body, its absorption induces cyclotron transitions, and the feedback to genome induces cyclotron transitions at the level of DNA inducing DNA expressions. This is of course only the simplest guess: one must start somewhere.

There are indeed objections against this view but the notions of magnetic body, dark matter has hierarchy of phases with non-standard value of Planck constant, and zero energy ontology solve these problems as the construction of a model for the findings of Pollack demonstrated [L14].

1. If one assumes that bio-photons are outcome from transformations of dark EEG photons to visible photons, one encounters a problem since the energies of bio-photons are in visible and UV range unlikes the Josephson photons from cell membrane with energy $E_J = ZeV$ in the range .1-.16 eV for $Z = 2$.

   The earlier proposal for the solution of this problem was that cell membranes can be near vacuum extremal so that classical Z^0 force gives dominating contribution to the membrane potential and increases it so that Coulombic energy has correct order of magnitude. This proposal emerged from a model for color qualia. The problem was that one had to assume for Weinberg angle a value about 1/10 from the standard model value.

2. The nominal value of metabolic quantum is about .5 eV and much larger than the Josephson energy $E_J = .1 - .16$ eV so that one cannot assume that mitochondrial membrane is battery unless there is large chemical potential or some additional contribution to single particle energy.

   In the case of proton Z^0 potential is negligible so that near vacuum extremal property does not solve the problem.

3. In the thermodynamical model of cell membrane and metabolism chemical potentials dominate over Coulomb energy.

   Zero energy ontology means that quantum theory in TGD sense is square root of thermodynamics. This leads to a modification of the thermodynamical model of cell membrane but chemical potential replaced with cyclotron energy of dark matter particle at magnetic flux tube. Also in the thermodynamical model the chemical potential would be replaced by cyclotron energy.

   This model gives hopes of resolving the listed problems. The model has as physical parameters bio-photon energy E_{bio} equal to energy of dark photon, $E_J = ZeV$ or equivalently membrane voltage V, and masses m_i and charges Z_i of charged particles involved, and magnetic field strengths at the portions of the magnetic flux tube at opposite sides of the cell membrane. The octaves of the endogenous magnetic field with value $B_{end} = .2$ Gauss are a good first guess for the values of B. Membrane potential is coded to the generalized Josephson frequency $f = f_{c,I} + f_{J,1}/n$ and the variations of membrane potential give rise to frequency modulation

with $\Delta f/f \sim .1$ which would characterize the width of EEG bands. EEG bands correspond to cyclotron frequencies.

Josephson current

Each junction has a background voltage over it. The basic hierarchy involves the p-adic length scales $L(k)$, $k = 151, 157, 163, 167$ corresponding to Gaussian Mersennes - or to be more precise - the scaled up variants of electron Compton scale for this p-adic scales, which seem to be biologically highly relevant. This suggests the importance of p-adic and dark scales coming in powers of 2. One could consider the possibility that not only $k = 151$ but all these length scales and also twin primes define their own Josephson junctions with their own values of Josephson potential.

Thee model for Josephson current relies on the model of cell membrane inspired by the findings of Pollack.

1. The generalized Josephson current for ion labelled by i can be written as

$$
\begin{aligned}
J_i &\propto R_{1,i}R_{2,i}sin[\omega_i t + \frac{Z_i e \int V_1 dt)}{\hbar_{eff}}] \ , \\
\omega_i &= \omega_{c,i,1} - \omega_{c,i,2} + \omega_{J,1} - \omega_{J,2} \ , \\
\omega_{J,i,k} = \frac{Z_i e V_k}{\hbar_k}, \ \ k &= 1,2 \ , \\
\omega_{c,i} &= \frac{Z_i e B_{end,i}}{m_i} \\
, R_{i,k} &= exp(\frac{nE_{c,i,k} + Z_i e V_k)}{2T}) \ , \ E_{c,i,k} = h_{eff,i}\omega_{c,i,k} \ , \ n_{i,k} = \frac{h_{eff,i,k}}{h} (9.2.1)
\end{aligned}
$$

Here V_k, $k = 1,2$ denotes electromagnetic potential at the two sides of the membrane and $V = V_1 - V_2$ defines the resting potential. Gauge invariance demands that one can choose $V_2 = 0$ so that one has $V_1 = V$. $R_{i,k}$ denotes the square root of Boltzmann weight defined by cyclotron energy and Josephson energy. T is the physiological temperature.

2. If $n_{i,1} \neq n_{i,2}$ is allowed, the frequency of Josephson radiation is not unique: $\omega_{J,1}/n_{i,1}$ or $\omega_{J,1}/n_{i,2}$. Gauge invariance requires unique Josephson frequency and thus $n_{i,1} = n_{i,2}$ In this case the values of magnetic field B_{end} must differ at the two sides of the cell membrane in order to get radiation with energy scale in that for biophotons. Octave hypothesis for the strength of B_{end} is attractive so that difference of two octaves of $B_{end} = .2$ Gauss would determine E_{bio}.

3. If $E = \hbar_1\omega_1 - \hbar_2\omega_2$ corresponds to bio-photon energy E_{bio} in (possibly IR,) visible or UV range, then the proportionality $h_{eff,i}/h = n \propto A_i$ of h_{eff} to the mass number A_i characterizing the cyclotron frequency of the ion is natural first guess. It implies that

$$E_{bio,i} = h_{eff,i,1}f_1 - h_{eff,i,2}f_2 = h_{eff,i,1}(f_1 - f_2)$$

depends only weakly on ion (through the additive contribution coming from Josephson energy which is smaller by factor 1/50 roughly).

4. The first guess suggested by octave structure of EEG is that $B_{end,i}$ and cyclotron frequency spectrum becomes in octaves so that spectrum to the cyclotron part of bio-photon energy would come as differences of octaves in the general case. These discrete energy values would be widened to bands with width $\Delta f/f$. The basic prediction is that bio-photon spectrum should reflect rather directly EEG spectrum.

5. There are additional complicacies due to the fact that also the harmonics of ω_i are allowed and the membrane potential is time dependent. EEG spectrum becomes effectively continuous and this reflects itself also in bio-photon spectrum. The membrane potential receives also feedback contribution from magnetic body coming through DNA in the simplest model assuming that magnetic flux tubes in the interior of cell connect it with DNA nucleotides [K2].

Some general comments are in order.

1. Generalized Josephson frequency ω_i would define a kind of drum beat whereas the frequencies associated with V_1 would represent modulation of this drum beat frequency so that the outcome would be like Chopin's piano piece with tempo rubato. ω_i also defines a candidate for the time unit in which the time scale of memories and intentional action of the living system are measured.

2. The phase transitions leading to swelling or contraction of cell can be identified as phase transitions changing the value possible at both sides of the cell and implying that equilibrium concentrations of ions are changed in the manner implied by the generalization of the Boltzmann weight formulas. The modulations of Josephson frequency implied by nerve pulses occur in time scale of few milliseconds and are fast in the time scale defined by cyclotron frequencies and it is quite possible that they modulate electron cyclotron frequency rather than ionic or protonic cyclotron frequencies.

The model for nerve pulse [K80] supports strongly the view that in resting state V corresponds to a propagating soliton sequence associated with Sine-Gordon equation. As described in the section about EEG, the situation is mathematically equivalent to a linear array of gravitational penduli coupling with each other and soliton sequence corresponds to a rotation of penduli with constant phase difference between neighbors so that a propagating wave would result. The analog of EEG would be associated also with ordinary cell membranes but the smaller value of $\hbar$ would imply that the frequencies involved are higher. Non-propagating EEG would accompany neuronal soma and possible propagating EEG waves with axons.

Thermodynamical considerations

The replacement of thermodynamics by its square root required by ZEO has been already explained. The key idea is that the density matrix is replaced with its hermitian square root multiplied by unitary S-matrix. The model of cell membrane would be the first real world application of ZEO.

If cyclotron energies at the two sides of membrane are different and their energy scale is in the range of bio-photons energies or if the membrane is almost vacuum extremal, generalized Josephson energy for ions corresponds to that for a visible or UV photon so that the Josephson photons are well above the thermal energy. The identification of EEG and bio-photons as decay products of large h_{eff} Josephson photons is possible. If the cyclotron energies are different then the generalized Josephson energy is above thermal energy always and Josephson frequency represents only 10 per cent modulation.

Josephson energy should be above thermal energy at physiological temperatures if one allows also the situation in which cyclotron energies are same at the two sides of the cell membrane. The conservative option is that the cell membrane is far from vacuum extremal phase with very small Z^0 field. From the resting potential whose nominal value is often taken to be for .08 V, f_J corresponds roughly to the energy .16 eV whereas the energies allowed by thermal stability must be larger than the energy corresponding to the maximum of black-body radiation intensity distribution as function of frequency and given by $E \simeq 3T_{phys} \simeq .93$ eV at $T_{phys} = 37$ C.

Nerve pulse is generated when the potential drops to about .055 eV: the corresponding Josephson energy for far from vacuum extremal Josephson junction is .11 eV, which is slightly above thermal energy .093 eV so that it seems that metabolic costs are minimized. The energy $E = .1$ eV is the universal transition energy of Cooper pairs of high T_c electronic super conductor [K17].

The generation of nerve pulse should involve h_{eff} changing transitions at either or both sides of the membrane forcing the equilibrium concentrations to change. They might also accompany the transition of the cell from a resting state to active state, which involves folding of the parts of straight unfolded parts of proteins and partial melting of globular proteins due to the melting of ordered water surrounding them.

For organisms possessing no nervous systems, in particular bacteria, this constraint is not relevant.

ZEO thermodynamics should explain why the temperature of brain must be in the narrow range 36-37 C to guarantee optimal functionality of the organism- one of the fundamental mysteries related to living matter.

1. Quantum criticality in some form is expected to be involved. Phase transitions changing the value of Planck constant at the flux tube portions at two sides of cell membrane must be possible. This would induce flows of ions through membrane and swelling and contraction of the cell which are basic phenomena at cell length scale. Phase transitions changing the length of flux tubes would be also involved with bio-catalysis. The possibility of wide spectrum of length scales is indeed key property of critical system. Temperature appears as a parameter in single particle wave functions in ZEO so that there are good changes to understand the thermodynamical aspects of the criticality at the level of first principles.

2. That the ordinary Josephson frequency is very just above the thermal energy should relate to the quantum criticality. If the temperature has too low, the value of h_{eff} is fixed to single value and bio-control - for instance that needed in basic bio-reactions - does not work. Hence h_{eff} changing phase transitions must be possible, and this requires high enough temperature. The temperature cannot be however too high since Josephson energy should be above thermal energy even in the case that cyclotron energies at two sides of the cell membrane are same. Thus biolocical activity and communications to magnetic body are competing factors and lead to a critical range of temperatures.

3. One could say that above critical temperature magnetic body becomes partially blind because communications with ordinary Josephson frequency are not present. Below the critical temperature the biological body becomes lame.

Classification of cyclotron frequencies

Consider now the classification of cyclotron frequencies ($B_{end} = .2$ Gauss will be assumed).

1. Cyclotron frequencies can be classified according to whether they are associated with atomic or molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band rather near 1 Hz irrespective of the length of DNA because the charge is 2 negative charge units per nucleotide.

   Thermal stability condition suggest a lower bound of ~ 1 Hz for significant frequencies of this kind. Thus one can ask whether delta band dominating during deep sleep could correspond to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions. For $B_{end} = .2$ Gauss this would require that DNA strands are at magnetic flux tubes and by previous argument at rather large distance from Earth. Interestingly, the large negative charge of DNA makes possible for it to levitate in the Earth's electric field of $E_2 \sim 100$ V/m at the surface of Earth up to heights about 30-50 km and $r \simeq 1.3 R_E$. At higher heights this field becomes small or reverses sign.

   O^{2-} is bosonic ion and of special interest because cyclotron frequency is about 37 Hz and near to the thalamo-cortical resonance frequency. O^{2-} also associated with bio-photon emissions so that a connection with EEG is suggestive.

2. Atomic ions can be classified into bosonic and fermionic ions. Practically all biologically important bosonic ions have $Z = 2$ and in alpha band: $f(^6Li^+) = 50$ Hz and $f(Mg^{2+}) = 25$ Hz are the only frequencies above alpha band (see Appendix). Situation is essentially the same for biologically interesting ions. $^7Li^+$ is exception and corresponds to 42.9 Hz. Thus the frequency range $7.5 - 15$ Hz is very strongly represented and expected to be fundamental.

3. The integer n characterizing the harmonics of the cyclotron frequency is an additional classificational criterion and n could correlate with the character of neural processing. The harmonics of Josephson frequency are present in Josephson radiationandinduce resonant cyclotron transitions with arbitrary high values of n if the ratio of Josephson frequency and cyclotron frequency is rational number. Note that the sensory representations at magnetic body are generated only at at critical values of the membrane potential. In case of hearing the values of n would characterize the harmonics of the fundamental and determine the character of the pitch.

4. Also the position in the periodic table of elements provides a classificational criterion (see Appendix) but this criterion does not seem to be so useful as thought originally.

What about electron? The mass ratio m_p/m_e is roughly 2^{-11} so that the cyclotron frequency is by factor about 2^{11} higher. Thus proton and various ions correspond to $h_{eff} = 2^{k+11}A$ and electron to $h_{eff} = 2^k$. This would give some motivation for the original quite too strong hypothesis that the values of h_{eff} come as powers of 2^{11}.

Basic contributions to EEG

The following general overview about quantum communication and control emerges in this framework.

There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions and Josephson frequencies f_J.

1. Schumann resonances do not depend on magnetic field strengths assignable with the magnetic flux sheets and would characterize Earth's magnetic field and collective aspects of consciousness. According to the model for sensory receptor and magnetic body [K39, K79] the inner rotating part of the Earth's magnetosphere could correspond to the third person aspect of sensory perception whereas the personal magnetic body would be anchored to body and move with it. Both inner and outer magnetosphere (which does not rotate with Earth) could receive sensory input from biosphere.

2. Cyclotron frequencies correspond to magnetic field $B_{end} = .2$ Gauss for the ordinary value of Planck constant and its $1/\hbar$ scaled down counterparts. The extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but non-vanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands.

3. Josephson frequencies f_J are associated with Josephson junctions assigned with transmembrane proteins. Far from vacuum extremals are assumed. Generalized Josephson frequency is given by $f_i = \Delta f_c + f_{J,1}/n$.

   (a) Bio-photons and EEG can be seen as manifestations of one and same thing: generalized Josephson radiation with a large value of Planck constant with energies of bio-photons and frequencies of EEG. Ordinary EEG photons result when dark visible photon decays into a bunch of ordinary ELF photons and bio-photons result when dark photon transforms to ordinary visible photon. Generalized Josephson radiation would propagate along flux tubes parallel to the cell membrane.

   (b) Generalized Josephson frequencies can be said to code for qualia if the generalized Josephson radiation is guided along magnetic flux tubes to a part of magnetic body specific to a given sensory receptor (or even neuron or cell in the case of cell level qualia). According to the model of sensory receptor [K39, K79] they do not however directly induce the sensory quale, which would be characterized by the net quantum numbers of quark pair (or two of them depending on the model).

   Generalized Josephson radiation can also regenerate the sensory quale along neural pathway. Therefore the original vision about spectroscopy of consciousness is realized in a limited sense. This implies that the precise value of the membrane resting potential could characterize both the parts of the organism and state of consciousness in the case of cortical neurons (say alertness) since depending on the value of membrane potential the neuron is in wake-up state or "sleeps". The value of the membrane potential would also directly correlate with the analog of EEG assignable to the body part. The fact that neuron types correspond to different membrane potentials conforms with this picture and suggest that they also correspond to different magnetic bodies with different field strengths.

4. Far from biological body one expects both kinds of flux quanta to fuse to form larger quanta so that one has parallel space-time sheets carrying cyclotron *resp.* generalized Josephson radiation, whose frequencies are rather near to each other so that flux tube with varying value of B can serve as receiver of the entire spectrum of Josephson radiation for a given ion. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

How these two kinds of radiations relate to the communication between magnetic and biological body and to the control of biological body by magnetic body is not quite clear.

1. One of the basic functions of the cell membrane is to monitor the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. Josephson frequencies would code various fundamental qualia assignable to DNA nucleotide-lipid pairs so that a sensory map defined by the cell membrane would be communicated to the magnetic body.

2. A good guess is that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via gene expression. This guess might be too naïve. Josephson radiation would induce transitions between cyclotron states and generate in this manner sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as a time reversal of sensory perception allowed by zero energy ontology would mean that the mechanisms of sensory perception are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

3. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. Note that for 10 Hz cyclotron frequency the estimate for $\hbar$ in the case of 2 eV dark photon is $r \simeq 3 \times 2^{46}$.

Far from critical vacuum extremals allow also classical W fields and gluon fields and they might be relevant for the quantum control via DNA flux sheets.

1. In the length scales below the weak length scale L_w also charged dark weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a non-local charge transfer. For instance, for $\hbar \sim 2^{89}$ W bosons behave like massless particles below the length scale 10^{-4} m and classical W fields and the exchange of W bosons might make possible charge entanglement. The hypothesis that Mersenne primes and Gaussian Mersennes correspond to a hierarchy of exotic weak physics leads to a highly unique vision for how life has evolved. In this model weak interactions play a key role in even macroscopic length scales.

2. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei could become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy. This provides a non-local quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control. Long range charge entanglement could be understood also in terms of classical W fields. Same applies to color entanglement which could be crucial element of topological quantum computation.

9.2.2 The Simplest Model For The Correspondence Between Generalized Josephson Frequencies And Cyclotron Frequencies

The vision is that generalized Josephson radiation is received resonantly at the magnetic flux tubes of the magnetic body and induces a phase transition like emission of cyclotron radiation

defining the response of the magnetic body communicated to DNA and possibly activating DNA expression and topological quantum computation like activities in DNA-membrane system [K2, K76]. A natural requirement is that membrane potential coding for the neural events and coded to generalized Josephson frequency is in turn coded to a position coordinate at flux tube by the resonance condition. The thickness and thus the local magnetic field at the flux tube must be varying in order that position coding is obtained.

Resonance condition equates generalized Josephson frequency with cyclotron frequency

The challenge is to understand the correspondence between Josephson and cyclotron frequencies and the what happens in the absorption of generalized Josephson radiation and how the response of magnetic body is generated. The following discussion represents a dramatic simplification of the earlier model.

1. The simplest coding would correlate $h_{eff}/h = n$ and the mass number A of ion: $n \propto A$ so that carrier frequency for Josephson radiation would correspond to cyclotron frequency. One could have $n = 2^k A$ and generalized Josephson frequency would correspond to cyclotron frequency through resonance condition at magnetic flux tube carrying particular ion and corresponding to a particular value of $h_{eff} \propto A$. Since Josephson contribution is small the two frequencies are near to each other with difference being of order 10 per cent.

2. The sub-band structure of EEG would naturally correlate with the cyclotron frequencies assignable to the biologically important ions. Bands with width about $\Delta f/f \sim .1$ would itself could correspond to the variation from the nominal value $B_{end} \simeq .2$ Gauss along flux tube. Proton would define the frequency scale with $f_c(p) = 300$ Hz and ion with charge Z and mass number A would have cyclotron frequency $f_c = Z f_c(p)/A$.

3. The atomic weight A has rather small number of values for biologically important ions if only bosonic ions are assumed (Bose-Einstein condensate). If also Cooper pairs are allowed, or if one accepts the suggestion of TGD inspired nuclear physics that exotic bosonic nuclei with mass of fermionic nuclei exist [L4], the situation changes. Many nucleon states in large h_{eff} phase can also allow pseudo Bose-Einstein condensates since anti-symmetrization in discrete degrees of freedom corresponding to sheets of multi-sheeted covering allows Bose-Einstein condensation like process in translational degrees of freedom. The anti-symmetrization gives also rise to negentropic entanglement [K59].

4. The magnetic field along flux tube could vary in range which is 10 percent of its mean value. The nominal values are $B_{end} = .2$ Gauss and its octaves. The variation along flux tube length would gives rise to a map of Josephson frequency - and thus membrane potential - to the flux tube coordinate. The variation of V would correspond to back and forth motion of "sensation" along the flux tube. Evoked potentials and neural noise would modulate the frequency and would be coded to this motion.

5. Resonance loop magnetic body-biological body requires that the motor response of the magnetic flux tube communicated to DNA has the same frequency spectrum as sensory input and thus correspond to a radiation at frequencies which correspond to differences of octaves of B_{end}. This can be achieved in several ways.

   (a) The change of B by octave at flux tube traversing cell membrane could be translated to phase transition changing the thickness of flux tube and thus the value of B. Generalized Josephson radiation could induce phase transitions reducing h_{eff} by a power of 2. If p-adic prime increases by the same power, do not change the length of flux tube but changes the value of B_{end} temporarily by flux conservation since the thickness of the flux tube changes. This would induce coherent emission of radiation at frequency very near to a multiple of cyclotron frequency and induce a response at DNA level if flux sheets traverse DNA strands. This response would induce genetic expression and possibly further transfer of cyclotron transition to Josephson junction so that a resonant feedback would result. Also topological quantum computation like activities might be induced.

(b) The magnetic field at the receiving portion of the magnetic flux tube receiving generalized Josephson radiation could have a value that corresponds to the difference of magnetic fields at the flux tube traversing cell membrane.

At the level of magnetic body the generalized Josephson radiation induces cyclotron phase transitions and in this manner communicate generalized sensory input to the magnetic body.

1. Chopin's piano pieces are highly emotional and half-jokingly one can ask whether tempo rubato due to the frequency modulation could code for the emotional content of the neural input. As a matter of fact, I have proposed that emotions correspond to the sensory experiences of the magnetic body. Frequency coding would provide the representation the information carried by nerve pulses and possible perturbations at cyclotron frequencies arriving from the magnetic body adding to the basic frequency.

2. The coherent photon state generated by J defines representation of evoked potentials V_1 as a generalized EEG interacting resonantly with magnetic body and providing feed back at harmonics of cyclotron frequency. This would create resonant feedback loops via DNA giving rise to biological representations as dark cyclotron photons interact with the living matter.

3. The scaling $h_{eff} \to n$ scales the time dependences of the Josephson current and Josephson radiation: $t \to t/n$. One obtains scaled variants of representations of the neural dynamics communicated to magnetic body. Different "stories" in various time scales is regarded as an essential element of intelligence and I have indeed proposed that they correspond to different values of h_{eff}. Different dark ions would correspond to these scaled variants of the representation.

To sum up, the model would realize the original idea about spectroscopy of consciousness rather concretely. The assumption that B_{end} has only the bands around preferred values differening by octaves is of course vulnerable to criticism. The model for hearing indeed suggests that instead of only octaves something analogous to music scale is needed. This well be discussed in more detail below. The role of fermionic ions remains open but there are slight indications that Na^+ might be importance for beta band.

Satellites

The input from cell membrane to the magnetic body can have two effects.

1. It can induce ordinary cyclotron transitions generating cyclotron radiation propagating from the magnetic body to genome to cell membrane as a small perturbation. This feedback could be called perturbative.

2. The input can also induce phase transitions by scaling the value of B_{end} by power of 2 (the simplest assumption) for the entire flux tube from the magnetic body to genome to cell membrane. This would give rise to a biological response as the ionic equilibrium concentrations change in accordance with the model based on "square root of thermodynamics" suggested by ZEO. Nerve pulse might be one such a response.

The perturbative feedback from the magnetic body to the DNA and from DNA to cell membrane would be present in two ways.

1. The feedback could affect the magnetic fields at flux tubes. Besides small oscillations also phase transitions This feedback could serve as basic control mechanism.

2. Feedback could affect also $V_1(t)$ besides the neural input such as evoked frequencies and give rise to additional frequencies satisfying the resonance condition. Nerve pulses generating motor actions could be one form of this feedback.

The general form of the perturbative feedback is easy to deduce.

1. Generalized Josephson current generating generalized Josephson radiation is trigonometric function of its argument of form $\int \omega(t)dt = \omega_0 t + \int \Delta\omega(t)dt$. $\Delta omega(t)$ contains a contribution coming from the modification of magnetic fields at both sides of the cell membrane and from $V_1(t)$.

2. If the amplitude of the feedback is small, it makes sense to develop the generalized Josephson current - essentially sine of its argument $\int \omega_0 t + \int \Delta\omega(t)dt$ - by using trigonometric formulas first and then expressing the trigonometric functions of $\int \Delta\omega(t)dt$ as Taylor series.

3. If $\Delta\omega(t)$ is superposition of trigonometric functions, this gives rise to series of higher harmonics involving integer combinations of generalized Josephson frequencies associated with various charged particles.

4. The simplest - perhaps un-necessary restrictive - possibility is that the feedback uses same frequencies as sensory input to magnetic flux tubes: this poses conditions on the allowed phase transitions inducing a change of B at the magnetic body. In this case only linear combinations of the basic frequencies ω_i with integer coefficients appear.

5. A sinusoidally varying perturbation would contribute to the generalized Josephson radiation frequencies of form

$$\sum_i n_i f_i \ ,$$

and give rise to what might be called satellites in EEG. These can contribute to conscious experience at magnetic body if the linear combination of the frequencies is cyclotron frequency. For instance, 5 Hz theta frequency could result as $f_c(Ca^{++}) - f_c(Co^{2+})$.

6. Simplest satellites are of form $f_i \pm f_j$ and thus appear as mirror pairs. In 10 per cent accuracy these frequencies are cyclotron frequencies and the first guess is that only bosonic ions contribute. The existence of the mirror satellites might be regarded as a killer prediction.

Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [**?**]. Besides alpha band at 11 Hz, Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as the bands at 13, 15 and 17 Hz in beta band [**?**]. All these frequencies are expressible in the form $f_c \pm f$, $f = 5$ Hz. $f = 5$ Hz would correspond to cyclotron frequency in alpha band during first stage sleep if the transition $B_{end} \to B_{end}/2$ occurs during this stage of sleep. Of course, several octavess of B_{end} are in principle possible during wake-up state too.

The cyclotron frequencies associated with the bands are 8, 10, and 12 Hz. The cyclotron frequencies of bosonic ions $^{80}Se^{2-}$, $^{64}Zn^{2+}$, and $^{55}Mn^{2+}$ for a magnetic field strength $B_{end} = .2$ Gauss are 8.00, 9.90, and 12.00 Hz. The cyclotron frequencies of bosonic ions $^{59}Co^{2+}$ and $^{56}Fe^{2+}$ would be 10.52 Hz and 11.36 Hz and the satellites are at frequencies 5.52 Hz and 6.36 Hz and 15.52 and 16.36 Hz. All these frequencies belong to the bands reported by Nunez since their widths are 1-2 Hz. Thus the frequencies of all bosonic ions in alpha band and in their satellites belong to the bands reported by Nunez for values of f_J and B_{end} very near to their nominal values used in calculations!

With these assumptions the frequencies $3f_c(Mn^{2+}) \pm f_J$ are 40.97 Hz and 30.97 Hz corresponding to 40 Hz band and the threshold of gamma band. That $f_c(O^{2-}) = 39.6$ Hz is also in this band suggests additional reason for why oxygen is so important for consciousness. $f_c(Mg^{2+}) = 26.3$ Hz is very near to Schumann resonance 26 Hz and its upper satellite corresponds to the threshold of gamma band.

What is also very remarkable that the 10 Hz magic frequency of the memetic code corresponding to the secondary p-adic length scale $L(2, 127)$ associated with Mersenne prime M_{127} characterizing electron and emerging as the basic prediction of the zero energy ontology appears. It should be also noticed that $f_J = 5$ Hz frequency corresponds to cognitive theta appearing during tasks requiring mathematical skills. Note that the scaling of ordinary value of h_{eff} by a factor of 2 scales 10 Hz frequency to 5 Hz.

Harmonics

As a special case about satellites one obtains harmonics $f = nf_i$ and these can induce both ordinary cyclotron transitions.

1. For alpha band the third harmonics of most bosonic ions are in the range 28.2-34.2 Hz and roughly in gamma band above 30 Hz assignable with the control of cognitive activities from a flux quantum of Earth's magnetic field.

2. Fifth harmonics of alpha band would are in the range 37.5-57 Hz. The fermionic ion Na^+ would correspond to 65 Hz. During REM sleep EEG very similar to awake but 65 Hz resonance is present. One can ask whether fifth harmonics are present during REM sleep and serve as correlates for conscious visual imagery.

3. The fourth harmonic of 40 Hz thalamo-cortical resonance band is very important EEG band. The upper satellite of the third harmonic of Mn^{2+} is 37.9 Hz. The third harmonics of fermionic ions $^7Li^+$ and Na^+ correspond to 42.9 Hz and 39 Hz (Schumann resonance) respectively.

   As will be discussed, a more natural interpretation for thalamo-cortical resonance frequency and also the observed 20 Hz and 80 Hz resonance frequencies is in terms of p-adically scaled values of both h_{eff} and B_{end}.

9.2.3 Music Metaphor

I have proposed music metaphor as a useful heuristic guideline in attempts to understand brain functioning and music metaphor can be also used in attempts to understand EEG.

Right brain sings, left brain talks

I have proposed that right brain sings and left brain talks metaphor could apply quite generally to the frequency modulated communications to the magnetic body. That it could distinguish between hemispheres is also an interesting hypothesis to study.

  1. Right brain sings

  Right brain sings would in the first approximation (forgetting glissandos!) mean that Josephson frequency and thus membrane potential is a piecewise constant function of time.

  "Singing" would represent a special case of frequency modulation for Josephson radiation and would require that various perturbations from neural activity and from feedback from magnetic body are small corrections possibly contributing to the emotional content of the signal (vibrato).

2. The metaphor would suggest that generalized Josephson frequencies have a set of discrete values analogous to the notes of the music scale which naturally spans one octave. This would reflect in the spectrum of bio-photons.

3. The variation range for the resting potential V is not a full octave so that the model involving only resting potential does not allow to realize the scale. The addition of the dominating cyclotron contribution saves the situation, and - just as in the case of hearing [K79] - the realization of scale in terms of the values of B_{end} becomes possible.

4. The resonance condition for cell membrane-magnetic body system requires that B_{end} has a spectrum of discrete values analogous to notes of the scale. If one takes 10 percent rule seriously and requires that the "note bands" do not overlap, one obtains $f_{n+1} = f_n + k_f n$, $k = .1$, giving $f_n = (1 + k)^{n-1} f_0$. $f_{n_{max}}/f_0 = 2$ gives that the number of "notes" is 7.3 suggesting that 8-note scale could relate directly to the spectrum of generalized cyclotron frequencies.

5. If this picture is correct, the existence of minor and major scales means that emotional content of major and minor scales could reduce to that for the membrane potential scales so that the spectrum of B_{end} would code for the emotional content of the scale.

2. Left brain talks

Left brain talks metaphor suggests that there is in some sense discrete carrier frequency which is frequency modulated in such a manner that the outcome is analogs for the phonemes of language.

1. Binary code for phonemes is suggestive and I have considered the possibility that genetic code might define the six bits of code words represented as phonemes with duration of about.1 seconds corresponding to the fundamental time scale identifiable as secondary p-adic time scale of electron in zero energy ontology. The occurrence/non-occurrence of nerve pulse having duration somewhat longer than millisecond is an obvious candidate for defining the values of the bit.

2. The coding of nerve pulse patterns to cyclotron frequencies suggest that the carrier frequency f_J is higher than kHz. This requires reduction of h_{eff} by a suitable power 2^{-k} and scaling of B_{end} by 2^k. Also flux tubes contain cyclotron condensate of electric Cooper pairs with cyclotron frequency of order 5.6×10^5 Hz suggest themselves.

   "No nerve pulse" situation would correspond to a situation in which generalized Josephson radiation with frequency f is generated and magnetic flux tube detects it: continual "beee...p" would characterize the "sensation" at the flux tube would definite bit "0". As the nerve pulse passes by the frequency of beep changes about.1 for a time of order millisecond and returns to a value differing slightly from the original value due to hyperpolarization increasing the value of the resting potential. Thus bit "1" would have just the obvious representation.

4. This form of proposal does not assume any time discretization as the earlier proposals and the code would thus be very flexible. The duration of phoneme would be however about.1 seconds. The capacity to code six bits would require allow 1.5 ms minimal duration for nerve pulse. If the duration of "beep" does not matter at all then only the number of pulses during.1 second interval matters, and one obtains the familiar rate coding and 6 bit reduce to 7 possible values for the number of nerve pulses. This cannot represent all phonemes of spoken language.

   The situation changes if there is background oscillation of the f with period of order nerve pulse duration of order.1/64 seconds $\simeq$ 1.6 ms. In this case it is possible to tell whether given period contains beep or nerve pulse. This would give rise to 6 binary digits able to code for 64 analogs of phonemes and one can consider also the analog of genetic code giving rise to redundancy. This kind of redundancy might be necessary since it can happe that given nerve pulse is present during two subsequent periods.

If this picture is on correct track, language would appear already at the level of communications to magnetic body and spoken and written languages would represent only its "externalizations". The first basic difference between speech and singing (and left and right brain) could be due to the fact that speech uses electronic Cooper pair condensates whereas singing uses ionic B-E condensates. Speech would also involve nerve pulse time scale in an essential manner an carry information about phase transitions changing the value of B_{end}.

Could the analogs of music scales appear in the communications to the magnetic body

The basic questions concern the allowed values of magnetic field B_{end} and the values of membrane voltage defining the scale of generalized Josephson frequencies.

Consider first hints concerning the spectrum of B_{end}.

1. Position coding suggests a band of about $\Delta B_{end}/B_{end} \simeq 10$ percent related to the position coding. This range would correspond to the frequency variation coming from the additive contributions to the resting potential from neural activity and magnetic body.

2. The model for the various stages of sleep relying on p-adic length scale hypothesis suggest that the scale of B_{end} comes as at least three powers 2^{-k}, $k = 1, 2, 3$ corresponding to alpha, theta, and delta bands. $h_{eff}/h = 2^k n$ would come as three powers in the same manner. It is also known that the frequencies 20, 40, and 80 Hz are resonance frequencies of EEG. 80 Hz is also resonance frequency in ERG.

3. This suggests that at least 6 octaves are involved. The next two powers of two correspond to 160 Hz and 320 Hz quite near to proton's cyclotron frequency 300 Hz for the nominal value of B_{end}.

These observations suggest that music metaphor is realized in rather concrete form. EEG would decompose to octaves just as music scale does. Each ion would define with its own scale scale and thus serve as an analog of instrument (note that the energy spectra of dark photons could be nearly identical for ions) corresponding a spectrum of values of B_{end}. The fundamental octave would correspond to scale with fundamental defined by $B_{end} = .2$ Gauss. In particular, 10-20 Hz interval would be associated with alpha band as the basic octave.

The attempt to identify different notes of the scale in terms of different bosonic ions does not look like an attractive idea. The region 10-20 Hz contains only 4 bosonic cyclotron frequencies: that of corresponding to Co, Fe, Mn in alpha band and Ca at 15 Hz and they need not correspond to notes of the same scale but fundamental frequencies of different keys. EEG could represents same piece in different keys labelled by bosonic ions. If this is the case, one could disentangle information from EEG by separating these contributions from each other by using the fact that they correspond to same function of time but with differently scaled argument.

9.2.4 An Attempt To Understand EEG In Terms Of The Resonance Model

In the following an attempt to understand the basic structure of EEG (`http://tinyurl.com/2mapqg`) and its relationship to state of consciousness is made.

Basic tests

The identification of EEG bands in terms of cyclotron frequencies identified as generalized Josephson frequencies is quite powerful prediction and deserves sensibility check.

1. The value of the endogenous magnetic field is $B_{end} = .2$ Gauss is 2/5: th of the nominal value of the Earth's magnetic field. B_{end} could be assigned to the magnetic field at flux tubes going through cell membrane (note however that also other values perhaps realizing the analogy of music scale with octaves is suggested by above considerations). The value of B at magnetic body, whose flux tubes would presumably be transversal to those connecting cell DNA and cell membrane, would be slightly different since Josephson frequency does not contribute to cyclotron frequency and have relative variation $\Delta B/B \simeq .1$.

   (a) If the variation $\Delta B/B$ corresponds to the variation of the Earth's magnetic field B_E scaling roughly like $(R_E/r)^3$ with the distance from the Earth's center, one would have $\Delta R/R_E \simeq .033$. This corresponds to $\Delta R \simeq 210.5$ km. Note that the F-layer of ionosphere - its densest layer - begins at about 200 km.

   (b) It could also be that B corresponds to the magnetic field of Earth. For Earth's magnetic field the distance at which its magnitude is about $2/5B_E$, $B_E = .5$ Gauss, would be roughly $r = 1.4R_E$. B_E defines the cyclotron frequencies of various ions and resonance condition must hold true for the resonant absorption of generalized Josephson radiation. The value of B_E should vary in some limits at flux tubes in order to achieve coding of generalized Josephson frequency by distance along flux tube: this gives rise to the EEG band.

2. If one assumes that only bosonic ions are relevant then for $B_{end} = .2$ Gauss, the values of relevant ionic cyclotron frequencies would be $f_c/Hz \in \{50, 27.4, 37.4, 25.0, 15.0, 11.4, 10.8, 9.5, 7.6\}$ Hz corresponding to $^6Li^+, Mg^{++}, Ca^{++}, Mn^{2+}, Fe^{2+}, Co^{2+}, Xn^{2+}, Se2-$ and 37.4 Hz near 40 Hz thalamo-cortical resonance frequency for molecular ion O^{2-} related to the bio-photon emissions in turn having interpretation as transformation of dark EEG photons to ordinary ones [K22]. There are three cyclotron frequencies in alpha band which makes it rather special.

3. The model could explain why wake-up consciousness is effectively lost when EEG frequencies are below 7.6 Hz: there would be no cyclotron condensates receiving input as generalized Josephson radiation and no consciousness assignable to the magnetic body.

An alternative possibility is that consciousness changes its character during sleep. If magnetic flux tubes with B_{end} scaled down most naturally by factor $1/2$ or $1/4$ suggested earlier to explain the stages of sleep and h_{eff} is scaled up by factor 2 or 4 respectively, cyclotron frequencies are reduced by factor $1/2$ or $1/4$, and can be low enough for cyclotron resonance conditions to be satisfied. This scales various frequency bands down by factor $1/2$ or $1/4$. This consciousness would differ from wake-up consciousness, and this might explain why we do not have memories about sleeping period and conclude that sleeping period is non-conscious.

If B correspond to the Earth's magnetic field at large enough distance so that the distance of the receiving flux tubes would increase roughly by a factor $2^{k/3}$, $k = 1, 2$, for theta and delta bands. The value of B_{end} could also change in a phase transition increasing p-adic prime approximately by a factor 2^k. This phase transition is proposed to be fundamental for metabolism [K76].

Theta and delta bands

Wikipedia article about EEG (`http://tinyurl.com/2mapqg`) summarizes the basic features of EEG bands.

1. Delta band is below 4 Hz and appears frontally in adults and posteriorly in children with high amplitude waves. It appears during adult slow wave sleep, in babies and during continuous attention tasks.

   Cyclotron frequency hypothesis and $h_{eff} \to 4h_{eff}$ hypothesis are consistent with these features. In particular, the model of slow wave sleep conforms with this picture. The satellite associated with Schumann resonance would be in alpha band and an interesting question is whether it appears in EEG during slow wave sleep.

2. Theta waves (4-7 Hz) appear in locations not related to task at hand, is higher in young children, correlates with drowsiness in adults and teens, is associated with "idling", and with inhibition of elicited responses.

   These features conform with the cyclotron frequency hypothesis and $h_{eff} \to 2h_{eff}$ hypothesis scaling alpha band to theta band corresponding to idling and also with the explanation of sensorimotor band 12-16 Hz in terms of satellites produced by input from magnetic body parts corresponding to alpha band. Also sleeping spindles can be understood. There would be no cyclotron frequency response at magnetic flux tubes responsible for wake-up sensory consciousness and motor activity. The performance of tasks would induce the transition $h_{eff} \to h_{eff}/2$ activating alpha band.

Alpha and Mu bands

Mu band is associated with sensorimotor motor cortex and is identified frequency range $8 - 12$ Hz and can be associated with rest-state motor neurons. Often one calls this band also alpha band.

Wikipedia definition identifies alpha band as $8-15$ Hz range. alpha band appears in posterior regions of at both sides and has higher amplitude on non-dominant sides. In a relaxed state beta band disappears and the spectral power in alpha band increases. alpha dominance correlates with relaxed/reflecting state of consciousness, appears when eyes are closed, and is also associated with inhibition control, seemingly with the purpose of timing inhibitory activity in different locations across the brain. alpha band appears also in coma.

A possible identification for Mu band is in terms of sub-bands associated with $f_J = f_c$ where f_c is cyclotron frequency for bosonic ions Se^{-2} (7.6 Hz), Zn^{2+} (9.4 Hz), Co^{2+} (10 Hz), Fe^{2+} (10.8 Hz), and Mn^{2+} (11.4 Hz). Depending on definition of alpha band it includes also Ca^{2+} (15 Hz). Also the sensorimotor rhythms belong to this band but in TGD framework it can be distinguished from genuine alpha band.

In a relaxed state beta band disappears and the spectral power in alpha band increases. The simplest explanation is that the value of h_{eff} corresponds to alpha band. An interesting question is whether the 10 Hz resonance frequency associated with the excitations of electric field in ionospheric cavity behaving like 2-dimensional waves on sphere is involved. Also the 10 Hz frequency assignable to electron's CD could be involved.

Sensorimotor rhythms in range 12-16 Hz

Sensorimotor rhythm corresponds the range 12-16 Hz and associated with physical stillness and body presence is a challenge for the model. For bosonic ions (Mn^{2+} and Ca^{2+} only the cyclotron frequencies 11.4 Hz and 15 Hz belong to this band. These are not enough if one is ready to losen the hypothesis $\Delta f_c/f_c \simeq 10$ per cent.

Two basis options can be considered.

1. If B_{end} indeed has spectrum of values analogous to music scale one could explain sensory motor rhythms in terms this spectrum for some ion. alpha band extended to a scale is the simplest possibility. The notes C, E_b, E, F G A_b, and A would correspond to $f/Hz \in \{10, 11.8, 12.6, 13.3, 14.9, 15.8, 16.8\}$. D would correspond 1.12 Hz still in alpha band.

2. The increase of h_{eff} by factor of two and satellite phenomenon provide an alternative identification of beta band. alpha band would be scaled down to about 5 Hz and would be fed by cyclotron frequencies in alpha band from magnetic body. Stillness would mean that order sensory input to the part of the magnetic body responsible for wake-up consciousness is absent since since 5 Hz does not correspond to any cyclotron frequency for the nominal value of B_{end}. The satellite frequencies for alpha band would be in the range 12.6-16.4 Hz. So called sleeping spindle during first stage of sleep for which also TGD model increase of h_{eff} by a factor of two, are also in this range. The interpretation would be as cyclotron communications from alpha part of magnetic body received by scaled down alpha part of neuronal membranes.

Beta band

beta band ranges from 16 to 31 Hz, appears in both sides, has symmetrical distribution, is most evident frontally, and waves have low amplitude. beta band is associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous.

Again one can consider several explanations.

1. The simplest explanation of beta band is in terms of octave wide scale associated with Ca^{++} ion with $f_c = 15$ Hz for $B_{end} = .2$ Gauss.

2. Second possibility is beta band involves in an essential manner the feedback from magnetic body and satellite frequencies which however need not induce cyclotron transitions unless one is willing to losen the basic criterion. If higher order effect is in question, the low beta amplitudes can be understood. Harmonics induce cyclotron transitions without further assumptions and one obtains a rich spectrum of sub-bands.

Besdes Ca^{++} octave beta band can contain resonances.

1. Mg^{++} is the only bosonic ion having cyclotron frequency in beta range at $f_c(Mg^{++})= 25$ Hz and could appear as resonance frequency in beta band. Alternatively it could correspond fundamental frequency assignable to gamma band.

2. If one accepts the hypothesis about octaves of B_{end} then gamma band should contain also resonance frequencies around 15.2 Hz, 20 Hz and 30 Hz corresponding to Se^{2+}, alpha band and Ca^{2+}. The resonance at 20 Hz is known to exist.

3. As already noticed, in slow wave sleep Schumann resonance at $f_S = 27.3$ Hz could generate this frequency by satellite mechanism but the amplitude would be smaller than for direct generation. Also 10 Hz alpha frequency and Ca^{2+} frequency can add up via satellite mechanism rise to $f_c(Mg^{++}) = 25$ Hz.

Gamma band

Gamma band is associated with somatosensory cortex and displays during cross-modal sensory processing and also during short memory matching of recognized objects, sounds or tactile sensations. Clearly gamma band relates associative regions of cortex. Thalamo-cortical resonance frequency with nominal value of 40 Hz belongs to gamma band.

The simplest option is that gamma band contaings several octave scales associated with $f_c(Mg^{++}) = 25$ Hz, $f_c(O^{2-}) = 37.4$ Hz and $f_c(6Li^+) = 50.1$. One can criticize this assumption: 25 Hz is roughly 15 per cent lower than 31 Hz. One the other hand, the identification of the various frequency is far from unique.

Ten percent rule for $\Delta f/f$ suggests that thalamo-cortical resonance of 40 Hz could correspond to 37.4 Hz. This would predict a large amplitude in accordance with resonance interpretation. Note that fourth harmonics of alpha frequencies are around the thalamo-cortical resonance frequency.

An alternative explanation of 40 Hz resonance is that it corresponds to the p-adic scaling of h_{eff} and B_{end}. Ca^{2+} would give rise to 60 Hz resonance frequency and also other bosonic ions would give rise to resonances in gamma band. The octave of $f_J(Mg^{2+})$ would give 50 Hz resonance in gamma band.

The strong amplitude of the feedback contribution in the argument of generalized Josephson current $J = J_0 sin(\omega_0 t + X)$ also means that the higher terms in Taylor expansion with respect to X are important and large number of satellites $\omega_0 + nf_c$) is important so that the amplitude becomes chaotic. The harmonics of bosonic cyclotron frequencies predict quite rich spectrum of sub-bands in beta and gamma banda and it would be highly interesting to test the prediction.

To sum up, according to the proposed picture the basic contribution to alpha, beta, and gamma bands correspond to octave scales associated with bosonic ions in alpha band around 10 Hz, Ca^{++} around 15 Hz, and Mg^{++} around 25 Hz. There are also resonance contributions and contributions from the octaves of the fundamental octaves. Besides the proposed picture many other options can be imagined. One must make working hypothesis and the basic challenge is to avoid too strong assumptions.

9.2.5 EEGDuring Sleep

The EEG during sleep [**?**, J4] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question.

The scalings of h_{eff} by factor 2 and 4 accompanied by corresponding compensating scalings of B_{end} so that generalized Josephson energies are almost invariant seem to explain the basic characteristics of these states but it is not completely clear whether the phase transitions occur for both cell membrane space-time sheets and flux quanta or only for the first ones.

EEG during stage 1

The stage 1 sleep is between wake-up state and full sleep involving sometimes hypnagogic hallucinations. During stage 1 of deep sleep [**?**] theta waves in frequency range 4-8 Hz beging to dominate and amplitudes increase as frequency is reduced. The transitiosn $h_{eff} \to 2h_{eff}$ and $B_{end} \to B_{end}/2$ should take place and would take place also in relaxed state and generates sensorimotor rhythms.

1. If $h_{eff} \to 2h_{eff}$ transition takes place alpha band is scaled down to the range 3.8-5.7 Hz. Ca^{++} frequency scales down to 7.5 Hz so that one indeed obtains theta band. The amplitudes associated with these frequencies are expected to be high. These amplitudes should dominate and EEG should look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/f_c$ and thus increase with decreasing f_c. The fact that the amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

2. The secondary amplitudes generated by satellite mechanism for alpha band give rise to sensorimotor rhythms appearing also in sleeping spindles. The mirror frequencies are in theta band below 5 Hz.

The most important range 7.5-15 Hz of cyclotron frequencies would be scaled down to 3.75-7.5 Hz which indeed corresponds to the theta band. If one excludes Ca^{2+}, the range for bosonic

ion reduces from $7.5 - 11.4$ to $3.75 - 5.7$ Hz. The satellites correspond to the range $.05 - 8.7$ Hz and $7.45 - 9.4$ Hz plus Ca^{2+} satellites at 3.8 Hz and 11.2 Hz. With Ca^{2+} forming a possible exception, the resulting frequency ranges are consistent with empirical facts. Of course, it is quite possible that magnetic body does not generate cyclotron transitions at Ca^{++} cyclotron frequency.

One must consider two options.

1. If both cyclotron frequencies at magnetic body and generalized Josephson frequencies are scaled down, the communication-control loop between magnetic and biological body remains intact. This might be necessary for the survival. This raises the question whether sleep actually means a loss of consciousness. Could it be that only the character of consciousness is changed? Since the magnetic body moves to a different page of the "Big Book" having as pages various singular coverings of the embedding space, one could argue that consciousness is not lost but that it is difficult to remember anything about this period during wake-up period since the negative energy signals responsible for memory recall should leak to another page of Big Book and this process could take place with a low rate. The mental images appearing just at the border of falling asleep could give a glimpse about the character of conscious experience in this.

2. The phase transition changing Planck constant could take place for cell membrane space-time sheets only so that only generalized Josephson frequencies would be scaled down. For flux sheets traversing through DNA the value of Planck constant would not be changed. In this case resonance conditions satisfied in wake-up state would be satisfied for the even harmonics of Josephson frequencies during stage 1 of sleep. Therefore the sensory-motor loop involving magnetic body would not be so active in the relaxed state and in the first stage of sleep.

EEG during stage 2

The appearance of sleep spindles distinguishes stage 2 from stage 1. Sleeping spindles are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [?]. The spindles last .5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

The natural interpretation of sleep spindles is in terms of input from magnetic body in alpha band which generates by satellite mechanism sensorimotor rhythms assignable to a relaxed state. Sleep spindles would thus correspond to the satellites of alpha band identifiable as responses of the corresponding Josephson junctions to occasional strong control signals at cyclotron frequencies in alpha band. K complexes could be interpreted as signals from magnetic body but inducing no response. It might be that these sudden responses reflect the fact that the left brain is not fully asleep yet.

EEG during stages 3 and 4

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [?]. The most straightforward interpretation is in terms of the scaling $\hbar \to 4\hbar$ so that alpha band would correspond to 2.5 Hz and beta frequency 15 Hz to 3.75 Hz.

Again one has two options corresponding to the scaling of $\hbar$ for all flux quanta and only for the cell membrane space-time sheets.

1. For the first option consciousness need not be lost during these phases of sleep if the above argument makes sense. The experiences just at the border of wake-up could give an idea about what this kind of consciousness is.

2. For the second option DNA cyclotron transitions could be important during deep sleep and it might be even possible to speak about DNA consciousness. For phosphorylated DNA sequences with charge of 2 units per single base-pair one would have $A \geq 300$. More precisely, the atomic weights for base pairs plus phosphate group and deoxyribose sugar are $327, 321, 291, 344$ corresponding to A, T, C, G. From the fact that proton's cyclotron frequency for $B_{end} = .2$ Gauss is 300 Hz one obtains that DNA cyclotron frequency is 1 Hz in

good approximation. This would suggest that during deep sleep DNA cyclotron transitions are induced by Josephson frequencies and that DNA defines the sensory perceiver.

9.2.6   Schumann Resonance And Consciousness

The lowest Schumann resonance frequency $f_S = 7.8$ Hz is conjectured to be important for consciousness.

1. One might imagine that the magnetic body of Earth as a conscious entity communicates to and controls brain using Schumann resonance. A possible mechanism is communication of Schumann radiation to DNA where it arrives along magnetic flux tubes to cell membrane as external perturbation superposing to membrane voltage as sinusoidal perturbation in the first approximation. One can decompose Josephson current as

$$ J = J_0 sin(\omega_J t + X) = J_0[sin(\omega_J t)cos(X) + cos(\omega_J t)sin(X)] \ , \ \ X = \omega_0 t + \frac{Ze}{\hbar_{eff}} \int V dt \ , $$

and expand $sin(X)$, and $cos(X)$ in powers series of X. If X is sinusoidal, a perturbation with frequency f the series gives rise to the spectrum $f = f_0 + nf$ which should be equal to f_c for some ion at magnetic body. In the case of Schumann frequency this would give lowest frequency $f_0 \pm f_S$. If there is cyclotron frequency satisfying the resonance condition $f_c = f_0 + f_S$, Schumann frequency is perceived at magnetic body.

2. If sleep means formation of a kind of collective consciousness, then one expects that during first and second state of sleep when the scale f_J is reduced by 1/2 *resp.* 1/4 the resulting frequency might correspond to cyclotron frequency. During second state of sleep alpha band is shifted to 2.5 Hz and $f_J + f_S = 10.3$ Hz is in alpha band so that Schumann resonance could contribute to alpha consciousness. For the first phase of sleep alpha band is at 5 Hz (theta band) and for $f_J = 10$ Hz one has $f_J + f_S = 12.8$ Hz in beta band - this is near to the scaled down cyclotron frequency of $f_c(Mg^{2+}) = 12.5$ Hz.

What about the interaction of higher Schumann resonances with consciousness? Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and could give rise to satellites, which for $f_J = 2.5$ Hz correspond to cyclotron frequencies. $f_c(Mg^{2+}) = 25.0$ Hz is not too far from $f_S = 27.3$ Hz Schumann resonance. During slow wave sleep the satellite $f_S - f_J = 27.3 - 2.5$ Hz equal to 24.8 Hz. For $f_S = 14.3$ Hz the satellite would be 11.8 Hz rather near $f_c(Mn^{2+}) = 11.4$ Hz.

9.2.7   What About Proton And Electron?

The model discussed has not said anything about proton and electron. with cyclotron frequencies of 300 Hz and 5.6×10^5 Hz for $B_{end} = .2$ Gauss. There are two hints about the role of these frequencies.

1. The spectrum of audible frequencies spans 10 octaves extending from 20 Hz to about 2×10^4 Hz. For bats the spectrum extends to MHz region. The frequency modulation of EEG frequencies by frequencies above 100 Hz produces a vanishing average effect analogous to small ripples much smaller than the wave-length of wave in water.

2. The durations associated with the nerve pulses are few milliseconds.

A natural manner to represent auditory information would be by using electron's cyclotron frequency as a carrier frequency. The proton cyclotron time 3.3 ms could be short enough to allow a representation of nerve pulse patterns as frequency modulation. This would require $f_J = f_c(p) = 300$ Hz for the neuronal membranes involved. Also electronic cyclotron frequency would allow the representation of neuronal events as slow frequency modulations. The effects of VLF radiation at these cyclotron frequencies on living matter could serve as a test for this proposal.

9.3 The Effects Of ELFFields On Brain And High T_c Ionic Super Conductivity

The article "Spin the tale on the dragon" by David Jarron [**?**] gives excellent popular review about the history of the bio-electromagnetic research and about the frequencies for which electromagnetic fields have special effects on living matter and brain. The material from this article led to the realization of how brain manages to be a macroscopic quantum system in TGD Universe. A more technical view about the effects can be found from review articles of Adey and Blackman [**?**]. The online review article of Cherry [**?**] provides a good technical representation about various effects of weak ELF em fields and ELF modulated radiofrequency em fields on brain and an extensive list of references.

9.3.1 Summary About Effects Of ELF EM Fields On Brain

The work by pioneers of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey, Blackman and many others) which began already at sixties led to amazing discoveries about ELF fields on brain. The article of Blackman [**?**] provides a detailed summary of these developments. The results of the work of Bawin, Adey, Blackman and others can be summarized by saying that radio frequency em fields amplitude modulated by ELF frequencies affect in certain frequency and amplitude windows brain tissue [**?, ?, ?**]. The function of the radio frequency carrier wave is to facilitate the penetration of em field into tissue and its frequency is not essential for the occurrence of the effect. Presumably nonlinear effects give rise to a secondary wave with modulation frequency which is the primary source of effects.

Basic effects

The effects of ELF em fields on brain include chemical, physiological and behavioral changes within windows in frequency and field intensity. It is essential that the effects have been observed only in vertebrates which thus possess EEG. A good summary is the online review article of Cherry [**?**].

The well documented and established non-thermal biological effects of EMR include significant alteration of cellular calcium ion homeostasis, reduction of melatonin, and the detection of Schumann Resonances by human and avian brains. A key effect is change in Ca^{2+} homeostasis: Ca^{2+} it is involved with both pre- and postsynaptic steps of nerve pulse transmission and also with intracellular communication. For instance, Ca^{2+} is involved with gene expression, the development and plasticity of nervous system, modulation of synaptic strengths, and with $Ca^{2+} - cAMP$ signal transduction process.

Change in Ca^{2+} homeostasis has harmful effects in central nervous system, endocrine system and immune system. At the level of CNS this means changes of reaction time and behavioral alterations. At the level of neuro-endocrine system a good example is the reduction of the melatonin production in pineal gland having wide variety of harmful effects since melatonin serves as effective scavenger of free radicals: among the effects are DNA strand breakage, chromosome aberrations and problems with gap junction communications. Melatonin is also crucial for healthy sleep and for the reduction of cholesterol and blood pressure. In the case of immune system an example is provided by the change of functioning of lymphocytes in turn reducing the competence of immune system making the subject more vulnerable to allergens, toxins and viruses.

Amplitude windows

There are several amplitude windows but here only the main amplitude windows will be discussed. For the first window ELF em fields have values of electric field in tissue around 10^{-7} V/m. The effects are high level effects and associated with navigation and prey detection in marine vertebrates and with the control of human biological rhythms. For ELF modulated radio frequency fields (RF) and microwaves (MW) the intensities are around $1 - 10$ V/m. In this case the effects are neurophysiological effects are lower level effects at the level of the brain tissue. In the case of brain tissue maximal sensitivity to electromagnetic fields occurs between 6 and 20 Hz.

In order to get grasp about orders of magnitude, it is good to notice that on some experiments cell membrane electric field has a strength about 10^7 V/m whereas EEG electric fields in the range

$5 - 10$ V/m. The fact that the second intensity window corresponds to $1 - 10$ V/m suggests that the em field simulates the em field associated with EEG: a valuable guideline in attempts to understand what is involved. For Schumann resonances electric field is of order .6 mV/m. For sferics (em perturbations associated with lightnings) magnetic field strength is not above nTesla: this corresponds to electric field strength 10 V/m associated also with EEG waves [F7]. Field strength of V/m corresponds roughly to energy flux $\mu W/m^2$.

The presence of windows and weak intensities implies that the effects cannot be thermal. A good metaphor is the effect of radio noise on radio receiver: it occurs at definite frequency and destroys the information content of the original transmission.

The effects occur at harmonics of cyclotron resonance frequencies

Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized a possible role of Earth's magnetic field [?]: it must be however emphasized that the value of magnetic field in question is $B_{end} = .2$ Gauss and smaller than $B_E = .5$ Gauss. A possible interpretation is that harmonics of cyclotron frequencies might be the information carrying frequencies in EEG.

In response to the results and speculations of Blackman, Liboff formulated ionic cyclotron resonance (ICR) model [?] based on the realization that the frequencies in question correspond to multiples of the cyclotron frequencies of Ca^{2+} ion in a magnetic field $B_{end} = .2$ Gauss. This model was classical. Later Blanchard and Blackman proposed so called ionic parametric resonance model (IPR) [?]. This phenomenological model combines ICR model with ideas about atomic physics. There are several objections against ICR model; classical orbits of ions in Earth's magnetic field have radius of order meters; dissipative effects and Brownian forces do not allow cyclotron orbits; charge-to mass ratios appearing in cyclotron frequencies correspond to vacuum rather than water environment characterized by a large value of dielectric constant; it is difficult to understand why odd multiples of cyclotron frequencies give rise to stronger effects [?]. Some of these objections apply also to IPR model.

The pattern of data seems to suggest that the interaction occurs at quantum level. This is in dramatic conflict with the predictions of the standard quantum theory and with the standard view about space-time.

Are quantal effects in question?

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field having same strength as Earth's magnetic field, is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of Ca^{2+} ion in magnetic field $B_{end} = .2$ Gauss. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. Transitions are not possible at all in the lowest order of perturbation theory since the interaction Hamiltonian describing the transitions in question has non-vanishing matrix elements only between states of opposite parities in the dipole approximation applying when the wavelength of the radiation is much larger than the size of the radiating system [B13]. Odd and even values of n for cyclotron states have opposite parities so that Δn odd rule results. In higher orders of perturbation theory also transitions for which transition frequency is even multiple of the cyclotron frequency are possible. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

   There are however also objections.

1. The cyclotron energy scale is about 10^{-14} eV and ridiculously small as compared to the energy scale .086 eV defined by room temperature so that quantal effects should be masked completely by thermal noise.

2. Also ELF em fields at spin flip frequencies (Larmor frequencies) should induce transitions. To my best knowledge these have not been reported.

3. The wave functions of ions in magnetic field are confined in a region of size of order

$$r_n \sim \sqrt{2n/eB} \ ,$$

which is of the order of cell size: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the p-adic length scale $L(169) = 5$ μm rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ (S denotes the area of the flux tube) and $Z = 2$. If one requires quantum classical correspondence, very large values of n are required and cyclotron radii would be much larger than flux tube radius.

A common resolution of all these objections is provided by large $\hbar$ phases and hierarchy of magnetic flux sheets with B scaling like $1/\hbar$ meaning that cyclotron frequencies scale down similarly and cyclotron energies remain invariant. Same applies to spin flip energies scaling in the same manner as cyclotron energies (for some time I thought that the scaling behaviors are different). By the quantization of the magnetic flux, predicted by TGD also classically, the minimal radius of the magnetic flux tube for the magnetic field of Earth of cell size for ordinary value of $\hbar$ but scales like $\hbar$ if magnetic field remains invariant and flux quantization $BS = n2\pi\hbar$ implying $S \propto \hbar$ holds true. This implies consistency with classical theory for large values of $\hbar$.

9.3.2 A Brief Summary Of The Model Explaining Cyclotron Frequencies

Some work is required to end up with the following interpretation based on a model for how the different levels of dark matter hierarchy communicate and control. This model already discussed at the general level relies on resonant cyclotron transitions induced by Josephson radiation from cell membrane Josephson junctions, which are almost vacuum extremals.

1. Ions with charge Z, mass m and spin S in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as

$$E = E_c + E_L \ , \quad E_c = (n + \tfrac{1}{2})\hbar\omega_c \ , \quad E_L = S_z \tfrac{g\omega_c}{2} \ , \quad \omega_c = \tfrac{ZeB}{m} \ (c = 1) \ .$$
$$(9.3.1)$$

The first contribution corresponds to cyclotron contribution. For a given value of n the component of angular momentum in the direction of B has $n + 1$ values $n, n - 2, ..., -n$. E_L denotes spin (Larmor) contribution. g is so called Lande factor which for free elementary fermions equals to $g = 2$. Since S_z is invariant under the scalings of $\hbar$, Larmor contribution is negligible as compared to cyclotron contribution for large values of $\hbar$. The contribution to energy coming from the free motion in the direction of magnetic field has not been written.

2. Experimental findings suggests strongly that external em field induces resonant transitions between cyclotron states: these transitions are identified as transitions inside the cell/nucleus or its fractally scaled up variant. Cyclotron radiation can drive charged particles to smaller space-time sheets and this is essential for the metabolism and this process is expected to be part of the interaction of ELF em fields with cell nucleus. This in turn induces a response of magnetic body affecting the state of brain.

3. Dark matter hierarchy leads to the hypothesis that there is entire hierarchy of EEGs generated as coherent photon states by Josephson currents associated with the Josephson junctions whose thickness scales as $\hbar$ and frequency scales as $1/\hbar$ so that cyclotron energy remains invariant and is above the thermal threshold. For each value of $\hbar$ there is also p-adic hierarchy corresponding to $k = 151, ..., 169$ with same Josephson frequency: these levels combine to form single block for dark matter hierarchy formed from the scaled up variants of this block. At least the magnetic flux tube structure of DNA and membrane structure appear as scaled up copies. The lowest level corresponds to cellular or nuclear membrane and ordinary value of $\hbar$.

9.3.3   Interpretation Of The Temperature Window

The effects of ELF em fields on matter have been observed only in a temperature window 36-37 C around body temperature. I have already proposed that this interval is due to competition of two effects.

1. High T_c super-conductivity and cyclotron condensates are possible below 37 C whereas near vacuum extremal property is possible above 36 C so that only a narrow temperature range remains making possible communications and control of the biological body by magnetic body.

2. Also the model of high T_c super-conductivity as a quantum critical phenomenon predicts that there is a narrow interval around T_c around which two competing phases corresponding to ordinary value and scaled up value of $\hbar$ compete.

   More generally, dark matter hierarchy should correspond to a hierarchy of quantum criticalities. A fractal hierarchy of cusp catastrophes such that the next cusp is inside the critical line of the previous cusp would be a convenient manner to visualize the situation. Each big leap in the evolution corresponds to the emergence of a new level in the dark matter hierarchy made possible by the external conditions allowing co-presence and competition of phases corresponding to different Planck constants.

   Quantum critical high T_c super-conductivity for electrons and protons (at least) is the essential prerequisite for the existence of Josephson currents through the cell membrane and its scaled up variants, and thus the hierarchy of generalized EEGs. Electronic super-conductivity is expected to be possible in a very limited temperature range usually idealized with single critical temperature.

   Quantum critical phase is analogous spin glass phase possible in a finite interval around critical temperature, and one can indeed speak of quantum spin glass phase for which the analogs of regions with fixed direction of magnetization are 4-dimensional rather than 3-dimensional and static. This relates to the breaking of the strict classical determinism of the basic variational principle of TGD having interpretation in terms of space-time correlate for quantum non-determinism in long time and length scales. Quantum coherence and quantum nondeterminism in long scales is obviously what makes system living. An educated guess is that the critical range of temperatures allowing quantum criticality and high T_c super-conductivity is just 36-37 C: this in turn implies that the effects of ELF em fields occur only in this temperature range.

9.3.4   How Could One Understand The Amplitude Windows?

The attempts to understand the mysterious looking amplitude windows for electric field have not been fruitful hitherto. The intuitive expectation is that the explanation could be in terms of the new physics provided by zero energy ontology and causal diamonds, hierarchy of Planck constants, and cyclotron frequencies of ions, proton, and electron and even quarks and maybe even Z^0 cyclotron frequency of neutrino. The following argument represents the latex trial based on the model for the DC currents of Becker as quantum currents discussed in [K80].

Can one take into account the complications due to modulation?

Before representing any arguments it must be emphasized that the actual signal is either ELF signal or ELF modulated signal -say microwave signal (frequency in the range is.3 GHz-300 GHz) modulated by cyclotron frequency. The effects are very similar in the two cases. The assumption is therefore that the eventual interaction of the tissue is with ELF frequency signal. This requires demodulation in the tissue. In the case of modulated signal one has to be careful with the experimental definitions of field amplitudes. It will be assumed that the reported amplitude windows correspond in the case of ELF modulated signals to the ELF amplitudes measured in the tissue after de-modulation.

   Not that even the question how linear superposition of fields takes place in TGD Universe is non-trivial. For given massless extremal linear superposition is possible only for signals propagating to fixed direction but need not correspond to that for fields since they are not the primary dynamical

variables. In fact, the basic argument against TGD is that linear superposition for fields does not hold in TGD Universe in general since classical gauge fields and gravitational field are not primary fields but expressible in terms of embedding space coordinates and their gradients. The solution of the problem is provided by many-sheeted space-time concept (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book). It is not field but their effects which superposed. In classical case the effects are the forces caused by the classical fields. This indeed happens if the fields involved correspond to different space-time sheets and particle suffers simultaneous topological condensation to the space-time sheets in question and experiences the sum of the forces caused by them. In quantum case the sum of gauge potentials and deviations of metric from Minkowski metric is what is experienced by the particle. This is discussed in detail in [K102].

Massless extremals represent the most promising classical description for the radiation fields. They allow arbitrary pulse shapes so that the modulation at the level of massless extremals is not a problem. This kind of modulation is indeed in question. Demodulation requires a highly non-linear mechanism leaving from the rapidly oscillating amplitude only the envelope. In TGD framework it is not difficult to imagine non-linear mechanisms since the dynamics of Kähler action is extremely non-linear. For MEs the time profile of the induced gauge field at given point is essentially arbitrary and one can easily imagine a process leading from ELF modulated field to a pure ELF field at given point. Energy conservation and effective 2-dimensionality of the signal (polarization direction and direction of 4-D wave vector) certainly puts bounds on the change of the amplitude and the simplest guess is that the amplitude squared for pure ELF corresponds to the average of the amplitude squared over the cycle of the carrier wave for the modulated radiation so that amplitude is reduced by $1/\sqrt{2}$ factor.

Direct quantum currents of Becker and explanation for the amplitude windows

The quantum model for the DC currents of Becker 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.

Explanation for the observed amplitude windows

The amplitude window occur in widely separate ranges 1-10 V/m and around 10^{-7} V/m. Of course, also other frequency ranges might be possible. Fractality and the notion of magnetic 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.

By fractality the most natural guess is that the voltage along the flux tube is invariant under the scale of Planck constant. This would mean that the electric field would behave as $1/L^2 \propto 1/\hbar^2$ as a function of the length scale characterizing the scale variant of the structure.

If so the range $E = 1 - 10$ V/m assignable also to EEG would correspond to a length scale of $7.7 - 24$ μm corresponding to cell length scale. Perhaps the direct currents run between cells layers. $E = 10^{-7}$ V/m would in turn correspond to 7.8 cm which corresponds to size scale of human brain hemisphere (experiments were carried out for vertebrates). Could the direct quantum currents in question run between brain hemispheres along corpus callosum?

9.4 How Does Generalized EEG Relate To Conscious Experience?

In this section possible interpretation of cyclotron phase transitions and EEG from the point of view of conscious experience are discussed.

9.4.1 Sensory Canvas Hypothesis

Sensory canvas hypothesis assumes that magnetic transition frequencies code for the temporal and possibly also spatial positions of the objects of the 4-D perceptive field at the personal magnetic body characterized by field strength B_{end}.2 Gauss at the surface of Earth. Magnetic transition frequencies are associated with MEs serving as sensory projectors to which various sub-selves representing features are entangled.

The view about evolution of consciousness as a gradual emergence of increasingly lower EEG frequency scales suggests a general paradigm concerning the assignment of the frequency bands with various cyclotron frequencies and possibly spin flip frequencies. 40 Hz band could naturally correspond to MEs projecting symbolic representations associated with the sensory input to the magnetic sensory canvas. The range 20-40 Hz could be associated with some simple cognitive features or emotions (say associated with odor discrimination) whereas 13-20 Hz interval could correspond to more refined cognitive features. alpha and theta bands could relate to the features representing memories. The possibility of communications at theta, delta and alpha frequencies to higher level many-brained magnetic selves representing collective levels of consciousness must be considered seriously in TGD framework.

The processing of the sensory input involves where-what division. The fact that "where" aspect has developed earlier encourages to think that it is more primitive aspect of perception so that the EEG frequencies associated with the simplest "where" aspects might be higher. This is supported also by the fact that the EEG rhythms associated with brain stem and cerebellum correspond to 80 Hz and 200 Hz respectively.

The narrow highly coherent frequency bands with width of order 1-2 Hz reported by Nunez at 3, 5 and 7 Hz, the alpha band at 11 Hz, and the narrow bands at 13, 15 and 17 Hz [?] plus the 8 Hz width band around 40 Hz provide empirical support for the basic assumptions and a good starting point for possible more detailed identifications.

9.4.2 Magnetic Quantum Phase Transitions And EEG

The original attempt to assign our qualia to magnetic and Z^0 magnetic transitions need not be correct. The following scenario looks a more realistic working hypothesis.

1. The EEG MEs associated with magnetic transitions serve as quantum entanglers of the bodily mental images to the personal magnetic body. If sensory representations are realized at the personal magnetic body, the magnetic quantum phase transitions at the personal magnetic body contribute to our conscious experience by the fusion of "simple feeling of existence" mental images with much more complex bodily mental images.

2. The field patterns associated with negative energy EEG MEs code for declarative long term memories perhaps using the hierarchy of p-adic cognitive codes discussed above. The model of long term declarative memories suggests that bodily magnetic qualia need not be conscious-to-us. The magnetic quantum phase transitions would represent a step in the transformation of the field patterns of EEG MEs representing declarative memories to conscious experiences.

The overall conclusion would be that, as far as primary sensory qualia are considered, magnetic transitions are not very interesting. On the other hand, the hypothesis that magnetic fields are such that magnetic transition frequencies tend to coincide with various universal frequencies (say those assignable toCDs), makes them very interesting concerning the practical models for what might be happening at the magnetic flux tubes of body and brain.

Sensory maps by magnetic frequency scale coding

There is a large temptation to assume that the great variety magnetic magnetic transitions in EEG frequency range make possible hierarchy of living maps. A varying magneti frequency scale would code for a position of neuron or some larger unit of brain and to which input from a point of perceptive field is mapped by entanglement (sharing of mental images) and/or by classical communications. Personal magnetic body would essentially remember what happens at material body by sending entanglement inducing negative energy ME to brain along magnetic flux tube and receiving positive energy MEs inducing self-organization and generation of mental images. The classical communication would be like communicating selectively by broadcasting radio waves to receivers each having their own narrow radio wave band.

The working hypothesis is that various mental images in the cortex are projected outside the cortex and CNS at the canvases formed by the magnetic flux quanta associated with various body parts. There are good reasons to believe that these maps are realized in the length scales of EEG wavelengths. The resulting 3-dimensionality of the map is a strong argument in favor of these maps as also the complete decoupling between representation and information processing yielding the representation.

Quantum maps could be realized by place coding using cyclotron frequencies associated with ELF MEs emerging radially from various parts of CNS, also from sensory organs even. If the time mirror mechanism (see **Fig. http://tgdtheory.fi/appfigures/timemirror.jpg** or **Fig. ??** in the appendix of this book) is a general mechanism of sensory perception, motor action, and memory applied by the magnetic body, the length along the magnetic flux tube codes for the temporal distance to the geometric past. This coding would rely on resonance mechanism involving also resonant interaction of MEs with Alfven waves associated with magnetic flux tubes (much like oscillations of string). The very slow dependence of these frequencies on distance would be determined by the strengths of the classical magnetic fields for which these flux tubes provide a representation as topological field quanta.

Positive energy magnetic transitions could be used for the temporal coding of the sensory representations whereas negative energy magnetic transitions could be used for the temporal coding of generalized motor actions. This would obviously help to avoid overlap between signalling associated with sensory representations and motor actions.

Magnetic quantum phase transitions could give rise to chemical maps of parts of organ. By using an appropriate value of frequency, magnetic quantum phase transitions can be induced and the intensities of these transitions would provide conscious measure for the densities of Bose-Einstein condensates of ions (and perhaps even their Cooper pairs if they manage to be thermally stable) whose densities in turn relate to those at atomic space-time sheets by many-sheeted ionic equilibrium conditions. If the thickness of the magnetic flux tube varies different quantum phase transitions occur at different points of the flux tube and kind of conscious spectrogram results. This kind of generalization of NMR spectroscopy need not be conscious to us although chemical senses could relate to it.

Place coding for the geometric parameters characterizing simple geometric features

Place coding for various geometric parameters characterizing simple geometric "features" could be realized using the variation of the cyclotron frequency along a magnetic flux tube of varying thickness. The hierarchy of the sensory canvases allows a modular structure in which a geometric feature such as triangle, line, or ellipse represented at a lower level sensory canvas is projected to a *single* point of "our" sensory canvas. If one accepts that only negative energy MEs can serve as entanglers, the conclusion would be that place coding must utilize negative energy MEs to entangle brainy mental images with the "simple feelings of existence" at the magnetic body.

Becker tells in his book "Cross Currents" [**?**] about a technique discovered by Dr. Elizabeth Rauscher, a physicist, and William Van Bise, an engineer. The technique uses magnetic fields generated by two coils of wire, each oscillating at a slightly different frequency and directed so as to intersect at the head of the subject person. When two energy beams with different frequencies intersect at some point in space, a third frequency, so called beat frequency is formed as the difference of the frequencies. What Bise and Rauscher found that this ELF frequency (unfortunately, I do not know what the precise frequency range was) generates simple visual percepts like circles, ellipses and triangles and that the variation of the second frequency induces the variation of the shape of the percept.

The simplest interpretation is that the beat frequency is extracted by non-linear effects in brain and induces a magnetic quantum phase transition at magnetic tubes whose thickness varies and codes for a parameter (say scaling in some direction) characterizing the geometry of the primitive percept (or "feature"). The proposed general mechanism for how EEG MEs give rise to declarative memories should apply also now and would mean that EEG MEs induce cyclotron transitions giving in turn rise to neural activity. If primary sensory organs are seats of sensory qualia, back-projection to the eyes is involved with the process as also in the case of electric stimulus of cortex inducing visual sensations. The intersection of ELF waves would wake-up symbolic mental images representing triangle and back-projection would make this concept visual. The geometric parameters characterizing the triangle would be coded to frequency differences. An analogous phenomenon occurs also for auditory inputs with slightly different frequencies fed into ears and makes it possible to "hear" sounds below the audible range. The mechanism could be the same.

Flag-manifold qualia and magnetic fields

Recall that the flag-manifold representing various choices of quantization axes is a coset space associated with the zero modes. The association of the six-dimensional flag-manifold of color group $SU(3)$ to honeybee dance and geometric aspects of honeybee's sensory experience (described in the chapter [K39] inspired the hypothesis that the values of the flag manifold coordinates might be quite generally mapped to magnetic or Z^0 magnetic frequencies by mapping these coordinates to the parameters characterizing magnetic flux tubes. Thus there are two frequencies involved and the mappings projects everything to 2-dimensional space.

The flag-manifold defined by the choices of the quantization axes for the super-symplectic algebra of the WCW is infinite-dimensional. One can however consider finite-dimensional flag-manifolds as lowest order approximation. In the case of MEs of type $E^2 \times CP_2$, the minimal flag-manifold would be the one defined by the Cartan group of $SO(2) \times SU(3)$, which is just the flag-manifold $F_3 = SU(3)/U(1) \times U(1)$ of color group introduced by Barbara Shipman. For MEs of type $S^2 \times CP_2$ which correspond to spherical light fronts the flag manifold is $S^2 \times F_3$. A very natural identification of S^2 is as labelling orientations of a vector in 3-space. Thus one might consider the possibility that the increments S^2 coordinates could represent changes of orientation at the level of conscious experience. On the other hand, linear sequence of sub-selves inside self would represent experienced orientations very concretely.

One could try to generalize, and consider the possibility that the proper flag manifold is defined by $SO(3,1) \times SU(3)$ by the division by Cartan subgroup. Lorentz group would give 4-dimensional flag-manifold $SO(3,1)/R \times SO(2)$. Lorentz rotations can be decomposed to boosts followed by rotations in rest frame of the resulting system. This suggests that $SO(3,1)$ flag-manifold has a bundle structure with the sphere S^2 defined by boost directions serving as the base and the sphere S^2 defined by the possible directions for the axis of rotation in the rest frame serving as the fiber. Again sub-self moving inside self could represent the direction of boost naturally.

There must be some correlation between the values of zero modes (in particular, flag manifold coordinates) and classical em Z^0 magnetic fields. For instance, color rotation affects the em and classical Z^0 fields. In this sense flag-manifold coordinates can be coded to em and Z^0 magnetic frequencies but the image is 2-dimensional. The work of Barbara Shipman with the dance of honeybee indeed implied that flag-manifold coordinates are mapped to spatial positions in *2-dimensional* plane representing the dance stage. This suggests that $F_3 = SU(3)/U(1) \times U(1)$ coordinates have representational role: they represent concrete geometric information about spatial positions. This representational role could derive from more general assumptions. The positions of plane are represented as frequencies by the place coding by magnetic and Z^0 magnetic frequencies

and $SU(3)$ rotations affect em and Z^0 magnetic frequencies so that plane points can be mapped to equivalence classes of $SU(3)$ rotations so that a 2-dimensional space associated with the flag-manifold F_3 emerges naturally.

Could magnetic phase transitions define sensory qualia?

If universality principle holds truemagnetic qualia can be divided to universal kinesthetic qualia and to generalized chemical qualia corresponding to the change of a number of particles in a state with given quantum numbers (say the integer n characterizing cyclotron state). The interpretation of these qualia is far from obvious.

1. Magnetic qualia could be "universal feelings of existence" associated with the place coding of the motor actions from the sensory canvas and also inside brain. This would mean a neat separation of sensory and motor representations from each other. Universal feeling of existence might also be the basic aspect of tactile senses and in fact, all sensations.

2. If the harmonic of the cyclotron frequency does not affect the character of the quale, the number of cyclotron qualia is finite. alpha band is expected to be the most interesting frequency range as far as qualia are considered. The five bosonic ions $Mn^{2+}, Fe^{2+}, Co^{2+}, Zn^{2+}$, and Se^{2-} have cyclotron frequencies 7.6, 9.4, 10.0, 10.8 and 11.4 Hz. The number of basic tastes is thought to be five, which could mean that magnetic cyclotron phase transitions code for the basic tastes. The number of odors is definitely larger than basic tastes as is also the number of exotic Z^0 ions, which are almost always bosons. Thus the identification of Z^0 magnetic cyclotron transitions as correlates for odors can be considered.

This proposal can be criticized. Any bosonic molecule with $A/Z \leq 223$ (thermal stability of the BE condensate at room temperature) could as such directly define a cyclotron quale so that tastes and odors would correspond to cyclotron transitions of molecules themselves rather than those of bosonic ions in alpha band. One could also argue that the odors and tastes should have a natural ordering according to the value of cyclotron frequency and be continuously transformable to each other by changing the strength of the magnetic field. This doesn't seem to be the case.

What about Larmor frequencies?

Larmor frequency characterizes the nuclear contribution of this interaction to energy and is related to the cyclotron frequency of a singly ionized atom by

$$\omega_L = g\frac{S}{2}\omega_c \ , \quad \omega_c = \frac{eB}{m} \ .$$

where S denotes the maximal projection of spin in the direction of the magnetic field and g is Lande factor, which equals to $g = 1$ in the ideal classical case for which spin corresponds to angular momentum whereas $g = 2$ holds true for elementary fermions. Nuclear contribution is the dominant contribution for ions Na_+, K_+, Cl_- since electron shell is full for the ions in question. The magnetic moments of ions Cl_-, K_+, Na_+ reduce to their nuclear magnetic moments and are rather large:

$$\mu = x\frac{e}{2m_p}S \ , \quad g \simeq 2xA \ ,$$

where m_p denotes proton mass and x is a parameter of order one so that Lande factor is proportional to the mass number A of nucleus. The reason for large value of μ is that magnetic interaction energy of the nucleus is essentially the sum over the interaction energies of nucleons.

If anomalous magnetic moment vanishes Larmor frequency differs by a factor 1/2 from cyclotron frequency: $f_L = f_c/2$ so that spin flip frequency is same as cyclotron frequency. For atomic nuclei the Larmor frequency tends to be larger than cyclotron frequency as the table of Appendix demonstrates. The effects of em fields in living matter at Larmor frequencies have not been however reported.

The interaction of the nuclear spin with magnetic field dominates over the cyclotron interaction energy by a factor of order A and that the natural frequency scale for the ionic Larmor frequencies is hundreds of cycles per second. The values of the parameter x are $x(Na) = 2.214$,

$x(Cl) = .82181$ and $x(K) = .3915$. For instance, for Na_+ spin flip transition frequency with $\Delta S = 1$ is $f \sim 222$ Hz. For Ca_{++} spin and magnetic moment vanishes. Note that for $J = 3/2$ ions there are in principle three kinds of transitions corresponding to $\Delta S = \pm 1, \pm 2, \pm 3$. If transition reduces to single nucleon level, $\Delta S = \pm 1$ is the only possibility. The conclusion is that Larmor frequencies probably correspond to different components of sensory modalities than cyclotron frequencies.

The transitions changing the direction of spin of the Cooper pair are induced by the frequencies

$$\omega = (2n + 1)\omega_c + 2\Delta m\omega_L = (2n + 1 + g\frac{\Delta m}{2})\omega_c \ .$$

Odd multiples of the cyclotron frequency are possible in the first order perturbation theory whereas even multiples are possible only in the second order.

The natural question is whether also spin flips to which Larmor frequencies are associated could be also important from the point of view of conscious experience. The natural expectation is that Larmor frequency behaves in the same manner as cyclotron frequency in the scaling of Planck constant and this is indeed the case since spin scales as $\hbar_{eff}$. This allows to consider the possibility that also spin flip transitions are of interest and perhaps define correlates for sensory qualia.

Consider now some examples.

1. For proton and neutron the Lande factors are $g(p) = 3.58$ and $g(n) = -3.82$ so that the spin flip transition frequencies in Earth's magnetic field would be $2\omega_L = 542$ cycles/second for proton and 570 cycles/second for neuron. The frequencies $2f_L$ and $2f_L + f_c = 842$ cycles/second could have something to do with the time scale of nerve pulse in case of proton. Note that $2f_L - f_c = 242$ cycles/second is of same order as f_c for proton so that corresponding qualia might resemble each other.

2. For electron $g = 2$ in excellent approximation and the Larmor frequency is very nearly identical with one half of cyclotron frequency. The deviation is

$$\frac{\Delta g}{g} = \frac{\alpha}{2\pi}$$

in the lowest order of perturbation theory ($\alpha \simeq 1/137$) and thus the frequency for the transition $(n + 1, up) \leftrightarrow (n, down)$ changing the spin direction of the second electron of the Cooper pair is $\omega \simeq 902$ Hz. This time scale corresponds to the duration of memetic codon fixed by the fact that memetic code corresponds to Mersenne prime M_{127}, which happens to be the p-adic prime characterizing also electron.

3. Spin flip frequencies for atomic nuclei are in general of order few hundred Hz for $B = .2$ Gauss. For instance, the spin flip frequencies of Mn, Co, Cu, and Na are for $B = .2$ Gauss 228 Hz, 199 Hz, 223 Hz, and 222 Hz. What makes this interesting is that cerebellar resonance frequency is around 200 Hz.

The eight ions listed in **Table 9.1** have however exceptionally low Larmor frequencies and, very importantly, the singly ionized states have vanishing electronic spin for all ions except Rh and IR for which electronic configuration corresponds to $J - e = 2/2$ (non-vanishing electronic spin implies that the Larmor frequency of ion is of order $f_L = f_c(e)/2 \simeq 3 \times 10^5$ Hz). This suggests that electromagnetic spin flip transitions for these ions at least could be related to our consciousness. Note that K, Ag and Au have spin flip frequencies near to the harmonics of the fundamental frequencies of exotic super-symplectic representations important in EEG frequency range. Note that the spin flip frequency of K is 39.1 Hz which is in 40 Hz thalamocortical resonance band. The spin flip frequency 82.2 Hz for Cl might relate to the resonance frequency 80 Hz associated with retina.

Magnetic states have momentum in the direction of the magnetic field and a priori the transition frequency spectrum is continuous rather than discrete. Energy and momentum conservation however imply that the increment of longitudinal momentum is fixed in transition and in excellent approximation transition energies are equal to those obtained by neglecting longitudinal momenta altogether.

Ion	(Z, A, S)	f_1/Hz	f_{flip}/Hz	J
Cl	(17, 35, F)	8.5	82.2	3/2
K	(19, 39, F)	7.5	39.1	3/2
Rb	(37, 85, F)	3.5	81.0	5/2
Y	(39, 89, F)	3.4	41.2	1/2
Rh	(45, 103, F)	2.9	26.6	1/2
Ag	(47, 107, F)	2.8	34.2 (39.2)	1/2
Ir	(77, 193, F)	1.6	17.0	3/2
Au	(79, 197, F)	1.5	14.0	3/2

Table 9.1: The ions for which electronic spin vanishes in ground state and minimum spin flip frequency f_{flip} is below 90 Hz. f_{flip} is defined as $f_{min} = 2f_L/J$m, where J is nuclear spin. Ag allows two stable isotopes with almost same abundances and the values of f_{flip} are given for both.

To get an idea about energy and momentum transfers involved with the transitions between magnetic states with longitudinal momenta k_1 and k_2, one one apply energy and momentum conservation by assuming that the classical field associated with ME, and thus propagating with light velocity, induces the transition. Let k_1 and k_2 denote the wave vectors of initial and final magnetic states in the direction magnetic field: the corresponding contributions to the energies of the magnetic states are $k_i^2/2m$, $i = 1, 2$. Let $k_{||} = kcos(\theta)$ denote the projection of the wave vector k of the ME em wave to the direction of the magnetic field satisfying $k = E$: momentum conservation gives $k_1 - k_2 = k_{||}$. Energy conservation in turn gives

$$\Delta E = \Delta E_B + \frac{k_1^2 - k_2^2}{2m} = E \ ,$$

where

$$\Delta E_B = n\omega_c + \omega_{flip}$$

denotes to the contribution of the cyclotron and spin flip components to the transition frequency. The condition

$$(k_1 + k_2)/m << 1$$

is certainly satisfied and this allows the approximations

$$k = \Delta E \simeq \Delta E_B$$

$$k_1 - k_2 \simeq \Delta E_B cos(\theta)$$

The result means that transition frequencies are not essentially affected by the energy transfer in longitudinal degrees of freedom and it is an excellent approximation to assume that the frequencies inducing magnetic transitions correspond to the transition frequencies associated with the transitions in cyclotron and spin-flip degrees of freedom.

9.4.3   Altered States Of Consciousness And EEG

The magnetic flux tubes in the length scale range determined by theta and delta band could quite well connect magnetic body to several different organisms and make possible sharing of experiences. Also magnetosphere and even larger magnetic structures could give rise to sensory and other representations receiving input from several organisms and sharing of mental images would allow to share these experiences.

If magnetic body is the experiencer applying time mirror mechanism and if positive energy EEG boundary MEs in delta and theta bands correspond to classical communications of declarative memories usually not conscious-to-us, the dominance of theta and delta waves during sleep suggests two alternatives.

1. During the sleep our attention is directed to transpersonal levels of consciousness but that we do not remember anything about this. The reason might be that no declarative memories are generated during this period.

2. We are entangled with transpersonal levels of consciousness and have lost our personal consciousness. A conscious contact with transpersonal levels requires sharing of mental images with these levels and this might occur during meditation. Theta and delta bands are also known to dominate during deep meditation.

One can consider two alternative interpretations corresponding to interior MEs (phase velocity equal to light velocity) and positive energy boundary MEs (phase velocity equal to EEG phase velocity) associated by scaling law with the negative energy MEs.

1. For positive energy interior MEs the frequencies would correspond to magnetic flux tube lengths up to about 10 Earth circumferences and contained within Earth's magnetotail at the night side. Time scale would be $T = 1/f$. These MEs could feed data using appropriate cognitive codes at p-adic resonances frequencies to the magnetospheric multi-brainy collective selves responsible for the transpersonal levels of consciousness.

2. The scaling law, assuming the alpha wave phase velocity to be the effective phase velocity v of boundary ME, would predict that the time $T_1 = \lambda/v$ needed by the boundary MEs to travel the distance $L = c/f$ defining the distance to the point of the magnetic body wherefrom the negative energy EEG ME was sent to the brain, is measured using decade as a natural unit. If magnetic body is the experiencer applying time mirror mechanism this would mean that delta band would correspond to memories with time span of about ten years. One might think that the magnetic body triggers boundary MEs using negative energy MEs in ULF range which automatically give rise to memories experienced after time T_1.

Transcendental states of consciousness and EEG

Transcendental states of consciousness are characterized by the presence of alpha and theta bands [?] (note that theta band is present also during childhood, youth and even early adolescence but usually disappears at older age). It is found that theta and alpha bands are preserved also during deep sleep [J11]. A possible interpretation is that the presence of alpha band signifies that left brain remains awake in a state of relaxed alertness involving weak signals from magnetic body. One could also argue that even deep sleep is a conscious state but that the presence of alpha band activity in left brain is necessary in order to have memories about this state.

Transpersonal levels of consciousness

Individual organisms or even larger structures could define the "pixel size" for higher level multi-brained selves realized as sensory, symbolic and cognitive representations at various magnetic structures like the magnetosphere of Earth. These levels could correspond to any p-adic length scale above brain size. These levels would obviously represent the consciousness of various kinds of groups and collectives.

1. Sleep and transpersonal states of consciousness

The simplest assumption is that one loses consciousness during sleep by entanglement with some higher level self, say magnetospheric multi-brained self. This would give rise to a fusion of mental images at this higher level and to a stereo consciousness representing "human condition".

One should not be however too hasty to make this kind of conclusion. If it is indeed biological body which sleeps, our field body could be full awake with attention directed to transpersonal levels of existence. If this is indeed the case, the basic question would be about how to have these experiences and simultaneously form long term declarative memories about them: some part of brain, probably including hippocampus, should be kept awake during these experiences. Perhaps meditative states, often characterized as transpersonal ego-free consciousness, are this kind of states.

2. Who am I?

These arguments raise the question "Who am I really?". What precise length scale my ME does corresponds size of Earth, of solar system, of galaxy? Or can my self size be literally infinite and correspond to some infinite p-adic prime and is only the localization for the contents of my conscious experience to this particular corner of this particular galaxy which creates the illusion that I am this biological body? During episodal memories and also ordinary memory recall parts of magnetic body and MEs having size $L = cT$, T the time span of the episodal memory are actively involved so that one can say that the size of "me" is measured in light years. But it is difficult to say whether the contents of my consciousness contains only personal memories even in ordinary states of consciousness. For instance, it is difficult to locate mathematical ideas in any particular portion of space-time and p-adic space-time sheets which are infinitesimally small p-adically are infinitely large in real sense.

Whatever the detailed answer to these questions is, this view allows to interpret physical death as a re-directed attention and giving rise to what might be called re-incarnation. What would differentiate between my and my dog's soul that our attentions are differently directed.

3. Examples of transpersonal experiences

Near-death experiences and out-of-body experiences could be examples of of almost transpersonal, "ego-free" consciousness. That these experiences often involve the experience of seeing one's own body from outside, is consistent with the transpersonal nature of the experience. As already noticed, delta band is peak frequency in the EEG of infant, which would suggest that children either direct their attention mostly to the transpersonal levels or that children are strongly entangled and almost unconscious as also we are when theta and delta bands of EEG dominate. That this would be the case would conform with the ideas about bicamerality. Otherwise our personal development would be gradual spiritual degeneration.

The experiences of what I call whole-body consciousness could also be example of consciousness involving transpersonal component. These states appear often at night time as dream like experiences and involve illusion of being in ordinary wake-up consciousness. The usual "noise" present everywhere in body, possibly due to the averaging over proprioceptive experiences of subselves, disappears totally and peculiar silence falls down. Whole-body consciousness starts as a stir in spine (same as generated by good music sometimes) extending gradually to the entire body. Experiences of weightlessness and of "wavy" nature of physical body, flying into roof and falling down smoothly back into bed are typical aspects of these experiences. During this kind of experience it is sometimes also possible to leave the room. During my "great experience" I experienced of leaving the hospital and walking along street knowing that I was invisible. This experience ended to experience of being brought back to hospital by hospital personnel.

Short lasting form of whole-body consciousness is also possible after waking-up immediately after falling asleep in daytime: perhaps theta consciousness prevails for a short time after wake-up. My personal "great experience" involved besides whole body consciousness enhanced cognition: entire flux of ideas many of which have later developed to basic principles of quantum TGD.

Meditative states of consciousness and EEG

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The proposed general picture allows to build a rough model for the mechanism leading to meditative states. One can also understand how so called ORMUS elements [H4] might help to achieve these states.

The harmonics of cyclotron frequencies in delta band should represent even more deeper transpersonal qualia with time scale of about $t_1 = (c/V) \times T$, $T = 1/f$ light years for $f = 1.5$ Hz and $V = 3$ m/s. One could of course argue that the concentrations of heavy ions in brain are so low so that corresponding cyclotron transitions do not give rise to any experiences even if scaling law would not forbid them. This objection is not necessarily very convincing since the needed densities of ions in cellular space-time sheet might be by a fraction of order $[L_e(137)/L_e(167)]^3 \sim 10^{-13}$ smaller than density of water and because heavier ions are in gas form and presumably tend to be mostly in non-atomic space-time sheets. TGD predicts also new electro-weak physics would could dramatically change the isotope ratios at cellular space-time sheets.

Delta waves might relate to the interaction of brain with sferics which are atmospheric em perturbations [F7]. The spectrum of sferics at delta frequencies resembles EEG spectrum at same

frequencies [F7]. The electric fields associated with sferics are of same order of magnitude as waves in delta band so that they are not amplified as much as alpha waves. This could explain why delta and theta consciousness is so weak.

One could also consider enhancing delta consciousness artificially: perhaps this could make enlightenment experience, if not more probable, at least more intense. This could perhaps be achieved by feeding in brain some heavy singly ionized ions with cyclotron frequencies in delta band and stimulating brain using ELF em field at corresponding cyclotron frequency in $B_{end} = 0.2$ Gauss. Some candidate ions are $Ag^+ : f_c = 2.8$ Hz; $I^+ : f_c = 2.4$ Hz and $Au^+ : f_c = 1.5$ Hz. Also heavy ions like Hg and Pb are in the same frequency range as Gold. For $Z = 1$ flux quantization these frequencies are halved since magnetic field strength is halved.

There are claims for so called ORMUS atoms which somehow differ from ordinary atoms [H4]. The persons involved take doses of what they call ORMUS elements, in particular so called White Gold, to induce spiritual experiences. In fact, Barry Carter who wanted to understand what is involved, contacted me about five years ago and told about these effects and I ended up the notion of wormhole Bose-Einstein condensate as a possible explanation of the claimed properties of White Gold. It might be that Gold ions and other heavy element ions enhance transpersonal sensory consciousness in delta band and lead therefore to spiritual experiences.

There is also a patented process developed by Robert Monroe and called Hemi-Synch [?] which might induce delta and theta consciousness. Feeding audible sounds to ears with carrier frequencies below kHz and frequency difference of say 10 Hz, which is as such not audible, generates binaural beat involving appearance of an EEG wave at difference frequency [?]. The difference frequency is not only "heard" but binaural beats in delta and theta range tend to induce relaxed, meditative and creative states [?]. This method might provide a test for the hypothesis that linear combinations or p-adic frequencies are crucial for consciousness by choosing beat frequencies equal to these frequencies. In a similar manner one could test the alternative hypothesis that cyclotron frequencies are fundamental for consciousness. One should know the precise value of local magnetic field and also take into account the possibility that brain could be able to regulate the value of the local magnetic field to some extend. It could be also possible to apply EEG biofeedback and delta and theta frequencies.

Empirical evidence for transpersonal levels of consciousness

Recall that hyper-genes would correspond to flux sheets traversing through cell nuclei belonging to several organisms. Obviously this level would correspond to a transpersonal level of consciousness: kind of multi-brained conscious entities receiving sensory input from several organisms and performing intentional control over their behavior would be in question. Strong correlations between EEGs of individuals, in particular those having a close personal relationship, would be the obvious implication.

The experiments of Mark Germine [?] provide evidence for the notion of transpersonal conscious entities and associated collective memory perhaps realized in terms of flux sheets traversing the neuronal nuclei of several persons. What was studied was the evoked EEG response to a series of random quantum stimuli which consisted of series of identical sound stimuli with randomly located deviant stimulus. Two subject persons, A and B, were involved. In the case that A observed the differing stimulus 1 second before B, the evoked EEG response of B became incoherent. Since evoked stimulus was oscillation at EEG frequency of about 11 Hz in the case that A had not observed the stimulus, one could understand the mechanism as a direct evidence for transpersonal conscious entity interacting with brains of both A and B. When transpersonal conscious entity had hear the stimulus once, it did not react to it in similar manner.

9.4.4 EEG And Golden Mean

Dan Winter has reported [H2] that in certain altered states of consciousness (described as experiences of bliss) the ratio of beta and alpha peaks approaches Golden Mean $\Phi \simeq 1.618...$ It is interesting to look what TGD based model for EEG could say about this finding.

1. For $f_J = 5$ Hz and $f_c = 10$ Hz (the p-adic frequency corresponding to the secondary p-adic time scale $T_2(127)$ associated with Mersenne prime M_{127}, and identifiable as a fundamental

biorhythm) one has $\beta/\alpha = 3/2$ which is the lowest approximation to Golden Mean in terms of ratios of Fibonacci numbers. The higher approximations approach to Φ. The approximation sequence would be consistent with the 1 Hz width for the narrow beta bands.

2. This would suggest that beta/alpha ratio is maximal in this state and approaches to Φ in a discrete manner. The question is whether the resting potential is quantized in terms of ratios of Fibonacci numbers $F_{2n}/F_{2n-1} \in \{3/2, 8/5, 21/13, ..\}$. At the limit theta peak would approach to 3.92 Hz: note that shamanic drumming rhythm corresponds to 4 Hz frequency. This hypothesis is testable by comparing possible changes in the measured resting potentials with subjective reports of meditators.

3. The sequence of ratios of F_{n+1}/F_n approaches Golden Mean in an oscillatory manner, which suggests that states of hyper-polarization following generation of nerve pulse correspond to ratios $F_3/F_2 = 5/3$, $F_8/F_5 = 13/8$, ... above Golden Mean. In the sate of "full bliss" there would be no hyper-polarization after the generation of nerve pulse. A possible interpretation is that there is no "dead" time after nerve pulse and system is immediately in a state of maximal possible alertness. On the other hand, the state of pure bliss should be ideally a state of pure alertness without mental images. In the state in which cell membrane in resting state is maximally hyperpolarized, nerve pulse generation does not occur too easily and thus sensory or other mental are not easily generated.

4. The sequence of Fibonacci numbers could relate to a hierarchy of finite-dimensional approximations for Jones inclusions for quantum phase $q = exp(i\pi/5)$ represented in terms of braids. $n = 5$ is also the minimal value of n allowing universal topological quantum computation [K3]. The state of full bliss would correspond to the limit at which the number of strands of braid is infinite so that topological quantum computations resources are maximal.

5. Dan Winter has also emphasized the importance of tetrahedral and icosahedral symmetries for DNA. These symmetries correspond to the only genuinely 3-dimension finite subgroups of rotation groups and are symmetries of water molecule clusters. Icosahedral group has $n = 5$ and would allow universal topological quantum computation.

9.4.5 Pineal Gland And EEG

Pineal gland is an unpaired structure and strictly speaking not part of brain being located outside the brain in primitive vertebrates. Pineal gland is known to play a role in the control of both central nervous system, endocrine system and immune system [**?**] . There is also strong evidence that pineal gland forms part of the magnetic navigation system in birds, and possibly also in humans who also have this system. Pineal gland is biological timekeeper and responsible for 24-hour circadian rhythms via a secretion of hormones, in particular melatonin. What pineal gland does is to inhibit secretion whereas pituitary gland facilitates it. Pineal melatonin level controls the hormone secretion and sleep wave cycle and magnetic exposure changes pineal melotonin secretion [**?**].

What makes pineal gland interesting is that it is accompanied by 10 Hz rhythms. This rhythm corresponds to the strongest resonance frequency in the alpha band for both EEG and ZEG.

Pineal gland as timekeeper

10 Hz corresponds to the p-adic frequency $f(2, 127)$ associated with the 126-bit memetic code, which is an especially important code in the hierarchy of the cognitive codes. The fact that tiny electric field at average alpha frequency of 10 Hz restores biorhythms in absence of local magnetic field [**?**], suggests that pineal gland has a coupling to some cavity resonances or some magnetic transition frequency equal to 10 Hz.

1. The lowest Schumann frequency 7.8 Hz is too low. On the other hand, the resonance frequency associated with effectively two-dimensional excitations of em fields inside Schumann cavity is exactly 10 Hz and could be involved with the realization of the memetic code.

2. Fe^{++} ion appears naturally and has cyclotron frequency of 10.74 Hz and provides a natural candidate for a biological clock, not necessarily associated with the pineal gland. A 3 per cent reduction of the Earth's magnetic field from the nominal value of .5 Gauss would reduce the cyclotron frequency to 10 Hz.

3. Co^{++} cyclotron frequency would be 10 Hz for $B = .5$ Gauss. Co^{++} has very high nuclear spin and is therefore a natural magnet: Yarrow has indeed suggested that vitamin B_{12} containing Co makes pineal gland magnetic hormone and fundamental biological clock at 10 Hz frequency [?]. Thus at least ELF ME with Co^{++} cyclotron frequency should go through pineal gland. In the case that they are singly ionized $n = 2$ multiples of corresponding cyclotron frequencies would be involved with the biological clocks in question: these transitions are possible in the second order of perturbation theory.

In darkness 24-hour circadian rhythm changes to 25-hour rhythm perhaps defined by the rotation of Moon and Earths's own rotation. The ratio of 24-hour period to 25-hour period is .96. The ratio of the average of Co^{++} and Fe^{++} frequencies to Fe^{++} frequency is .964 giving period of 24 hours 53 minutes if the average period is 24 hours. This observation suggests that circadian period is measured during daylight in time unit given by the period of Fe^{++} rhythm possibly associated with some visual pathway, perhaps even with eyes, and in darkness by the slightly slower Co^{++} rhythm associated with the pineal gland. Under this assumption the ordinary circadian rhythm f is weighted average of Fe^{++} and Co^{++} rhythms:

$$f = xf(C0^{++}) + (1 - x)f(Fe^{++}) \ ,$$

In ideal circumstances circadian rhythm is 24 hours: this gives $x = .44$ with roughly 13.5 day hours and 10.5 dark hours. In continual darkness the rhythm would transform to the slower Co^{++} rhythm of 25 hours with $f = f(Co^{++})$. These two rhythms would presumably distinguish between sleep and awake since pineal gland closely related to the regulation of sleep-wake cycle.

The deviation of x from ideal value $x = .44$ could be an important factor in some disorders. It is known that human melatonin levels do not depend very strongly on season except in arctic latitudes (seasonal affective disorder) but that melatonin levels affect sleep-wake cycle. Abnormally high activity of pineal gland is associated with the hallucinatory periods of schizophrenia: perhaps visual hallucinations of schizophrenic are partially mediated by pineal gland. The manic (depressive) phase of bipolar disorder correlates also with over- (under-) activity of the pineal gland [?]. Keeping x by artificial lighting near its ideal value could be of help. The artificial modification of the strength of the local magnetic field should modify the unit of biological time: perhaps this could provide a manner to cure not only jet lag but even much more serious mental disorders.

Pineal gland as "third eye"

The question is whether the 25-hour rhythm equals to the rhythm defined by moon's rotation or is it a mere coincidence. If not, then the MEs going through through pineal gland might mediate unconscious-to-us information about the rotation of Moon. Could higher level self "see" moon in its orbit? Perhaps in some sense! The ability to restore circadian rhythms is based on the photosensitivity of the pineal gland. Pineal gland has been indeed regarded as "third eye" by mystics. As a matter fact, in some lower vertebrates pineal gland serves as a genuine eye [?]. For long it has been thought that in mammals pineal gland is not (or perhaps cannot be!) directly photosensitive. Indeed, there is a pathway from the retinas to the hypothalamus called the retinohypothalamic tract [?]. It brings information about light and dark cycles to a region of the hypothalamus called the suprachiasmatic nucleus (SCN). From the SCN, nerve impulses travel via the pineal nerve (sympathetic nervous system) to the pineal gland. These impulses inhibit the production of melatonin. When these impulses stop (at night, when light no longer stimulates the hypothalamus), pineal inhibition ceases and melatonin is released. The pineal gland is therefore a photosensitive organ and an important timekeeper for the human body.

The belief that pineal gland receives information about changes in the lighting from retinas only, has turned to be wrong: mammals lacking ordinary rods and cones genetically, can preserve they circadian rhythms [?] ! Thus pineal gland must perceive changes in lighting somehow. TGD based explanation for pineal vision is based on the many-sheeted space-time concept (see **Fig.**

`http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) and ELF selves: light reaches pineal gland via MEs associated with EEG frequencies. Why we do not then see with our third eye? Or do do we actually see?: perhaps visual dreaming involves also seeing with the third eye providing "spiritual input" ! This hypothesis can be tested by checking whether the dreams of people with pineal gland injury somehow change. This explanation also suggests that also eyes are foci of converging MEs so that eyes would be rather concretely mirror of the soul!

Perhaps Descartes was not so wrong after all!

Descartes has been ridiculed for his belief that pineal gland is the seat of soul. Perhaps this sentence has been precipitate as suggested by a clinical case in which over-activity of 5-year old child had led to premature adolescence. Here is a fragment from Frederic Tilney's book "The Pineal Gland":

Until a few decades ago scant attention was paid to the pineal gland. Then came the case, noted by Dr. Berman, in which a child was brought to a German clinic suffering from eye trouble and headaches. He was five years old and very mature, and apparently had reached the age of adolescence. He was abnormally bright mentally, discussing metaphysical and spiritual subjects. He was strongly group-conscious and only happy when sharing what he had with others. After his arrival at the clinic, he rapidly grew worse and died in a month. An autopsy showed a tumor of the pineal gland.

Pineal gland is one of so called chakras in mystic teachings and it is known that pineal gland is involved with altered states of consciousness [**?**]. Meditation practices assign to third-eye meditation development of "light in the original cavity or center of spirit" located in the center of the brain and "waking of Kundalini" is associated to pineal gland [**?**].

The fractal hierarchy of the magnetic flux tubes corresponds to a hierarchy of selves and pineal gland is known to contain magnetic crystals. These crystals create magnetic fields which are much weaker than Earth's magnetic field. Their flux tubes, with thickness measured in centimeters, could thus be carriers of super-conducting BE condensates with cyclotron time scale measured in the range year–thousand years. These higher level magnetic selves together with corresponding MEs could be responsible for the higher levels of the self hierarchy. One could perhaps understand also the various characteristics of near death experiences in terms of higher level magnetic consciousness [K19]. Thus Descartes could have been right after all!

9.5 Great Vision About Biological Evolution And Evolution Of Brain

9.6 Great Vision About Biological Evolution And Evolution Of Brain

The following great vision about evolution and is not perhaps strictly about hierarchy of EEGs. The hierarchy of dark matter and EEGs however leads to this vision naturally. The first part of vision relates to biological evolution. Second part is about the evolution of brain. Here the key thread is evolution of two kinds of intelligences, the ordinary fast intelligence evolving via the emergence of fast computation type activities and emotional slow intelligence developing via the emergence of higher levels of dark matter hierarchy. The latter intelligence is what distinguishes us from animals.

9.6.1 Basic Assumptions

The great vision about evolution and brain relies on two several new notions and ideas.

1. Life as something in the intersection of real and p-adic worlds making possible negentropic entanglement- both space-like and time-like. This makes possible to understand what conscious intelligence is and NMP reduces evolution to a generation of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book). DNA as topological quantum computer hypothesis [K2] finds also a justification.

2. The notion of many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) suggesting a universal hierarchy of metabolic energy quanta, and the notion of magnetic body.

3. Communication and control based on Josephson radiation and cyclotron transitions crucial for understanding bio-photons and EEG and its fractal generalization as a key element of bio-communications.

4. Zero energy ontology and the closely related notion of causal diamond (CD) assigning a hierarchy of macroscopic time scales to elementary particles coming as octaves of the basic time scale and justifying p-adic length scale hypothesis. Zero energy energy ontology also justifies the vision about memory and intentional action and the idea that motor action can be seen as time reversal of sensory perception.

5. The hierarchy of Planck constants and the identification of the fundamental evolutionary step as an increase of Planck constant. Evolutionary steps mean migration to the pages of the Big Book labeled by larger values of Planck constant and living system can be regarded as a collection of pages of the Big Book such that a transfer of matter and energy between the pages is taking place all the time. The change of the Planck constant implies either reduction or increase of the quantum scales-this leads to a model for biocatalysis and a model of cognitive representations as scaled down or scaled up "stories" mimicking the real time evolution.

6. A resonant like interaction between hierarchy of Planck constants and p-adic length scale hierarchy favoring the values of Planck constant proportional to powers of two, and idea that weak and color interactions are especially important in the length scales which correspond to Mersenne primes and Gaussian Mersennes. The simplest option is that weak bosons have their standard masses but appear as massless below their Compton length which scales up like $\hbar$ and preferred p-adic length scales correspond to Mersenne primes. Also copies of weak bosons and gluons with ordinary value of Planck constant and reduced mass scale can (and will) be considered.

How to identify the preferred values of Planck constant?

The basic problem is to identify the preferred values of Planck constant and here one can only make theoretical experimentation and all what follows must be taken in this spirit. One can consider assumptions which become increasingly stronger.

1. If only singular coverings of CD and CP_2 are possible Planck constant is a product of integers. Algebraic simplicity of algebraic extensions of rationals favors ruler and compass integers (Appendix).

2. A resonant interaction between the dark length scales and p-adic length scales with ordinary value of Planck constant favors Planck constants coming as powers of two.

3. An even stronger assumption would be that p-adic length scales coming as Mersennes and Gaussian Mersennes are especially interesting.

   (a) If weak bosons can appear with the ordinary value of Planck constant only in the p-adic length scale $k = 89$, one obtains the condition

   $$k_d = k - 89 \quad , \quad k \in \{89, 107, 113, 127, 151, 157, 163, 167\} \tag{9.6.1}$$

   for the values of of $r = 2^{k_d}$ allowing dark weak bosons in p-adic length scales assignable to Mersennes. These values of k_d assign to electrons and quarks dark p-adic length scales $L(k_{eff}) = \sqrt{r}L(k)$, $r \equiv \hbar/\hbar_0 = 2^{k_d}$. The scales could correspond to size scales of basic units of living systems.

(b) If weak bosons and possibily also gluons with ordinary value of Planck constant are possible in all p-adic length scales $L(k)$, $k \in \{89, 107, 113, 127, 151, 157, 163, 167\}$, one obtains much richer structure. This hierarchy defines defines secondary dark matter hierarchies from the condition that the scaling the p-adic length scale $L(k_1)$ in this set by $\sqrt{r}$, $r \equiv \hbar/\hbar_0 = 2^{k_d}$, gives a p-adic length scale equal to another p-adic length scale $L(k_2)$ in this set. This requires $k_d + k_1 = k_2$ so that the values

$$k_d = k_2 - k_1 \tag{9.6.2}$$

are favored for the scaling of $\hbar$. In this case the hierarchy of dark scales assignable to quarks and leptons is much richer. The tables below demonstrate that electron appears as its dark variant for all Mersennes and also in atomic length scales $k = 137, 139$ so that this option puts electron in a completely unique position.

4. Also other scales are possible. For instance, $r = 2^{47}$ required by 5 Hz Josephson frequency gives dark weak scale which corresponds $k = 136$ as a p-adic scale. The stages of sleep can be understood in terms of scaling of $\hbar$ by factor 2 and 4 so that also the atomic length scale $k = 137$ and the scale $k = 138$ are involved.

Since the experimental input is rather meager, one is forced to do theoretical experimentation with various hypothesis. The quantitative experimental tests are rather primitive but basically quantal.

1. The time scales assignable to CDs of leptons and quarks and their scaled up counterparts for the preferred values of Planck constant should define biologically important time scales. One might even speak about evolutionary level of electron. These time scales could define fundamental biorhythms and also time scales of long term memory and planned action.

2. Josephson frequencies and cyclotron frequencies scaling like $1/\hbar$ (if magnetic field scales down like $1/\hbar$) charactering biologically important ions and elementary particles. In accordance with the quantum criticality of living matter it is assumed that cell membrane corresponds to almost vacuum extremal so that classical Z^0 force is an essential element of the model. Also these frequencies should define fundamental bio-rhythms and characterize the evolutionary level of cell. Experimentally of special importance are the cyclotron frequencies assignable to Ca^{++} ions.

3. The amplitude windows for electric field scaling like $\hbar$ for a particular cyclotron frequency define a basic prediction.

Tables about predicted time and length scales

The following tables summarize various predictions for time scales and length scales. They correspond to the most general assumption that exotic bosons with the ordinary value of Planck constant are possible in all length scales associated with Mersennes and Gaussian Mersennes.

Note that **Table 9.2** includes only the dark length scales associated with $k = 89$ gauge bosons.

Electron and u quark are different

Before continuing an important observation is in order. Electron is exceptional when compared to quarks. It appears as a dark particle in all p-adic length scales defined by biologically important Gaussian Mersennes and also in atomic length scales $k = 137$ and $k = 139$. The reason is trivial: by the basic assumptions electron must appear at same length scales as weak bosons above $k = 127$ since it corresponds to Mersenne prime. Also for the less general option (exotic intermediate gauge bosons are possible only as the dark variants of the standard ones) it appears at cell membrane length scale $k = 151$, which is due to the fact that one has $113 - 89 = 151 - 127 = 24$. Also u quark can appear with $k_{eff} = 137, 139, 163, 167$ and also this is an accident. The light invariants of intermediate gauge bosons appearing in long p-adic length scales would naturally correspond to

k_d	p_1	p_2		k_d	p_1	p_2
4	163	167		38	**89**	127
6	107	113		38	113	151
6	151	157		40	127	167
6	157	163		44	107	151
10	157	167		44	113	157
12	151	163		50	107	157
14	113	127		50	113	163
16	151	167		54	113	167
18	**89**	107		56	107	163
20	107	127		60	107	167
24	**89**	113		62	**89**	151
24	127	151		68	**89**	157
30	127	157		74	**89**	163
36	127	163		78	**89**	167

Table 9.2: The integers k_d characterizing the preferred values of $r = \hbar/\hbar_0 = 2^{k_d}$ identified from the condition that the dark variant of p-adic length scale $L(p_1)$ corresponding to some ordinary p-adic length scale defined by Mersenne prime M_p or Gaussian Mersenne $M_{G,p}$, $p \in \{89, 107, 113, 127, 151, 157, 163, 167\}$ corresponds to similar p-adic length scale $L(p_2)$. If one assumes that weak bosons can appear with ordinary value of Planck constant only in the p-adic length scale $k = 89$, only the rows with $p_1 = 89$ of the table are possible: in these cases p_1 is in boldface and the row has double underline. The corresponding values of k_d are in the set $\{18, 24, 38, 62, 68, 74, 78\}$.

almost vacuum extremals making possible the criticality as the basic aspect of life. One must of course be very cautious about the masses of exotic counterparts of u and d quark: one can also consider the possibility that masses are identical.

9.6.2   Dark Matter Hierarchy And Big Leaps In Evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

The appearance of CDs scaled up in size by $r = \hbar/\hbar_0$ and space-time sheets scaled up in size by $\sqrt{r}$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of emergence of new larger matter carrying space-time sheet magnetic flux sheets and corresponding magnetic bodies. If magnetic flux quanta are scaled by r magnetic flux quantization conditions remain unaffected if magnetic field strengths scale down by $1/r$ so that the energies of cyclotron photons are not affected. The thickness of flux tubes can remain unchanged if the currents running at the boundaries of the flux quantum cancel the magnetic flux. As already found, this mechanism must be at work inside living organisms wheras in far away region flux quanta are scaled up in size.

The attractive hypothesis is that the leaps in evolution correspond to the emergence of dark variants of weak and possibly also color interactions in dark p-adic length scales which correspond to ordinary p-adic length scales characterized by Mersenne primes. These leaps would be quantum leaps but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by r as the new level of dark matter hierarchy emerges. The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with

Z, W	d	u	e	k_d
89	120	124	127	**0**
93	124	127	131	4
95	126	129	133	6
99	130	133	137	10
101	132	135	139	12
103	134	137	141	14
105	136	139	143	16
107	138	141	145	**18**
109	140	143	147	20
113	144	147	151	**24**
119	150	153	157	30
125	156	159	163	36
127	158	161	165	**38**
129	160	163	167	40
133	164	167	171	44
139	170	173	177	50
143	174	177	181	54
145	176	179	183	56
149	180	183	187	60
151	182	185	189	**62**
157	188	191	195	**68**
163	194	197	201	**74**
167	198	201	205	**78**

Table 9.3: The dark p-adic length scales $\sqrt{r}L(k) = L(k_{eff})$, $k_{eff} = k + k_d$, of intermediate gauge bosons Z, W, d and u quarks, and electron for the values $r = 2^{k_d}$ of Planck constant defined in **Table 9.2**. The uppermost row gives the integers characterizing the p-adic length scales of the particles for the standard value of Planck constant. k_{eff} characterizes also the CD times scale through the formula $T(CD, k_{eff}) = 2^{k_{eff}-127} \times .1$ seconds. The rows which correspond to the less general option for which only M_{89} corresponds to weak bosons with ordinary value of Planck constants have double underline and the corresponding values of k_d are in boldface.

k_1	k_M		k_1	k_M		k_1	k_M		k_1	k_M
113	89		113	107		163	127		163	157
127	89		119	107		167	127		169	157
151	89		123	107		133	127		173	157
157	89		113	107		139	127		163	157
163	89		117	107		143	127		167	157
167	89		111	107		133	127		161	157
95	89		175	113		137	127		169	163
109	89		181	113		131	127		183	163
133	89		187	113		225	151		207	163
139	89		191	113		229	151		213	163
145	89		119	113		157	151		219	163
149	89		133	113		171	151		223	163
103	89		157	113		195	151		177	163
127	89		163	113		201	151		201	163
133	89		169	113		207	151		207	163
139	89		173	113		211	151		213	163
143	89		127	113		165	151		217	163
113	89		151	113		189	151		187	163
119	89		157	113		195	151		193	163
125	89		163	113		201	151		199	163
129	89		167	113		205	151		203	163
95	89		137	113		175	151		169	163
101	89		143	113		181	151		175	163
105	89		149	113		187	151		179	163
95	89		153	113		191	151		169	163
99	89		119	113		157	151		173	163
93	89		125	113		163	151		167	163
145	107		129	113		167	151		187	167
169	107		119	113		157	151		211	167
175	107		123	113		161	151		217	167
181	107		117	113		155	151		223	167
185	107		195	127		235	157		227	167
113	107		201	127		163	157		181	167
127	107		205	127		177	157		205	167
151	107		133	127		201	157		211	167
157	107		147	127		207	157		217	167
163	107		171	127		213	157		221	167
167	107		177	127		217	157		191	167
121	107		183	127		171	157		197	167
145	107		187	127		195	157		203	167
151	107		141	127		201	157		207	167
157	107		165	127		207	157		173	167
161	107		171	127		211	157		179	167
131	107		177	127		181	157		183	167
137	107		181	127		187	157		173	167
143	107		151	127		193	157		177	167
147	107		157	127		197	157		171	167

Table 9.4: Table gives all weak boson length scales -both non-dark and dark implied by the assumption that all Mersennes primes and their Gaussian counterparts and their dark counterparts defined $k_d = k_i - k_j$ them are possible.

particle	Z, W	d	u	e
k	89	120	123	127
f(CD)/Hz	2.7488×10^{12}	1280	160	10

Table 9.5: The fundamental frequencies associated with the CDs of intermediate gauge bosons Z, W, d and u quarks, and electron. Note that for intermediate gauge bosons the frequency of CDs corresponds to energy $E = 1.13 \times 10^{-2}$ eV and wavelength $\lambda = 1.01 \times 10^{-4}$ m (size of a large neuron).

Z, W	d	u	e	k_d
3.64e-13	7.81e-04	6.25e-03	1.00e-01	**0**
5.821e-12	1.25e-02	1.00e-01	1.60e+00	4
2.31e-11	5.00e-02	4.00e-01	6.40e+00	6
3.73e-10	8.00e-01	6.40e+00	1.02e+02	10
1.49e-09	3.20e+00	2.56e+01	4.10e+02	12
5.97e-09	1.28e+01	1.02e+02	1.65e+03	14
2.38e-08	5.12e+01	4.10e+02	6.55e+03	16
9.54e-08	2.05e+02	1.64e+03	2.62e+04	**18**
3.81e-07	8.19e+02	6.55e+03	1.05e+05	20
6.10e-06	1.31e+04	1.05e+05	1.68e+06	**24**
3.91e-04	8.39e+05	6.71e+06	1.07e+08	30
2.50e-02	5.37e+07	4.30e+08	6.87e+09	36
1.00e-01	2.15e+08	1.72e+09	2.75e+10	**38**
4.00e-01	8.59e+08	6.87e+09	1.10e+11	40
6.40e+00	1.37e+10	1.10e+11	1.76e+12	44
4.10e+02	8.80e+11	7.04e+12	1.12e+14	50
6.55e+03	1.41e+13	1.13e+14	1.80e+15	54
2.62e+04	5.63e+13	4.50e+14	7.21e+15	56
4.19e+05	9.01e+14	7.21e+15	1.15e+17	60
1.68e+06	3.60e+15	2.88e+16	4.61e+17	**62**
1.07e+08	2.31e+17	1.84e+18	2.95e+19	**64**
6.87e+09	1.48e+19	1.18e+20	1.89e+21	**74**
1.10e+11	2.36e+20	1.89e+21	3.02e+22	**78**

Table 9.6: The $\hbar$-scaled fundamental time scales $T(CD, k_{eff}) = 2^{k_{eff}-127} \times .1$ seconds associated with the CDs of intermediate gauge bosons Z, W, d and u quarks, and electron for the values $\hbar/\hbar_0 = 2^{k_d}$ of Planck constant defined in **Table 9.2**. The scales are expressed in seconds. The uppermost row gives the time scales of CDs for the standard value of Planck constant. The rows which correspond to the less general option for which only M_{89} corresponds to weak bosons with ordinary value of Planck constants have double underline and the corresponding values of k_d are in boldface.

high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

Certainly also other scalings of Planck constant than those summarized in tables are possible but these scalings are of primary interest. This intuition is supported by the observation that electron is completely exceptional in this framework. Electron's dark p-adic length scales corresponds to p-adic length scales $L(k)$, $k = 167, 169$, assignable to atomic and molecular physics and to the Gaussian Mersennes $M_{G,k} = (1 + i)^k - 1$, $k \in \{151, 157, 163, 167\}$, assignable to the length scale range between cell membrane thickness 10 nm and nucleus size 2.58 μm. The corresponding p-adic length scales or corresponding electronic Compton lengths, the number of which is 23, are excellent candidates for the scales of basic building brickes of living matter and vary from electron's p-adic length scale up to 1.25 m ($k = 167$ defining the largest Gaussian Mersenne in cell length scale range) and defining the size scale of human body. The corresponding p-adic time scales are also highly interesting and vary from.1 seconds for electron defining the fundamental biorhythm to 9.6×10^{14} years which is by 4-5 orders longer than the age of the observed Universe. For $k = 167$ the time scale is 1.1×10^{11} years and is by one order of magnitude longer than the age of the observed Universe estimated to be 1.37×10^{10} years [E1].

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a more detailed vision about big evolutionary leaps. Note that in the sequel only the general option is considered: the justification for this is that for this option electron appears as a dark particle for all length scales defined by Gaussian Mersennes as well as in atomic length scales. The basic vision in nutshell is that evolution means the emergence of dark weak and gluonic physics in both dark and ordinary length scales and that the size scales of the basic biostructures correspond to Mersenne primes and their Gaussian variants.

A sketch about basic steps in evolution

The vision about evolution depends on what one assumes about the initial state.

1. If one assumes that weak bosons with ordinary value of Planck constant were present in the begining, evolution would mean a steady growth of k_d. The problem is that small values of $k_d = k_1 - k_2$ correspond to the Gaussian Mersennes defining cellular length scales. If these exotic weak physics were present from the beginning, large parity breaking in cellular length scales would have been present all the time.

2. An alternative and perhaps more realistic view is that the evolution means the emergence of exotic weak physics corresponding almost vacuum extremals in increasingly longer length scales. A possible mechanism could have been the induction of exotic $\hbar_0$ variant of weak physics at the nearest Mersenne length scale k_{next} by the dark variant of weak physics at level k so that one would have $k_d = k_{next} - k$. The simplest induction sequence would have been $89 \rightarrow 107 \rightarrow 113 \rightarrow 127 \rightarrow 151 \rightarrow 157 \rightarrow 163 \rightarrow 167$ corresponding to $k_d \in \{18, 6, 14, 24, 6, 6, 4\}$. A possible interpretation of exotic $\hbar_0$ physics is in terms of almost vacuum extremals and non-standard value of Weinberg angle: also weak bosons of this physics would be light. This sequence defines the minimal values for k_d but also larger values of k_d are possible and would correspond to steps between neighbours which are not nearest ones.

The following sketch about the basic steps of evolution relies on the latter option.

1. Elementary particle level

Magnetic bodies with size scale defined by the sizes of CDs assignable to quarks and leptons and possibly also weak bosons (already now the size of big neuron emerges) corresponds to the lowest level of hierarchy with the sizes of the basic material structures corresponding to the Compton lengths of elementary particles. The fundamental bio-rhythms corresponding to frequencies 10, 160, and 1280 Hz appear already at this level in zero energy ontology which suggests that elementary particles play a central and hitherto unknown role in the functioning of living matter.

2. $89 \rightarrow 107$ step with $k_d = 18$

The first step would have been the emergence of $k_{eff} = 107$ weak bosons inducing $\hbar_0$ weak physics in $k = 107$ length scale characterizing also ordinary hadrons. This in turn would have

led to the emergence of exotic nucleons possibly corresponding to almost vacuum extremals. The reduction of the model for the vertebrate genetic code to dark hadron physics [K114] is one of the most unexpected predictions of quantum TGD and assumes the existence of exotic- possibly dark- nucleons whose states with a given charge correspond to DNA, RNA, mRNA, and tRNA. The $\hbar_0$ variants of these nucleons would interact via weak bosons with hadronic mass scale. The exotic variants of the ordinary $k = 113$ nuclei would correspond to the nuclear strings consisting of exotic nucleons [K28, K114] and define nuclear counterparts for DNA sequences. Their dark counterparts could define counterparts of DNA sequences in atomic physics length scales. Therefore a justification for the previous observation that genetic code could be realized at the level of hadron physics and that chemical realization would be higher level realization finds justification. The anomalous properties of water could be also partly due to the presence of dark nucleons and the proposal was that the presence of exotic nuclei is involved with water memory [K42]. The possible existence of the analog of DNA-RNA transcription between ordinary DNA and its nuclear counterpart would have dramatic implications. For instance, one can imagine a mechanism of homeopathy based on this kind of transription process which would also allow a modification of genome by using dark nuclei to communicate the DNA sequences through the cell membrane to the target nuclei.

3. $107 \to 113$ step with $k_d = 6$

The next step would have been the emergence of $k_{eff} = 113$ weak bosons inducing $\hbar_0$ weak physics in $k = 113$ length scale characterizing also ordinary hadrons. Exotic variants of the ordinary nuclei possibly corresponding to almost vacuum extremals could have emerged interacting weakly (or actually relatively strongly!) via the exchange of weak bosons with mass scale of order 100 MeV. Also dark variants of the exotic $k = 107$ nucleons could have have emerged and formed exotic nuclei of size scale $k = 119$.

4. $113 \to 127$ step with $k_d = 14$

At this step weak bosons in electron mass scale would have emerged. Whether these weak bosons could have induced large parity breakings in atomic and molecular length scales is not clear. Viruses, which do not yet possess cell membrane could correspond to this level of hierarchy.

5. $127 \to 151$ step with $k_d = 24$

This step would have been fundamental since weak bosons in cell membrane length scale would have appeared. Note that by $113 - 89 = 24$ this step also leads from $k = 89$ weak bosons to $k = 113$ weak bosons. The weak bosons assignal to $k = 151$ could correspond to the weak interactions associated with almost vacuum extremals and $sin^2(\theta_W) = .0295$ could correspond to the weak physics in question.

$k_d = 24$ step for $k = 113$ $\hbar_0$ weak bosons would have produced them in $k_{eff} = 137$ atomic length scale with $L(137) \simeq .78$ Angstrom This could have naturally led to large parity breaking effects and chiral selection.

Dark $k_{eff} = 151$ electrons appearing in the TGD inspired model of high T_c super-conductivity would have been a by-product of this step. Whether dark electrons could have transformed to light $\hbar_0$ electrons (of mass .25 keV) with a common mass scale of order 10^2 eV with exotic weak bosons is an interesting question. The model of high T_c super-conductivity predicts the presence of structures analogous to cell membrane. This would suggest that cell membranes emerged and chiral selection emerged at this step so that one could not distinguish the emergence of molecular life as a precedessor for the emergence of cell membrane like structures. This would conform with the fact that DNA molecules are stable only inside cell nucleus. Note that for $k_{eff} = 151$ electron's CD has time scale $2^{24} \times .1$ seconds -that is 19.419 days (day=24 hours).

The smallest nanobes [I5] appearing in rocks have size 20 nm and could have emerged at this step. The size of the viruses [I9] is between 10-300 nm covers the entire range of length scales assignable to Gaussian Mersennes, which suggests that smallest viruses could have emerged at this step. Also the smallest [I4] [I4], which by definition have size smaller than 300 nm could have appeared at this stage.

6. The remaining steps

The remaining steps $k = 151 \to 157 \to 163 \to 167$ could relate to the emergence of

coiling structure DNA and other structures inside cell nucleus. $k = 167$ would correspond to $k_d = 167 - 89 = 68$ to be compared with the value $k_d = 47$ required by 5 Hz Josephson frequency for the neuronal membrane for -70 mV resting potential. Note that $k_d = 48$ (state 1-2 of deep sleep) corresponds to $k = 163$.

By their smallness also double and triple steps defined by $k_d = k_{i+n} - k_i$, $n > 1$, are expected to be probable. As a consequence, electrons can appear as dark electrons at all the Gaussian Mersenne levels. At these steps the dark electrons corresponding to primes $k_{eff} = 137, 139$ would appear. For $k = 137$ dark electron appears with CD time scale equal to 128 seconds- rather precisely two minutes. The model for EEG suggests that the exotic weak bosons appear in the scales $k_{eff} = 136, 137, 138$.

Further multisteps from the lower levels of hierarchy would give structures with size scales above the size of cell nucleus possibly assignable to organs and structural units of brain. The dark levels assignable to electron are expected to be of special interest. It is encouraging that the longest scale assignable to electron in this manner corresponds to $k = 205$ and length scale of 1.28 m defining body size. As a consequence dark electrons are predicted at levels $k = 137, 139, 141, 143, 145, 147$ coming as octaves.

Prokaryotic cells (bacteria, archea) without cell nucleus for which cell membrane is responsible for metabolic functions and genome is scattered around the cell could have emerged at this step. This would mean that the emergence of the cell membrane thickness as a fundamental scale is not enough: also the size scale of membrane must appear as p-adic length scale. The sizes of most prokaryotes vary between 1 μm and 10 μm: the lower bound would require $k = 163$. There also prokaryotes with sizes between.2 μm ($k = 157$ corresponds to.08 μm) and 750 μm. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. The sizes of eukaryote cells are above 10 μm and the fact that multicellular organisms are in question strongly suggests that the higher multisteps giving rise to weak bosons and dark electrons in length scales above $L(167)$ are responsible for multi-cellular structures.

This scenario leaves a lot of questions unanswered. In particular, one should understand in more detail the weak physics at various length scales as well as various exotic nuclear physics defined by dark nucleons and dark variants of nuclei.

Division of the evolution to that of biological body and magnetic body

Electron's Mersenne prime M_{127} is the highest Mersenne prime, which does not correspond to a completely super-astrophysical p-adic length scale. In the case of Gaussian Mersennes $M_{G,k}$ one has besides those defined by k in $\{113, 151, 157, 163, 167,\}$ also the ones defined by k in $\{239, 241, 283, 353, 367, 379, 457, 997\}$ [A2]. The appropriately extended model for evolution allows to distinguish between three kinds of values of k_{eff}.

1. The values of k_{eff} for which electron can appear as dark particle and thus satisfying $k_{eff} \leq 205$ (Table 5). These levels would correspond to structures with size below 1.25 m defined roughly by human body size and it is natural to assign the evolution of super-nuclear structures to the levels $167 < k_{eff} \leq 205$.

2. The values of of k_{eff} for which dark gauge bosons are possible in the model. This gives the condition $k_{eff} \leq 235$. These levels correspond to structures in the range 1.25 m-40 km. The identification as parts of the magnetic body can be considered.

3. The values of k_{eff} obtained by adding to the system also the Gaussian Mersenne pair $k \in \{239, 241\}$ allowing also the dark electrons. The lower size scale for these structures is 640 km.

4. The higher levels corresponding to k_{eff} in $\{283, 353, 367, ...\}$. The lower size scale for these structures is 3 AU (AU is the distance from Earth to Sun).

$k_{eff} > 205$ levels would correspond to the emergence of structures having typically size larger than that of the biological body and not directly visible as biological evolution. This evolution could be hidden neuronal evolution meaning the emergence of extremely low Josephson frequencies of the neurons modulating higher frequency patterns and being also responsible for the communication of long term memories.

Biological evolution

In principle the proposed model allowing multisteps between hierarchy levels defined by Mersenne primes and their Gaussian counterparts could explain the size scales of the basic structures below the size scale 1.25 m identified in terms of the $k_{eff} \leq 205$ levels of the hierarchy.

1. The emergence of cells having organelles

The appearance of the structures with $k_{eff} > 167$ (possibly idetifiable as magnetic body parts) should correlate with the emergence of simple eukaryotic cells and organisms, in particular plant cells for which size is larger than 10 μm, which could correspond to $k_{eff} = 171$ for electron and dark variants of weak gauge bosons. $k_{eff} = 177$ is the next dark electron level and corresponds to 80 μm scale. It seems natural to assume that these dark weak bosons do not transform to their $\hbar_0$ counterparts at these space-time sheets.

Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles would live in symbiosis by topologically condensing to $k_{eff} \geq 171$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. A possible interpretation is that they are also life forms and that magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtobuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. There would be no need for a static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on Josephson radiation consisting of photons, weak bosons, and gluons defining the counterpart of EEG associated with the level of the dark matter hierarchy in question.

3. The emergence of organs and animals

The emergence of magnetic bodies with k_{eff} in the range (177, 181, 183, 187, 189, 195, 201, 205) allowing both dark electron and weak bosons could accompany the emergence of multicellular animals. Magnetic body at this level could give rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures

formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

k_{eff} in the range $(187, 189, 195, 201, 205)$ allowing dark electrons and weak bosons gives size scales $(.25, .5, 4, 32, 128)$ cm, which could correspond to the scales of basic units of central nervous system. What would be of special interest would be the possibility of charged entanglement based on classical W fields in macroscopic length scales. The emergence of the new level means also the integration of axonal microtobuli to "text lines" at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

The evolution of magnetic body

For mammals with body size below 1.25 m the levels $k_{eff} > 205$ cannot correspond to biological body and the identification in terms of magnetic body is suggestive. The identification of EEG in terms of Josephson frequencies suggests the assignment of EEG with these levels.

1. The emergence of EEG

EEG in the standard sense of the word is possessed only by vertebrates and one should understand why this is the case. The value of Josephson frequency equal to 5 Hz requires only $k_d = 47$ so that something else must be involved. A possible explanation in the framework of the proposed model comes from the following observations.

1. Besides the maximal p-adic scale $k = 205$ for which electron and weak bosons appears as dark variants the model allows also levels at which only gauge bosons appear as dark particles. From **Table 9.6** one finds that levels $k \in \{207, 211, 213, 217, 219, 221, 223, 225, 229, 235\}$ are allowed. Could it be that these levels and possibly some highest levels containing both electrons and gauge bosons as dark particles are a prerequisite for EEG as we define it. Its variants at higher frequency scales would be present also for invertebrates. The lowest Josephson frequency coded by the largest value of $\hbar$ in the cell membrane system determines the Josephson frequency.

2. The membrane potentials -55 mV (criticality against firing) correspond to ionic Josephson energies somewhat above 2 eV energy $((2.20, 2.74, 3.07, 2.31)$ eV, see Table 1). For 2 eV the wavelength 620 nm is near to $L(163) = 640$ nm. Therefore the Josephson energies of ions can correspond to the $L_e(k = 163)$ if one assumes that a given p-adic mass scale corresponds to masses half octave above the p-adic mass scale so that the opposite would hold true at space-time level by Uncertainty Principle. Josephson frequencies $f_J \in \{5, 10, 20, 40, 80, 160\}$ Hz correspond to $k_d \in \{47, 46, 45, 44, 43, 42\}$ giving $k_{eff} \in \{210, 209, 208, 207, 206, 205\}$.

   (a) Cerebellar resonance frequency 160 Hz would correspond to $k = 205$ -the highest level for for which model allows dark electrons (also 200 Hz resonance frequency can be understood since several ions are involved and membrane potential can vary).

   (b) The 80 Hz resonance frequency of retina would correspond to $k_{eff} = 206$ -for this level dark electrons would not be present anymore.

   (c) 40 Hz thalamocortical frequency would correspond to $k_{eff} = 207$.

   (d) For EKG frequencies are EEG frequencies below 20 Hz 12.5 and heart beat corresponds to .6-1.2 second cycle (the average.8 s corresponds to $k_{eff} = 212$).

3. Even values of k_{eff} are not predicted by the model based on Mersenne primes allowing only odd values of k_{eff} so that the model does not seem to be the whole truth. The conclusion which however suggests itself strongly is that EEG and its variants identified as something in the range 1-100 Hz, are associated with the levels in at which only dark weak bosons are possible in the proposed model. Note that the size scales involved with EEG would be

k_d	f_1/Hz	f_2/Hz	f_3/Hz
0	707	1000	1412
4	177	250	354
6	89	1250	177
10	22.1	31.3	44.2
12	11.1	15.6	22.1
14	5.5	7.8	11.1
16	2.8	3.9	5.5
18	1.4	2.0	2.8
20	0.7	1.0	1.4
24	0.2	0.2	0.3

Table 9.7: The Compton frequencies obtained by scaling $2^{k_d/2}$ from the basic triplet $k_{eff} = (239, 240, 241)$. The values of k_d correspond to those predicted by the model based on Mersenne primes.

above the size scale of human body so that we would have some kind of continuation of the biological body to be distinguished from the magnetic body. The time scales assignable to the dark CDs would be huge: for instance, $k = 205$ would correspond to $T = 2^{42} \times .1$s making about 1395 years for electron.

2. Does magnetic body correspond to the space-time sheets carrying dark weak bosons?

The layers of the magnetic body relevant for EEG have have size of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and the basic building blocks of our sensory experience corresponds to a fundamental period of .1 seconds. This scale appears already at $\hbar_0$ level for electron CD. The natural question concerns the relationship of the magnetic body to the $k > 205$ space-time sheets carrying only gauge bosons in the model and having size scale larger than that of biological body. Do they correspond to an extension of biological body or should they be regarded as parts of the magnetic body? The following observations suggest that they could correspond to layers of the magnetic body responsible for the fractal variant of EEG.

1. The primary p-adic time scales (Compton times) $T(239)$ and $T(241)$ correspond to frequencies, which are $2^{\pm 1/2}$ kHz. The geometric average $k = 240$ corresponds to kHz frequency. Is the appearance of kHz scale a mere accident or do the frequencies assignable to the quark CDs correspond to Compton times $\propto \sqrt{2^{k_{eff}/2}}$?

2. One can apply scalings by 2^{k_d} to the triplet $(239, 240, 241)$ to get a triplet $(239 + k_d, 240 + k_d, 241 + k_d)$. The results are summarized in **Table 12.4**. Clearly the frequencies in question cover also the EEG range. Note that these frequencies scale as $\sqrt{1/r}$ whereas Josephson frequencies scale as $1/r$.

Also ZEG and WEG would appear but in much shorter scales dictated by k_{eff} and might accompany EEG. Somehow it seems that the effective masslessness of weak bosons below given scale is highly relevant for life. One can of course ask whether some larger Gaussian Mersenne could change the situation. There is a large gap in the distribution of Gaussian Mersennes after $k = 167$ and the next ones correspond to $M_{G,k}$, with k in $(239, 241, 283, 353, 367, 379, 457, 997)$ [A2]. The twin pair $k = (239, 241)$ corresponds to a length scales $(1.6, 3.2) \times 10^2$ km and the minimum value for k_d are $(72, 74)$ $(167 \rightarrow (239, 241)$ transition).

3. Long term memory and ultralow Josephson frequencies

What determines the time scale associated with long term memory is a crucial question if one really wants to understand the basic aspects of consciousness.

1. Does the time scale correspond to the size scale of CD assignable to electron scaled by $r = \hbar/\hbar_0$? In this case relatively small values of r would be enough and $r = 2^{47}$ would give time scale of 10^{13} s for for electron's CD, which is about 3×10^5 years. This does not make sense.

2. Does Josephson frequency define the relevant time scale? In this case the long term memory would require the analog of EEG in the time scale of memory span. $k_{eff} = 205$ would give 6 ms time scale for memory from the assignment of $k_{eff} = 163$ to the Josephson photons at V=-50 mV implying $k_d = 42$. Minute scale would require $k_{eff} = 217$. The highest level $k_{eff} = 235$ allowed by the model involving only Gaussian Mersennes with $k \leq 167$ would correspond to a time scale of 77.67 days (day is 24 hours). For Gaussian Mersennes defined by $k_{eff} = (239, 241)$ the time scales become about $(41.4, 82.8)$ months (3.4 and 6.8 years). These scales should also define important biorhythms. The claimed 7 years rhythm of human life could relate to the latter rhythm: note that the precise value of the period depends on the membrane potential and thus varies. The presence of the scaled up variants of the by $k_d \leq 78$ allows longer time spans of long term memory and the scaling defined by $k_d = 167 - 163 = 4$ scales up the span of long term memories to $(54.4, 108.8)$ years.

4. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the nucleotides involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough. Already EEG seems to correspond to dark layers of biological body larger than biological body so that one can cask whether the weak bosons and dark electrons in the length scales $k = 239, 241, 283, 353, 367, ...$ could be relevant for the collective aspect of consciousness and cultural evolution. Maybe the size scales $(175, 330)$ km and their scaled up variants by $k_d \leq 78$ might have something to do with the spatial scale of some typical social structure (not city: the area of New York is only 790 km^2).

9.7 Appendix

9.7.1 Hierarchy Of Planck Constants And The Generalization Of The Notion Of Embedding Space

In the following the recent view about structure of embedding space forced by the quantization of Planck constant is summarized. The question is whether it might be possible in some sense to replace H or its Cartesian factors by their necessarily singular multiple coverings and factor spaces. One can consider two options: either M^4 or the causal diamond CD. The latter one is the more plausible option from the point of view of WCW geometry.

The evolution of physical ideas about hierarchy of Planck constants

The evolution of the physical ideas related to the hierarchy of Planck constants and dark matter as a hierarchy of phases of matter with non-standard value of Planck constants was much faster than the evolution of mathematical ideas and quite a number of applications have been developed during last five years [K93, K69, K37]

1. The starting point was the proposal of Nottale [E3] that the orbits of the 4 inner planets correspond to Bohr orbits with Planck constant $\hbar_{gr} = GMm/v_0$ and outer planets with Planck constant $\hbar_{gr} = 5GMm/v_0$, $v_0/c \simeq 2^{-11}$. The basic proposal [K93, K69] was that ordinary matter condenses around dark matter which is a phase of matter characterized by a non-standard value of Planck constant whose value is gigantic for the space-time sheets mediating gravitational interaction. The interpretation of these space-time sheets could be as magnetic flux quanta or as massless extremals assignable to gravitons.

2. Ordinary particles possibly residing at these space-time sheet have enormous value of Compton length meaning that the density of matter at these space-time sheets must be very slowly

varying. The string tension of string like objects implies effective negative pressure characterizing dark energy so that the interpretation in terms of dark energy might make sense [K94]. TGD predicted a one-parameter family of Robertson-Walker cosmologies with critical or over-critical mass density and the "pressure" associated with these cosmologies is negative.

3. The quantization of Planck constant does not make sense unless one modifies the view about standard space-time is. Particles with different Planck constant must belong to different worlds in the sense local interactions of particles with different values of $\hbar$ are not possible. This inspires the idea about the book like structure of the embedding space obtained by gluing almost copies of H together along common "back" and partially labeled by different values of Planck constant.

4. Darkness is a relative notion in this framework and due to the fact that particles at different pages of the book like structure cannot appear in the same vertex of the generalized Feynman diagram. The phase transitions in which partonic 2-surface X^2 during its travel along X_l^3 leaks to another page of book are however possible and change Planck constant. Particle (say photon -) exchanges of this kind allow particles at different pages to interact. The interactions are strongly constrained by charge fractionization and are essentially phase transitions involving many particles. Classical interactions are also possible. It might be that we are actually observing dark matter via classical fields all the time and perhaps have even photographed it [K111].

5. The realization that non-standard values of Planck constant give rise to charge and spin fractionization and anyonization led to the precise identification of the prerequisites of anyonic phase. If the partonic 2-surface, which can have even astrophysical size, surrounds the tip of CD, the matter at the surface is anyonic and particles are confined at this surface. Dark matter could be confined inside this kind of light-like 3-surfaces around which ordinary matter condenses. If the radii of the basic pieces of these nearly spherical anyonic surfaces - glued to a connected structure by flux tubes mediating gravitational interaction - are given by Bohr rules, the findings of Nottale [E3] can be understood. Dark matter would resemble to a high degree matter in black holes replaced in TGD framework by light-like partonic 2-surfaces with a minimum size of order Schwartschild radius r_S of order scaled up Planck length $l_{Pl} = \sqrt{\hbar_{gr}G} = GM$. Black hole entropy is inversely proportional to $\hbar$ and predicted to be of order unity so that dramatic modification of the picture about black holes is implied.

6. Perhaps the most fascinating applications are in biology. The anomalous behavior ionic currents through cell membrane (low dissipation, quantal character, no change when the membrane is replaced with artificial one) has a natural explanation in terms of dark supra currents. This leads to a vision about how dark matter and phase transitions changing the value of Planck constant could relate to the basic functions of cell, functioning of DNA and amino-acids, and to the mysteries of bio-catalysis. This leads also a model for EEG interpreted as a communication and control tool of magnetic body containing dark matter and using biological body as motor instrument and sensory receptor. One especially amazing outcome is the emergence of genetic code of vertebrates from the model of dark nuclei as nuclear strings [L4, K111], [L4].

The most general option for the generalized embedding space

Simple physical arguments pose constraints on the choice of the most general form of the embedding space.

1. The fundamental group of the space for which one constructs a non-singular covering space or factor space should be non-trivial. This is certainly not possible for M^4, CD, CP_2, or H. One can however construct singular covering spaces. The fixing of the quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP_2} = CP_2 \backslash S^2$ have fundamental group Z since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. CP_2 allows two geodesic spheres which left invariant by $U(2$ *resp.* $SO(3)$. The first one is homologically non-trivial. For homologically non-trivial geodesic sphere $H_4 = M^2 \times S^2$ represents a straight cosmic string which is non-vacuum extremal of Kähler action (not necessarily preferred extremal). One can argue that the many-valuedness of $\hbar$ is un-acceptable for non-vacuum extremals so that only homologically trivial geodesic sphere S^2 would be acceptable. One could go even further. If the extremals in $M^2 \times CP_2$ can be preferred non-vacuum extremals, the singular coverings of M^4 are not possible. Therefore only the singular coverings and factor spaces of CP_2 over the homologically trivial geodesic sphere S^2 would be possible. This however looks a non-physical outcome.

   (a) The situation changes if the extremals of type $M^2 \times Y^2$, Y^2 a holomorphic surface of CP_3, fail to be hyperquaternionic. The tangent space M^2 represents hypercomplex sub-space and the product of the Kähler-Dirac gamma matrices associated with the tangent spaces of Y^2 should belong to M^2 algebra. This need not be the case in general.

   (b) The situation changes also if one reinterprets the gluing procedure by introducing scaled up coordinates for M^4 so that metric is continuous at $M^2 \times CP_2$ but CDs with different size have different sizes differing by the ratio of Planck constants and would thus have only piece of lower or upper boundary in common.

3. For the more general option one would have four different options corresponding to the Cartesian products of singular coverings and factor spaces. These options can be denoted by $C - C$, $C - F$, $F - C$, and $F - F$, where C (F) signifies for covering (factor space) and first (second) letter signifies for CD (CP_2) and correspond to the spaces $(\hat{CD}\hat{\times}G_a) \times (\hat{CP_2}\hat{\times}G_b)$, $(\hat{CD}\hat{\times}G_a) \times \hat{CP_2}/G_b$, $\hat{CD}/G_a \times (\hat{CP_2}\hat{\times}G_b)$, and $\hat{CD}/G_a \times \hat{CP_2}/G_b$.

4. The groups G_i could correspond to cyclic groups Z_n. One can also consider an extension by replacing M^2 and S^2 with its orbit under more general group G (say tetrahedral, octahedral, or icosahedral group). One expects that the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds M^2 or S^2. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of M^2 the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tetrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

About the phase transitions changing Planck constant

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the embedding space to another one.

1. How the gluing of copies of embedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of CD factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of CD metric can make sense. On the other hand, one can always scale the M^4 coordinates so that the metric is continuous but the sizes of CDs with different Planck constants differ by the ratio of the Planck constants.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in M^4 degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where X^1 is light-like geodesic. The requirement that the partonic 2-surface X^2 moving from one sector of H to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that X^2 has single point of M^2 as M^2 projection. Hence no sudden change of the size X^2 occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunnelling. Classical

non-vacuum extremals of Chern-Simons action have two-dimensional CP_2 projection to homologically non-trivial geodesic sphere S_I^2. The deformation of the entire S_I^2 to homologically trivial geodesic sphere S_{II}^2 is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that CP_2 projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere S_I^2 of CP_2 can be deformed to that of S_{II}^2 using 2-dimensional homotopy flattening the piece of S^2 to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

How could one fix the spectrum of Planck constants?

The question how the observed Planck constant relates to the integers n_a and n_b defining the covering and factors spaces, is far from trivial and I have considered several options. The basic physical inputs are the condition that scaling of Planck constant must correspond to the scaling of the metric of CD (that is Compton lengths) on one hand and the scaling of the gauge coupling strength $g^2/4\pi\hbar$ on the other hand.

1. One can assign to Planck constant to both CD and CP_2 by assuming that it appears in the commutation relations of corresponding symmetry algebras. Algebraist would argue that Planck constants $\hbar(CD)$ and $\hbar(CP_2)$ must define a homomorphism respecting multiplication and division (when possible) by G_i. This requires $r(X) = \hbar(X)\hbar_0 = n$ for covering and $r(X) = 1/n$ for factor space or vice versa.

2. If one assumes that $\hbar^2(X)$, $X = M^4$, CP_2 corresponds to the scaling of the covariant metric tensor g_{ij} and performs an over-all scaling of H-metric allowed by the Weyl invariance of Kähler action by dividing metric with $\hbar^2(CP_2)$, one obtains the scaling of M^4 covariant metric by $r^2 \equiv \hbar^2/\hbar_0^2 = \hbar^2(M^4)/\hbar^2(CP_2)$ whereas CP_2 metric is not scaled at all.

3. The condition that $\hbar$ scales as n_a is guaranteed if one has $\hbar(CD) = n_a\hbar_0$. This does not fix the dependence of $\hbar(CP_2)$ on n_b and one could have $\hbar(CP_2) = n_b\hbar_0$ or $\hbar(CP_2) = \hbar_0/n_b$. The intuitive picture is that n_b- fold covering gives in good approximation rise to $n_a n_b$ sheets and multiplies YM action action by $n_a n_b$ which is equivalent with the $\hbar = n_a n_b\hbar_0$ if one effectively compresses the covering to $CD \times CP_2$. One would have $\hbar(CP_2) = \hbar_0/n_b$ and $\hbar = n_a n_b\hbar_0$. Note that the descriptions using ordinary Planck constant and coverings and scaled Planck constant but contracting the covering would be alternative descriptions.

This gives the following formulas $r \equiv \hbar/\hbar_0 = r(M^4)/r(CP_2)$ in various cases.

	$C - C$	$F - C$	$C - F$	$F - F$
r	$n_a n_b$	$\frac{n_a}{n_b}$	$\frac{n_b}{n_a}$	$\frac{1}{n_a n_b}$

Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of n_F of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, CP_2 radius and Planck length appearing in the expression for the tension of cosmic strings, and I have considered the possibility that the powers of 2^{11} are favored as values of n_a in living matter.

How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anti-commutation relations of various super-conformal algebras. Only the ratio of M^4 and CP_2 Planck constants appears in Kähler action and is due to the fact that the M^4 and CP_2 metrics of the embedding space sector with given values of Planck constants are proportional to the corresponding Planck constants [K37]. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of $\hbar$ coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high T_c superconductors.

Do factor spaces and coverings correspond to the two kinds of Jones inclusions?

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups Z_n label these inclusions. The interpretation of Z_n as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For $\mathcal{M} : \mathcal{N} = 4$ the interpretation of Z_n has remained open. Obviously the interpretation of Z_n as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

   For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{M}^2 \hat{\times} G_a$ and $\hat{CP}_2 \hat{\times} G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by n_a *resp.* n_b and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by G_a *resp.* G_b and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$, which both are labelled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group G_1, two-element group G_2 consisting of reflection and identity, the cyclic groups Z_p, p prime, and tetrahedral, octahedral, and icosahedral groups are the generators of this algebra.

   By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group G_1, two-element group $G_{2\text{¡}}$ generated by reflection, and tetrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups Z_p generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" N^{11} (N denotes natural numbers). Leaving away reflections, one obtains N^7.

The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions. One could introduce generalized WCW spinor fields in the WCW labelled by sectors of H with given quantization axes. By introducing Fourier transform in N^{11} one would formally obtain an infinite-component field in 11-D space.

5. How do the Planck constants associated with factors and coverings relate? One might argue that Planck constant defines a homomorphism respecting the multiplication and division (when possible) by G_i. If so, then Planck constant in units of $\hbar_0$ would be equal to n_a/n_b for $\hat{H}/G_a \times G_b$ option and n_b/n_a for $\hat{H} \hat{\times} (G_a \times G_b)$ with obvious formulas for hybrid cases. This option would put M^4 and CP_2 in a very symmetric role and allow much more flexibility in the identification of symmetries associated with large Planck constant phases.

9.7.2 Em Cyclotron Frequencies Of Biologically Important Ions

A detailed study of the cyclotron frequencies demonstrates that they indeed seem to correspond to important EEG frequencies. The cyclotron frequencies associated with other singly ionized atoms can be obtained by the formula

$$f = \frac{A}{20} \times f(Ca^{2+}) \qquad f(Ca^{2+}) \simeq 15 \ Hz \ . \tag{9.7.1}$$

Here the strength of the magnetic field is assumed to be $B_{end} = .2$ Gauss $= 2 \times 10^{-5}$ Tesla. Note that published material there was an erratic identification $B = B_E = .5$ Gauss due to the calculational error.

Table 9.8 lists cyclotron frequencies and their lowest multiples for some of the most important ions.

9.7.3 Cyclotron Frequencies Of Exotic Ions And Periodic Table

Exotic em and Z^0 ions result when some color bonds in atomic nucleus become charged and are simultaneously ordinary ions. By magnetic flux quantization Z^0 magnetic cyclotron frequencies differ from their electromagnetic counterparts for singly charged ions only by charge ratio factors $Q_Z/Q_{Z,0}$. Hence it is convenient to represent electromagnetic cyclotron frequencies instead. The ions in various periods correspond to bands of EEG: it seems however that satellites of the harmonics of cyclotron frequencies beta and theta bands and that harmonics of frequencies in alpha band provides a more natural explanation for gamma and higher bands. For completeness cyclotron frequencies for all periods are given although the biologically important heavy ions are rather scarce.

Ions in Helium period correspond to beta and gamma bands

Table 9.9 lists the relevant data about ions in He period. Cyclotron frequencies are in the range $(15.8 - 75)$ Hz for nuclear exotic ionization which respects statistics. Note that Be and N atoms are exceptional being fermions in ground state. Li ion has rather high cyclotron frequency 42.9 Hz.

Ions in Neon period correspond to alpha band

For Neon period nuclear exotic ionization the frequencies span the range $8.5 - 15.0$ Hz: only 15 Hz cyclotron frequency of Ne belongs to beta band.

Ions in Argon period correspond to theta band

Singly ionized exotic ions in Argon period have cyclotron frequencies in the range $(3.6 \ Hz < f \le 7.5 \ Hz)$.

Elementary particle	f_1/Hz	J	f_L/Hz
e	5.6×10^5	1/2	2.8×10^5
p	300	1/2	419
Bosonic ions			
^6Li	50.1	1	88.3
O^{2-}	37.4	0	0
Mg^{++}	25.0	0	0
Ca^{++}	15.0	0	0
Mn^{2+}	11.4	5/2	520
Fe^{2+}	10.8	0	0
Co^{2+}	10.0	7/2	695
Zn^{2+}	9.4	0	0
Se^{2-}	7.6	0	0
Fermionic ions			
$^7Li^+$	42.9	3/2	489
N^+	21.4	1	60.6
F^-	15.8	1/2	395
Na^+	13.0	3/2	333
Al^+	11.1	5/2	546
Si^+	10.7	0	0
P^+	9.7	1/2	170
S^-	9.4	0	0
Cl^-	8.5	3/2	130
K^+	7.5	3/2	58.5
Cr^-	5.7	3/2	71.1
Cu^+	4.8	3/2	333.9
Ag^+	2.8	1/2	17
I^+	2.4	5/2	420
Au^+	1.5	3/2	21

Table 9.8: The first column gives cyclotron frequency in cycles per second for some ions in Earth's magnetic field assumed to have strength $B_{end} = .2 \times 10^{-4}$ Tesla. The remaining columns give spin or nuclear spin and Larmor frequency f_L.

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
He	(2, 4, F)	75	C	(6, 12, F)	25.0
Li	(3, 7, F)	42.9	N	(7, 14, B)	21.4
Be	(4, 9, B)	33.3	O	(8, 16, F)	18.8
B	(5, 11, F)	27.3	F	(9, 19, F)	15.8

Table 9.9: Basic data for the ions in Helium period. Cyclotron frequency and nuclear spin for exotic ion with unit electric charge due to the charged color bond in nucleus. F or B tells the statistics of the electronically ionized atom (most atoms are bosons in ground state).

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
Ne	(10, 20, F)	15.0	Si	(14, 28, F)	10.7
Na	(11, 23, F)	13.0	P	(15, 31, F)	9.7
Mg	(12, 24, F)	12.5	S	(16, 32, F)	9.4
Al	(13, 27, F)	11.1	Cl	(17, 35, F)	8.5

Table 9.10: One can arrange the exotic ions in Neon period to one triplet of exotic ions allowing also spin flip qualia and to a quintet assigned with cyclotron qualia. For the meanings of various notations see previous table.

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
Ar	(18, 40, F)	7.5	Co	(27, 59, F)	5.0
K	(19, 39, F)	7.5	Ni	(28, 58, F)	5.2
Ca	(20, 40, F)	7.5	Cu	(29, 63, F)	4.8
Sc	(21, 45, F)	6.7	Zn	(30, 64, F)	4.7
Ti	(22, 48, F)	6.3	Ga	(31, 69, F)	4.3
V	(23, 51, F)	5.9	Ge	(32, 74, F)	4.1
Cr	(24, 52, F)	5.7	As	(33, 75, F)	4.0
Mn	(25, 55, F)	5.5	Se	(34, 80, F)	3.8
Fe	(26, 56, F)	5.4	Br	(35, 79, F)	3.8

Table 9.11: Basic data for singly charged exotic ions with frequencies in Argon period and having cyclotron frequencies in theta band.

Ions in Krypton period correspond to delta band

Krypton period provides an almost identical copy of Argon period. The cyclotron frequencies of Krypton band are in the range $2.3 - 3.5$ Hz.

Basic data for Xenon period

Table 9.13 lists ions with [Xe] ground state. Note that all ions in Xe band do not have stable isotopes and it is questionable whether any biologically interesting ions are in this period. Cyclotron frequencies of singly charged exotic ions in Xenon period vary in the range $1.5 - 2.2$ Hz.

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
Kr	(36, 84, F)	3.6	Rh	(45, 103, F)	2.9
Rb	(37, 85, F)	3.5	Pd	(46, 108, F)	2.8
Sr	(38, 86, F)	3.5	CD	(48, 114, F)	2.6
Y	(39, 89, F)	3.4	Ag	(47, 107, F)	2.8
Zr	(40, 90, F)	3.3	In	(49, 115, F)	2.6
Nb	(41, 93, F)	3.2	Sn	(50, 120, F)	2.5
Mo	(42, 98, F)	3.0	Sb	(51, 121, F)	2.5
Tc	(43, 99, F)	3.0	Te	(52, 130, F)	2.3
Ru	(44, 102, F)	2.9	I	(53, 127, F)	2.4

Table 9.12: Table 15. Basic data for singly charged exotic ions having [Kr] as ground state configuration. Tc does not allow stable isotopes but the lifetimes of two long-lived Tc isotopes are 1.5×10^6 years and 2.1×10^5 years.

Ion	(Z, A, S)	f_1/Hz	Ion	(Z, A, S)	f_1/Hz
Xe	(54, 132, F)	2.3	Yb	(70, 174, F)	1.7
Cs	(55, 133, F)	2.3	Lu	(71, 176, B)	1.7
Ba	(56, 138, F)	2.2	Hf	(72, 178, F)	1.7
La	(57, 139, F)	2.2	Ta	(73, 181, F)	1.7
Ce	(58, 140, F)	2.1	W	(74, 184, F)	1.6
Pr	(59, 141, F)	2.1	Re	(75, 187, F)	1.6
Nd	(60, 142, F)	2.1	Os	(76, 192, F)	1.6
Pm	(61, 147, F)	2.0	Ir	(77, 193, F)	1.6
Sm	(62, 152, F)	2.3	Pt	(78, 195, B)	1.5
Eu	(63, 154, B)	1.9	Au	(79, 197, F)	1.5
Gd	(64, 158, F)	2.0	Hg	(80, 202, F)	1.5
Tb	(65, 160, F)	1.9	Ti	(81, 205, F)	1.5
Dy	(66, 164, F)	1.8	Pb	(82, 206, F)	1.5
Ho	(67, 165, F)	1.8	Bi	(83, 209, F)	1.4
Er	(68, 166, F)	1.8	Po	(84, 209, F)	1.4
Tm	(69, ?, ?)	?	At	(85, 211, F)	1.4

Table 9.13: Basic data for ions with having [Xe] as ground state configuration.

Chapter 10

Quantum Model for EEG

10.1 Introduction

In previous chapter the overall TGD based view about EEG was discussed. According to this view, the basic function of EEG is to induce cyclotron phase transitions at the magnetic body and thus allows magnetic body to share the standarded mental images produced by brain via negentropic quantum entanglement. Magnetic body would also produce what might be called higher level sensory qualia identified as emotions and cognitions. In this chapter the relationship between EEG and nerve pulse patterns is discussed in TGD framework.

10.1.1 Vision About Eeg

The general model for EEG relies on the idea that EEG frequencies correspond to Josephson frequencies defined by membrane potentials and provide cognitive and one might also say emotional representation of the sensory input at the magnetic body in terms of cyclotron transitions. The perturbations of the membrane potentials caused by spikes, neurotransmitters affecting alertness reducing the magnitude of the resting potential induced frequency modulations of the membrane potentials and one can say that the cell is like a singing whale with evoked potentials and nerve pulse patterns coded to the varying frequency. Song is expression of this singing but also speech involves frequency modulation as one learns by playing slowly recorded spoken language.

The scale of the frequency assignable to a given neuron is determined by the value 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-adically scaled up electronic Compton length scales with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) 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 [K35].

This proposal will be referred to as Mersenne hypothesis and it leads to strong predictions about EEG since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to given value of $\hbar$ a fixed size scale having interpretations as size scale of body part or magnetic body.

An essential assumption is that cell membrane corresponds to almost vacuum extremal so that classical Z^0 field proportional to em field is present and leads to the replacement of ionic

charges with effective charges much larger than ionic charges so that that membrane voltage corresponds to a photon energy in visible or UV range and the energies of biologically most important ions span half octave. From this it follows that for given ion and membrane voltage the value of r fixes completely the Josephson frequency. For instance 5 Hz frequency corresponds to $r = 2^{k_d}$, $k_d = 47$.

Armed with this picture one ends up with a rather detailed quantitative model for EEG discussed already in [K35]. In this chapter this model is applied in more detail. Features, synchronization, stochastic resonance, temporal codings, and what I have used to called scaling will be discussed.

10.1.2   Features

Walter Freeman has identified spatially amplitude modulated synchronous but non-periodic EEG patterns serving as correlates for conscious percepts. The duration of features is in the range 80-120 ms and there is spatial coherence but no strict periodicity but 1 ms temporal resolution so that one can speak of spatial amplitude modulation of a temporal pattern which is same over the spatial cross section of the feature. The basic patterns recur with a period of 5-7 Hz. The sizes of features are in the range 1-2 cm.

The model of EEG and bio-photons in terms of large $\hbar$ Josephson radiation generated by cell membrane Josephson junctions predicts that the wavelength of Josephson photon with energy of visible or UV photon and scaling like $\hbar$ is dictated by the size scale of the structure generating ELF radiation with frequency scaling as $1/\hbar$. This hypothesis combined with the Mersenne hypothesis [K35] allows to build a picture about the values of Planck constant involved with the features. Also the fact the causal diamonds (CDs) of d quark and electron correspond to kHz and 10 Hz frequencies is expected to be relevant for the model.

10.1.3   Synchronization

Synchronization in and between various cortical areas is known to occur with millisecond precision. Also disjoint brain regions can be in synchrony. This is difficult to understand without synchronizing agent oscillating at kHz frequency.

Again kHz frequency brings in mind d quark CD. kHz Josephson frequency is second candidate. If this frequency is also realized as cyclotron frequency identifiable as a scaled up alpha frequency, the value of the magnetic field must be by a factor 2^7 stronger than $B_{end} = .2$ Gauss and thus about 2 mTesla. The model for hearing requires the hierarchy of magnetic field values so that this hypothesis might make sense.

In TGD framework magnetic body and hierarchy of Planck constants inducing the scaling of p-adic length scales is the natural agent inducing the synchrony and MEs could induce the synchronization. Synchronization would naturally occur at the frequency corresponding to a duration of the bit of the memetic code. kHz frequency corresponds to the size scale of head and makes possible the synchronization of cortical areas.

10.1.4   Stochastic Resonance

Concerning the mapping of EEG frequencies to nerve pulse patterns, stochastic resonance promotes itself as a basic mechanism. In bistable systems stochastic resonance allows to amplify very weak periodic signals by utilizing white noise. Stochastic resonance is known to be relevant also at the neuronal level as demonstrated by the autocorrelation functions for spike sequences exhibiting peaks at the harmonics of the signal frequency. Neuron is however far from being bistable system, and this raises the question whether bi-stability might be present at some deeper quantal level.

Nerve pulses generate EEG MEs and the frequency of the nerve pulses determines the rate at which EEG MEs are generated rather than the frequency of EEG MEs. TGD inspired model of nerve pulse assigns to the resting state of cell a propagating soliton sequence and nerve pulse corresponds to a perturbation which locally transformation propagation to oscillations. The states correspond to the states of the bistable system. The system in resting state is near criticality in the sense that rotation velocity is slightly above the minimum one so that reduction of membrane potential transforms rotation motion to oscillatory motion locally. Stochastic resonances makes

itself visible in the autocorrelation function of the spike sequence and in this way also in the membrane potential of say glial cells coupling to neurons. In fact, glial cells could play the role of listener of radio turning the knob (noise level) to tune the neurons to a particular spiking frequency.

10.1.5 Temporal Codings

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework where massless extremals suggest a coding preserving phase information and based essentially on coherent summation of perturbations of membrane voltages coming from presynaptic neurons. The superposition of contributions to membrane voltage imply interference effects. It is known that spike interval statistics allows to regenerate recognizable speech artificially by stimulating neurons electrically. The destruction of phase information while keeping spike rate as such lhowever eads to a loss of experienced emotional content of artificial spike patterns. This suggests that the interference effects code for the emotional content of nerve pulse pattern and the outcome is cognitive and emotional representation at the magnetic body.

One can consider also cognitive codes for which only spike patterns are significant and analogous to the rhythmic patterns of music. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input. For high stimulus intensities the duration of the bit of the p-adic cognitive codeword tends to become shorter. This is comparable to the increase of the speech rate during a high state of arousal, and conforms with the observed shift of EEG towards higher frequencies in this kind of situation. There is a lot of experimental evidence supporting the existence of various kinds of temporal codings, and these codings are discussed in TGD framework.

10.1.6 Scaling Law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. The law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form $L = v/f$ and relates ELF self size characterized by ELF frequency f to the self size L and to the effective phase velocity v of the EEG wave.

Scaling law also suggested by the experimental work with the effects of ELF radiation in water [I14]. As discussed in [K42] scaling law can be explained in terms of phase transitions transforming large $\hbar$ photons to ordinary ones. The chapter ends with the discussion about possible implications of the scaling law concerning EEG.

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` [L11].

10.2 Eeg, Meg, Nerve Pulse And Mini-Potentials

In this section the basic facts about EEG, MEG, nerve pulse and mini-potentials are briefly reviewed.

10.2.1 EEG

E(lectro)E(ncephalo)G(ram) is the study (or graphing) of the electric potential on the surface of the skull [**?**]. EEG waves are oscillations of the membrane potential with frequency varying in the range 1-100 Hz. The amplitude of the oscillating membrane potential is typically 10^{-4} Volts and by a factor 10 smaller than postsynaptic potential. EEG waves is a vertebrate phenomenon, insect ganglia do not exhibit comparable potentials.

Four basic rhythms have been identified in EEG wave spectrum and their amplitude and frequency correlate strongly with the state of awareness [**?**]. It must be emphasized that the

boundaries of frequency ranges vary by few Hz depending on author.

i) α rhythm. $f = 8$-13 Hz and amplitude is about 20 micro-volts. α dominates in rest but not in the sleep state. A sudden illumination by light leads to the disappearance of the α component of EEG.

ii) β rhythm. $f = 14$-30 Hz with amplitude about 40-100 micro-volts. β dominates during a conceptual thinking.

iii) γ rhythm. $f = 30$-90 Hz with. Gamma rhythm is associated with temporal coding of sensory information.

iv) θ rhythm. $f = 4$-7 Hz. θ dominates during sleeping without dreams. Dreams in turn correspond to β waves.

v) δ rhythm. $f = 0.5$-3 Hz. δ corresponds to deep sleeping without dreaming.

In general the amplitude is smaller the larger the frequency is.

EEG reflects also alarm reaction and sensory responses. Various mental disorders, brain tumors and brain injuries reflect themselves in EEG. Epilepsy, which corresponds to hyperexcitability of some part of the nervous system induces characteristic changes in the EEG pattern. EEG varies also considerably during the development. EEG appears at the age of year as occasional bursts with frequency 4-8 Hz and the adult form of EEG is established before the age of 19.

The question whether all EEG waves genuinely propagate or not is not resolved experimentally yet. It is known that alpha waves propagate and that the propagation velocity is about $v \sim 10$ m/s. There is also evidence for the propagation of 40 Hz EEG waves [**?**, **?**].

There is no doubt that EEG waves are deeply involved with the basic functioning of the brain but the origin and the exact function of EEG has remained a mystery. The EEG waves associated with two distant neurons are strongly correlated and this supports the view that EEG waves are related to the properties of the brain as a coherent quantum system.

10.2.2 MEG

This subsection gives a brief summary about magnetoencephalography (MEG). The motivation is that brain could act with MEs by acting effectively like magnetometer somewhat in the same way as SQUID magnetometer measures the magnetic fields generated by brain.

SQUIDs

SQUIDs [**?**, **?**, **?**] are instruments used to measure extremely weak magnetic field in the case that the resolution needed is below the magnetic flux quantum $h/2e$ ($\hbar = c = 1$) for magnetic flux in super conductor. An important application of SQUIDs is to the measurement of the weak magnetic fields generated by brain and having strengths as weak as fT. SQUID technology has been used to detect the weak magnetic fields created by brain (10^{-13} Tesla region) and quite an impressive knowledge exists about the magnetic correlates of the brain activity in ELF region [**?**].

A rough description of SQUIDs goes as follows.

1. The current in SQUID measures the deviation of the external magnetic field from a multiple of magnetic flux quanta which is reflected as a presence of a current in SQUID which creates magnetic field compensating this deviation.

2. The circuit equations can be written for the magnetic flux through SQUID and differ from the equations for RCL resonance circuit only by the presence of Josephson current non-linear with respect to the magnetic flux. If the super current is accompanied by a white noise with a correct intensity, SQUID amplifies the periodic signal in resonant manner. The stochastic resonance in SQUIDs has been demonstrated experimentally [**?**].

3. SQUID consists of a closed current loop decomposing to two parts connected by thin non-super-conducting insulators. This makes possible rapid dissipation of the current to the minimal value needed by flux quantization. Small deviations from the quantized flux can be accurately measured by measuring the persistent supra current.

The basic equation governing the behavior of SQUID relies in the following simple model. SQUID is characterized by inductance L relating magnetic flux to current ($\Phi = LI$ modulo integer

number of flux quanta). The potential difference around SQUID is by Faraday's induction law equal to $eV = d\Phi/dt$. SQUID can be regarded as a capacitor (capacitance C) formed by the two halves of SQUID coupled by the insulators to which one can assign internal resistance R. Insulating parts serve as Josephson junctions through which ordinary Ohmic currents run besides the Josephson current depending sinusoidally on the magnetic flux. The equation for the time derivative of the potential difference around the SQUID loop reads as

$$LC\frac{d^2\Phi}{dt^2} = -\tau\frac{d\Phi}{dt} - \Phi - \beta sin(\Phi) - \xi \ ,$$
$$\beta = \frac{Li_c}{\Phi_0} \ , \quad \tau = \frac{L}{R} \ , \quad \Phi_0 = \frac{\hbar}{2e} \ . \tag{10.2.1}$$

Here ξ denotes the white noise contribution to the Josephson current. Φ is measured in units of Φ_0 and in the equation above Φ denotes the deviation of Φ from an integer multiple of Φ_0. The equation is obviously invariant under the symmetry $\Phi \to \Phi + n2\pi$. i_c denotes the critical current for which the super current in the circuit becomes dissipative. Usually also an additional external current guaranteeing a slight over-criticality is added. If the inertial term proportional to LC can be made small, the system rapidly dissipates to equilibrium configuration. For small deviations of Φ from a valued corresponding to a quantized magnetic flux system indeed exhibits stochastic resonance [**?**].

Magnetic fields associated with brain activity

SQUIDs (super-conducting quantum interference devices) have made it possible to measure the magnetic fields associated with the brain activity. The magnetic fields accompanying the evoked responses [**?**] and the background activity of brain are in the range $10 - 10^3$ fT, in general below the level of the geomagnetic noise but above the thermal magnetic noise produced by body which is roughly .1 fT. The frequency range is typically between 0-100 Hz in these measurements and corresponds to the frequency range of EEG. alpha rhythm at 10 Hz generates a sharp peak with a peak value about 1-2 pT, which is slightly above the level of the geomagnetic noise. Eyes create static magnetic fields of about 10^{-11} T. Heart creates an oscillatory field with somewhat stronger intensity below 10^{-10} T and with the frequency of heart beat: this field is in the intensity region of the geomagnetic noise having frequencies above .01 Hz. Sensory stimuli generate typically responses with a strength of few hundred fT consisting of oscillations which start few tens of milliseconds after the stimulus and end few hundreds of milliseconds after the beginning of the stimulus (natural time scale is .1 seconds for the duration of the magnetic response.

The simplest model for the magnetic field associated with an evoked response is as being generated by a point like magnetic dipole or a collection of point like magnetic dipoles. This means that the measured fields are essentially superpositions of radiation fields generated by dipoles. It is possible to determine rather accurately the positions of these effective dipoles in brain and thus to localize various brain functions. Also the dependence of the shape of the frequency spectrum on brain function can be studied and the distribution of the net power in a given frequency range as a function of the location can be studied. Often the ratio of the responses before and after stimulus is measured as a function of position near the surface of the skull.

The simplest hypothesis is that far-away radiation fields decompose into MEs propagating in the radial direction. In TGD based model of EEG, brain is in electromagnetic bath provided by "free" ELF MEs moving along the surface of cortex with the velocity of nerve pulse, and generating electromagnetic responses which decompose in far-away region into MEs propagating into the radial directions. In the induction region more complex flux quanta are possible. The criterion for the radiation region reads as $r \geq \sqrt{\lambda L}$ and relates the distance r between observation point and source, the size L of the source region, and the wavelength. For a point like source this criterion holds everywhere.

Dipole approximation is used in the analysis of the data to determine the position of evoked response. If λ corresponds to the wavelength of 10 Hz radiation and L is of order 10 microns, the the criterion for faraway region is roughly $r > 10$ meters and classical radiation fields measured in the region near brain are induction fields. Hence one cannot regard the magnetic fields induced by the brain activity as consisting of MEs in the measurement region. This is of course natural, since in radiation region a lot of information is lost since the system looks point like in this region.

On basis of EEG one can expect that the intensities of the magnetic fields associated with MEs providing the electromagnetic bath for brain are weaker than the intensities of the evoked fields. The intensity of ELF em radiation in delta band, which is of the same order of magnitude as the radiation associated with [F7] [F7], provides the first guess.

10.2.3 Nerve Pulse

Nerve pulse is the tool used by the nerve cells to communicate information to each other [I50], [?]. Nerve pulse is generated, when the potential difference through the cell membrane, rest potential, changes from its rest value about of -80 millivolts to about -50 millivolts, the threshold potential: after this the action potential about 40 millivolts is generated and begins to propagate along the axon with approximately constant velocity varying between 1-100 meters.

For resting potential the concentration of Na_+ ions, Ca_{++} and Cl_- concentrations are much larger outside the cell than in its interior whereas K_+ concentration is larger inside the cell. Thus in absence of constraints ($Na_+ - K_+$ pump) forcing membrane potential to its resting value Na_+, Ca_{++} and Cl_- would flow to cell interior: obviously, the flow of first two tends to reduce the resting potential. K_+ in turn would would flow out of cell interior. Nerve pulse is indeed generated when Na_+ conductance increase and Na_+ rush to cell interior, the return to resting state involves temporal flow of K_+ ions to cell exterior.

The generation of the nerve pulse involves the increase of Na and K conductivity through the cell membrane so that a flow of K and Na ions through cell membrane takes place and action potential is generated. The increase of the conductivity is caused by the opening of Na and K channels. According to the classical model of Hogkin and Huxley [I50] the opening of the Na channels involves the participation of three so called m particles and one so called h particle. The rapid increase of Na conductivity is possible to understand only provided the charge of the m particles is -2 and they are electron pairs [I50]. A possible identification is as Cooper pairs.

The axon consists of two kinds of segments. The first segment having typically a length of the order of 10^{-3} meters is surrounded by a myelin shell: in this region no Na and K currents appear. The velocity of the nerve pulse is of the order of 10^2 m/s in these regions. Between the myelinated regions appear unshielded regions, where Na and K flow appears: these have length of order of 10^{-6} meters: velocity is in general smaller in these regions. The function of the unmyelinated regions is probably to refresh the nerve pulse since the dissipation causes the decrease of the height of the pulse during the propagation through the myelinated regions. The completely unshielded propagation is not economical since metabolic energy gets wasted.

Nerve pulse either ends up to a muscle or is transferred to a neighboring cell through a synaptic connection. There are two kinds of synaptic connections. Gap junctions are direct contacts between two cells and the nerve pulse is transferred electrically to the second cell. In chemical synapses the axon is separated from the dendrite of the receiving cell by a synaptic cleft having width of the order of $10^{-8} - 10^{-7}$ meters. The nerve pulse is transferred chemically via the so called synaptic transmitter substance. The nerve pulse generated in the dendrite can be either excitatory or inhibitory depending on whether the sign of the voltage difference is favorable for the generation of the action potential or not. The value of the postsynaptic potential is about 10 millivolts.

Whether the nerve pulse is generated depends on the inputs received by the nerve cell. In neural network models the output is generated provided the sum of the inputs exceeds a certain threshold value. It is not at all clear however whether the inputs correspond to potentials or something else, but closely related to postsynaptic potentials. What seems to be clear is that this quantity can have only two values corresponding to exhibitory and inhibitory inputs respectively. The nerve pulses coming from the sensory organs obey frequency coding. The stronger the sensory input the greater the frequency of the nerve pulses. The duration of the nerve pulse, about few milliseconds, sets of course a limit for the frequency of the pulses.

To summarize, the propagation of the nerve pulse is a well understood process and the interpretation of the action potential as one bit of information is attractive. The idea that nerve pulse is generated, when the sum of inputs (in some sense) exceeds some threshold value seems to be well established. The details related to the generation of the threshold potential and the relationship of the nerve pulse generation to the general state of awareness and memory content

of the brain is however unclear. Also the relationship between nerve pulses and EEG waves is unclear.

10.2.4 Miniature Postsynaptic Potentials

Miniature postsynaptic potentials have quantized amplitude of order .5 mV to be compared with the value of the rest potential, which is roughly 100 times larger [**?**]. Miniature potentials are generated in the postsynaptic neuron, when it has received nerve pulse. The quantized packets of neurotransmitters such as ACh give rise to the emission of miniature potentials. According to [**?**] miniature potentials might consist of superpositions of much smaller micro-potentials of amplitude of order .3 μV generated by single neurotransmitter molecule. One could however consider also the possibility that the minimum size for the quantized packet of neurotransmitter is dictated by the requirement that the packet is able to generate the mini-potential.

10.3 Features And Synchronization

The model for sensory receptor discussed in the previous section is inspired by the general vision for how magnetic body controls biological body and receives information from it. The model generalizes straightforwardly to a model of features. What is new that features would most naturally be induced by W MEs affecting glial cell groups which in turn would induce the synchoronous neuronal firing.

Cyclotron phase transition at appropriate magnetic body induced by cyclotron and Josephson radiation generated by the corresponding biological body defines the feature. Both Josephson and cyclotron frequencies associated with scaled up EEG would scale as $r = \hbar/\hbar_0$. The modulated cyclotron frequency could place code a position of the representation at magnetic body representing some geometric quantity, say the distance of the object of perceptive field. The temporal modulation pattern of the amplitude of cyclotron radiation by some EEG frequency in turn would define the feature assigned at this position. One can distinguish between speech and song like features responsible for cognitive and emotional aspects of perception. Also spatial modulation is present but temporal pattern is same at all points of feature.

Geneticandperhaps even memetic codons with duration of.1 seconds are good candidates for the "phonemes" of speech like features. Recurring feature corresponds to a plasma oscillation with frequency below 10 Hz generated by the charge entanglement by W ME inducing exotic ionization. Ca^{2+}, Mg^{2+} and possibly also other bosonic ion waves are physiological correlates of the features.

1 kHz synchronization frequency reduces in this picture to DNA cyclotron frequency associated with the scaled up variant $\lambda B \simeq .02$ Tesla of the magnetic field $B = B_{end}/2 = .1$ Gauss assignable to the right brain hemisphere and having cyclotron frequency.5 Hz and carrying single flux quantum $h_5 = 5h_0$. Also 2 kHz synchronization frequency is highly suggestive. The dark photons of this radiation could result as DNAs drop to excited cyclotron states at the magnetic flux sheets traversing through the sequences of DNA double strands defining lines of a page of a book represented by the flux sheet. The text line has an interpretation as a supergene expressed collectively during synchronous firing.

Also fractally scaled up variants of features with duration of short term memory and realized as modulations of EEG frequencies are predicted with alpha band taking the role of 1 kHz synchronization. Scaled up variants of memetic/genetic codons would code for information now. In this case the size scale of the features would be $\lambda \times .02 = 40$ m suggesting that collective mental images involving several brains are in question.

10.3.1 Features

The notion of p-adic cognitive representation seems to have an impressive explanatory power. These representations are however local in the spatial degrees of freedom, and the further challenge is to understand how the p-adic codons from various points of cortex are combined to more complex features/symbolic mental images. The work of Freeman with odor perception gives valuable guidelines in this respect [E4]. The findings of Freeman suggest that neurons in a given cortical area define temporally synchronous patterns, features. The temporal synchrony would mean that

all spatial points correspond to the same p-adic codon in the temporal domain. There is however an arbitrary dependence of the feature on the two transversal coordinates of the cortical surface for a given time value. Hence the situation is 3-dimensional but the third dimension is time rather than space.

Features as AM modulated EEG patterns

The coherence lengths for EEG inside cortex are in general much shorter than at the surface of the skull and complex patterns are encountered. In particular, synchronous cortical EEG patterns with coherence length of order 1-2 cm appear (size of Brodmann's areas). Freeman identifies these patterns as basic units, "features", of perceptual activity (the activity related to subjective experience rather than sensory input) [E4], and calls these patterns mesoscopic activity as opposed to the microscopic activity represented by nerve pulse patterns. According to Freeman these patterns are observed besides olfactory bulb also in visual, auditory and somatic cortices.

These synchronous EEG patterns have a non-periodic time dependence which does not depend on position: this would be consistent with the frequency coding of the time span of declarative memory. The amplitude is spatially amplitude modulated. The AM patterns are measured at two-dimensional surface so that the question whether the spatial amplitude modulation is 3-dimensional or 2-dimensional remains open. The patterns are recurring 2-7 times per second, which corresponds to theta band in frequency space. This conforms with the assumption that memories are coded by the same features as direct experiences and that carrier frequency is in theta range unlike for purely symbolic representations of sensory experiences for which it is in gamma range. The duration of the patterns is $T = 80 - 120$ ms.

How to understand the time and length scales associated with the features

The first thing to be understood are the time scales and here TGD inspired model for EEG based on the identification of EEG and bio-photons in terms of Josephson radiation generated by cell membrane acting as Josephson function is the natural starting point. This model is made quantitative by the Mersenne hypothesis to which TGD inspired model of EEG and also biological evolution is based [K35].

1. The time scales bring in mind the causal diamonds (CDs) of d quark and electron with time scales of 100 ms and 1/1.28 ms. For u quark the time scale is 6 ms which corresponds to 160 Hz cerebellar synchrony. What is disturbing is the large relative variation of the durations. These time scales are in rest system of CD and Lorentz transform of CD scales up the time scale. The needed Lorentz boosts look however unrealistic since they would require relativistic velocities for electrons and would explain only the interval 100-120 ms but not 80-100 ms.

2. A more promising hypothesis is that the duration relates to the Josephson frequency of the cell membrane proportional to the resting potential which varies in rather wide limits: -40 mV for visual receptors and -80-90 mV for glial cells. The ratio of the neuron resting potential -70 mV to the critical potential -55 mV for firing and average resting potential -70 mV is 1.2 whereas the ratio for durations is 1.5. The Josephson frequencies of the basic biological ions for almost vacuum extremal cell membrane are modified by the contribution of classical Z^0 field correspond to half octave range and the ratio of maximum to minimum membrane voltage is is quite near to $\sqrt{2} \simeq 1.4$ not too far from 1.5. This option looks the most promising one and would predict a discrete spectrum for the durations smoothed out partially by the variation of the resting potentials.

3. kHz frequency could correspond to Josephson frequency of membrane potential inducing an additive modulation of membrane voltage in turn inducing frequency modulation of Josephson frequencies of in nearby cells. For instance, glial cells could induce this modulation. The model for EEG would suggest that also 5-7 Hz frequency corresponds to a Josephson frequency for cell membrane and thus to $r = \hbar/\hbar_0 = 2^{k_d}$ if one accepts the Mersenne hypothesis to which TGD inspired model of EEG and also biological evolution is based [K35]. This would suggest a hierarchy involving the Josephson frequencies 5-7 Hz, 8.4-12.5 Hz, and 1 kHz.

A three-level hierarchy could be in question with the slowest frequency assignable to hippocampus, next frequency to the higher sensory areas, and kHz frequency possibly to head itself. The identification is supported by internal consistency: kHz frequency defines synchrony in the size scale of entire brain and corresponds to the p-adic length scale assignable to brain. This picture would conform with much more general hypothesis about brain as an orchestra with neurons and glial cells as instruments whose octave is specified by the value of Planck constant restricted by Mersenne hypothesis.

4. The question about interpretation of frequencies assignable to $\hbar_0$ CDs remains. One possibility is that the kHz Josephson radiation with large Planck constant decays to bunches of ordinary kHz quanta as its leaks to $\hbar_0$ page of the Big Book. Other transition would be a transformation to single $\hbar_0$ visible or UV photon having identification as a bio-photon.

One should also understand the size scale of features. Suppose in accordance with Mersenne hypothesis that Josephson wavelength define the structures as scaled up variants of the wave length assignable to $\hbar_0$ Josephson frequencies of basic biological ions, which corresponds to $k_{eff} = 163$ for 2 eV energy. This implies that 5 Hz Josephson frequency corresponds to to $k_{eff} = 210$ - a p-adic length scale, which is roughly 15 meters. 1 cm sized features would correspond to Josephson frequency of about 2×10^5 Hz rather than kHz frequency but one could argue that these features integrate to a larger structure during kHz synchrony making possible binding of mental image in the scale of entire brain. Of course, nothing prevents the presence of also 100 kHz frequency scale and for bats and sea mammals the hearing range extends up to 2×10^5 Hz [?, ?] .

MEs as AM patterns representing features

The identification of massless extremals (MEs) as representations of the features is suggestive since for MEs the time dependence is same for all points in the 2-D transversal cross section. Temporal coherence in turn corresponds to the arbitrary but synchronous dependence of the field pattern on the temporal coordinate at this cross section. Thus MEs are ideal for the communication of the information contained by features to the magnetic body.

MEs allow arbitrary direction and magnitude of transversal polarization and arbitrary time dependence which does not depend on position. 2-dimensional instead of 3-dimensional AM patterns are predicted but this is consistent with empirical data. Note that MEs in question are like light fronts going through the two-dimensional surface where the measurement is performed. One might argue that the character of MEs as topological field quanta of classical radiation means that they are not sufficiently general to model the nearby ELF fields in brain. This might be the case. On the other hand, the solution ansatz defining MEs is extremely general [K68]. In geometric optics picture this means that paths of light rays inside MEs can be also curvilinear light like curves expressible as gradient lines for a Hamilton Jacobi functional S whereas the transverse polarization is defined by a gradient of a polarization function E.

The spectrum of durations for the synchronous time patterns encourages also to consider an interpretation of these patterns as an electromagnetic realization of genetic code words. Also more general p-adic codes can be considered. A compression of the memetic code words defined by the nerve pulse patterns giving rise to abstraction and classification could be in question. The representation would be achieved by the modulation of the alpha waves by higher harmonics of alpha frequencies analogous to ripples. Essentially an interference of slow alpha wave with faster wave containing frequencies up to kHz would be in question.

In the case of hearing the contraction could take place but one can also consider the possibility that entire 126 bit memetic code is realized and that the large number of bits codes for information relation to delicate factors like the emotional coloring of the speech. This would explain the completely exceptional role of the language in cognition.

MEs need not nor cannot be purely electromagnetic and for far from vacuum extremal MEs with vanishing classical Z^0 field classical W fields are necessarily present. W MEs as possible realizers of the generalized motor actions of the magnetic body could induce plasma oscillations and ionic waves define also candidate for the inducers of AM patterns.

Genetic code and odors

The interpretation of AM patterns as sub-selves representing standardized mental images is natural. The average duration of these sub-selves is of 100 ms which is the duration of the memetic codeword [K41]. According to Freeman, the time dependence of AM patterns is chaotic: this does not however mean that it is random. That also time coding is involved looks plausible because both temporal and spatial patterns of nerve pulses are crucial for the neural coding of odors [**?**].

The first thing to come in mind that temporal patterns correspond to memetic code words having length of almost 127 bits ($2^{127} - 1$ patterns are possible) with bits represented by a pulse or absence of it. The presence of pulse would correspond to some minimum intensity of field. The first bit would be always 1 to signify the beginning of the codon which would give 126 bits. Also a formal representation as superpositions of Fourier components with frequencies $f_n = n/T$, $n = 1, ..., 127$ with coefficients can be considered but would not be so natural than pulse representation.

There are however objections against this identification.

1. p-Adic length scale hypothesis would predict duration of 100 ms for AM patterns representing memetic code words if.1 second time scale corresponds to the time scale assignable to electron CD. Quite wide length variation for MEs is however possible and 100 ms MEs predicted by p-adic length scale hypothesis could be interpreted as resonant MEs in this picture, ELF frequency counterparts of on mass shell particles whereas other durations would correspond to off-mass shell "virtual" MEs. This interpretation is consistent with the generalization of the ideas of Jaynes [K89, K90].

2. That memetic code could be represented also in terms of MEs conforms with the computer metaphor which suggests myriads of representations of the memetic code. On the other hand, the highest frequency involved would be of order kHz and outside EEG range. Furthermore, AM patterns should represent abstraction and classification of temporal nerve pulse patterns associated with the memetic code words. The generalization of EEG to a fractal hierarchy of EEGs allows however to circumvent the objection.

The simplest thing one can imagine is that a compression of the $2^{127} - 1$ neuronal memetic codewords to genetic code words having length of 7 bits giving 127 code words occurs: in this case the the highest frequency would be in the range $58.3 - 87.5$ Hz which relates very naturally to the EEG frequency range and is above the 40 Hz band and various lower bands related to the place coding. One can argue that just as at DNA level only the 64 mutually consistent Boolean statements amongst the $2^7 - 1 = 127$ Boolean statements are realized physically.

Genetic code could be also realized as nerve pulse patterns. This option looks natural in the case of rate coding with almost random time intervals between nerve pulses. If stochastic resonance forcing the autocorrelation function of the nerve pulse pattern to have peaks at the multiples of the forcing frequency is involved, then the number of distinguishable code words would be also around 64. Also the discrete values of the pulse rate varying from 0 to 64 pulses per.1 seconds could define genetic codons.

Magnetic representation of the genetic codewords

Genetic code for odors is consistent with the assumption that the modulation frequencies are in the range $20 - 80$ Hz. The cyclotron frequencies of all biologically important ions including DNA are above 1 kHz so that amplitude modulations at EEG frequencies are slow.

The modulated cyclotron frequencies would naturally represent carrier waves coding for some geometric data, for instance the distance of the object of perceptive field on the sensory magnetic canvas. This prediction could be tested by looking whether the attention directed to a moving object is accompanied by a shift of some cyclotron frequencies.

EEG waves with well defined frequencies would have interpretation in terms of frequency coding by sequences of "notes" whereas chaotic EEG waves such as beta waves might be assignable to the speech like representation. For "note" representation trivial code word would correspond to a mere alpha wave modulation. alpha wave begins to dominate when eyes are closed which suggests alpha wave modulation represents "no sensory input". In the case of vision alpha wave would assign the color quale black and the mental image "darkness" to the region of the perceptive field. In the

case of hearing the trivial codeword would represent the experience of silence, something different from the absence of auditory experience.

Data compression as frequency cutoff and threshold coding

Some comments about the compression process and about the plausibility of the representation of Boolean statements at the level of conscious experience are in order.

1. The compression process simply drops away the bits corresponding to the frequencies above 80 Hz. This kind of frequency cutoff is precisely what is carried out in quantum field theories when the effective action for low energy theory is constructed. For quantum field theorist this means functional integral over the frequencies and wavelengths above the cutoff frequency and cutoff wavelength. Thus brain would apply the counterpart of the same procedure as quantum field theorist or statistical physicist uses to build simplified models applying in time and length scales above the inverse of the cutoff frequency and cutoff wavelength.

2. The values of the EEG potentials need not be discrete to yield bit representation at the level of the conscious experience if magnetic quantum phase transition is induced only if the intensity of the oscillatory magnetic perturbation defined by ME is above certain threshold value. Threshold coding is actually what is expected since phase transitions should occur as a kind of domino effect. There is also an upper bound for the harmonics of the cyclotron frequency which can be amplified to a macroscopic quantum phase transition. This yields automatically frequency cutoff even in absence of a frequency cutoff for EEG waves.

10.3.2   Synchronization

Cognitive functions like perception, memory and language are based on parallel and highly distributed information processing. What brain does is the analysis of the sensory input into bits. One of the major unresolved questions of brain science is how the information these bits can be integrated to sensory percept and how coherent representational states can be established. Temporal binding has been suggested as a mechanism making this possible. The synchronized neuronal firing has been proposed as an underlying mechanism of temporal binding inside and between various cortical areas. The assemblies of neurons firing synchronously could even define neuronal correlates for objects of perceptive field. Synchrony mechanism would apply also to motor actions and allow selection of perceptually and behaviorally relevant information. Temporal binding has been proposed by Crick and Koch as a necessary and sufficient condition for the generation of conscious percepts. It however seems that 40 Hz synchrony corresponds to generation of information.

   In TGD framework the synchronously firing neuronal assemblies are excellent candidates for sub...selves. Synchrony should result from the presence of a TGD counterpart of a computer clock ticking with a frequency of order kHz associated with the memetic code.

Empirical evidence for kHz synchronization

Neuronal synchronization is by now a well established phenomenon (see [**?**] and references therein).

1. Synchronization inside and between sensory, motor and associative areas has been established. Synchronization has been observed also inside subcortical structures such as lateral geniculate nucleus, superior colliculus and brain stem and even in retina [**?**]. Synchronization has also found even between areas belonging to different hemispheres.

2. Synchronization in visual system predicts synchronization inside visual areas and between areas across large cortical distances. These predictions have been verified. For instance, two neurons fire synchronically only if they respond to the same visual object but not otherwise. It has been found that the basic criteria for the gestalt formation (such as continuity and coherent motion), shown to support by perceptual grouping, are also important for the formation of a synchrony between the neurons of the visual cortical. Synchronization has been studied also in non-visual modalities: synchronization in the olfactory systems of various vertebrate and invertebrate species has been found and both auditory and somatosensory

cortex has been demonstrated to show precise synchronization. Synchronization has been observed also in hippocampus and frontal cortex.

3. Synchronization has been observed in motor areas and between areas of sensory and motor system. For instance, the study of cats performing visuomotor tasks has shown that the synchronization between visual and parietal as well as visual and motor areas occurs in those task epochs where the animal processes attentively information to direct the required motor response.

4. Synchronization seems to serve as a neural correlate for conscious percepts [**?**]. For instance, in binocular rivalry, the neuronal activity in V1 does not change when the consciously perceived stimulus changes. However, highly synchronous firing is what distinguishes the perceived stimulus from the non-perceived one.

In TGD framework this would mean that the entanglement with magnetic body serving as the correlate for the directed attention would have synchronization as a neural correlate. The interpretation would be that without synchronization no coherent cognitive or emotional mental image is formed at the magnetic body.

Charge entanglement involving W MEs makes possible superpositions of several sensory percepts and state function reduction would select one of them. The possibility to build quantum superpositions of alternative percepts means metabolic economy since only single percept need to be realized in a given quantum parallel universe. The selection of percepts in binocular rivalry might be a basic example about state function reductions at the level of perception. Information processing resembling quantum computing could be realized using quantum superpositions of nerve pulse patterns. Same picture applies also to motor action. When a large number of similar systems (say sensory receptors) is involved, quantum statistical determinism guarantees reliable perception.

EEG and MEG studies demonstrate that high frequency components of sensory evoked potentials exhibit precise neuronal synchrony in the awake state but disappear in deep anesthesia [**?**]. A possible interpretation is that Josephson radiation at 1 kHz frequency ceases as a consequence of anesthesia. This conforms with the fact that anesthetes affect cell membrane. For instance, a phase transition changing the Planck constant associated with 1 kHz cell membranes by the action of anesthate could lead to the disappearance of 1 kHz frequency.

Also gamma (40 Hz) synchronization is enhanced during arousal and focused attention as well as during a conscious perception of distinct auditory events and of coherent visual stimuli during attentive visual search. Again the interpretation would be in terms of Josephson currents which get more intense or appear as a phase transition increasing the Planck constant by factor 4 for neuronal membranes with 10 Hz Josephson frequency. Note that 40 Hz Josephson frequency corresponds to Josephson wavelength of about 3 meters.

Dark Josephson frequencies and corresponding parts of the magnetic body scale like $r = \hbar/\hbar_0$ whereas the corresponding body parts would scale like $\sqrt{r}$. This gives the map of wavelengths to the sizes of the body parts suggested by the findings about water memory and which I have used to refer to as scaling law. Scaling law will be discussed in the last section.

Temporal binding by synchronization

The article of Engel *et al* [**?**] provides an excellent representation about the development, motivations and the recent empirical status of temporal binding by neuronal synchrony. The article contains also references to the original work and the references to the results represented below can be found from this article and are not separately mentioned.

There are many reasons why for binding by synchronization. Later also empirical evidence suggesting that synchronization accompanices only the formation of percept rather than percept itself is discussed.

1. Synchrony provides the counterpart of computer clock making possible a precise presynaptic summation of the neural inputs in turn implying fast and precise and fast neural processing. Synchrony makes also possible coordinated changes of the synaptic efficacies: this is of obvious importance for the associative learning at synaptic level. Also the robustness of neural processing is implied: army does not need single man.

2. Synchronized neuronal assemblies define natural candidates for the neural correlates of conscious percepts and synchronization might be a basic mechanism of attention.

3. The information processing in brain is known to be highly parallel and distributed: for instance, there are about 30 distinct visual areas in monkey brain. Synchronization between various sensory, motor and associative areas has been proposed as a candidate for the mechanism generating coherent gestalts.

4. Synchronization has been proposed as key element for functions like learning and short term memory. Quite generally, it seems that non-synchronized brain regions are analogous to a computer without a global computer clock and thus seats of neural chaos.

5. Synchronization has been also suggested by Crick and Koch to be a necessary and sufficient condition for conscious experience to occur. From the TGD point of view and on general philosophical grounds this hypothesis seems to be too far-fetched. Rather, synchronization seems to provide the counterpart of computer clock in TGD framework feeding order in neuronal chaos. Synchronized regions define however natural correlates for sub...selves.

What is the dynamics of volition and thought?

The proposed simplified view leaves open some fundamental questions which basically relate to how the geometric correlate of intentional action. There are two basic questions.

1. How the dynamics of thought generation is realized?

The understanding of the feedback from the sensory (real) level to the cognitive (p-adic) level is required. More precisely, how sensory (real physics) input is transformed to cognition.

p-Adic physics as physics of cognition is a fundamental key idea of TGD inspired theory of consciousness. For long time I believed that p-adic-to-real transformations of space-time sheets realized as quantum jumps could serve as correlates for the transformation of intentions to actions allow deeper understanding of also psychological time as a front of p-adic-to-real transition propagating to the direction of the geometric future. It turned out that the mathematical realization of this idea might involve unsurmountable challenges and the natural vision is based on adeles: both reals and various p-adic number fields would be present and cognition would be present already at elementary particle level as also the p-adic mass calculations suggest.

The original belief was that the transformation of real space-time sheets to p-adic l ones in quantum jump would correspond to the generation of thoughts. It is now clear that this hypothesis is both un-necessary and difficult to realize mathematically.

Rather, TGD Universe is adele meaning that both embedding space, space-time, and WCW are adelic structure containing real sector and various p-adic sectors as correlates of cognition. Real space-time sheets representing classical space-time correlates of physical events are automatically accompanied by p-adic space-time sheets defining what might be called cognitive representations. Intention in turn is part of the experience of self identified as a sequence of state function reductions at fixed boundary of CD and dying when the first state function reduction to opposite boundary occurs and gives rise to a volitional act of higher level self having self as a mental image.

2. How the dynamics of volition is realized?

The idea that negative energy MEs representing signals propagating to the geometric past represent volitional acts conforms with the ZEO based view about volitional action as state function reduction at opposite boundary of CD reversing the arrow of geometric time.

Zero energy ontology allows to formulate the notion of negative energy ME rigorously. They are space-time sheets associated with CDs for which time runs in non-standard direction. In ZEO volitional action would be in a formal sense time reversal of the sensory perception with signals initiating the action propagation in time reversed direction from magnetic body to brain and eventually to the level of motor neurons.

This idea has become rather precise after the formulation of quantum measurement theory in terms of ZEO [K59, **?**, K7]. In ZEO self corresponds to a sequence of state function reductions at fixed boundary of CD changing only the situation at the opposite boundary (in standard quantum measurement theory nothing would happen to the state). This sequence gives also rise to the

development of intention. The volitional action begins with the first state function reduction to the opposite boundary of CD and means that the sub-self (mental) images dies and reincarnates at the opposite boundary of CD. This picture leads to a simple answer to most basic questions and seems to be the correct one.

A general view about the role of synchrony

The hypothesis that synchronization is due to the presence of MEs suggests the following general view about how conscious brain functions.

1. The basic states for the various areas of brain could represent more or less chaotic neuronal activity without synchrony. During sleep primordial neuronal chaos might be realized in the scale of the entire cortex.

2. Negative energy MEs would select from the sea of cortical chaos islands of order and generate objects of perceptive field or behavior (by sensory-motor analogy one might perhaps speak of "behavioral field") realized as sub-selves. MEs would obviously feed negentropy to the neuronal primordial chaos and generate macro-temporal quantum coherence and thus sharp sub-selves lasting for a sufficiently long time to contribute significantly to the contents of consciousness and behavior (note the analogy with a social group: very short-lived member does not contribute significantly to the development of the social group).

3. The question whether there exist non-neuronal correlates for consciousness is definitely settled in this framework: they do exist and correspond to both p-adic and real charged and neutral MEs both in the sense of electro-weak and color interactions and the synchronous firing of neurons provides a direct experimental evidence for these correlates visible already at the primary sensory areas.

4. The mesoscopic feature level visible in EEG and reflecting the synchrony MEs could represent a higher abstraction level in which memetic code words are compressed to the genetic code.

This view combined with the general vision about the realization of the various representations represents a reasonably coherent vision about how magnetic body controls brain. There remains of course challenges even at the level of principle.

10.3.3 40 Hz Synchrony And Negentropic Entanglement

If one accepts the vision about life as something in the intersection of real and p-adic worlds 40 Hz EEG synchrony can be interpreted as a correlate for the generation of negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) between cortical neurons. Before proposing this interpretation let us first describe the experimental findings of a finnish neuroscientist Antti Revonsuo [**?**] challenging the simplest view about the role of 40 Hz synchrony in binding.

Findings

The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [**?**]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. There could be also some time lapse between the unified percept and the report about it but probably this cannot explain the entire lapse. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [**?**]. Note

that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [K35].

That the change in activity is associated with the emergence of a new percept suggests that the temporary increase of the EEG power could be assigned to the communications of the forming percept to the magnetic body.

Interpretation in terms of generation of negentropic entanglement

A fresh view about what really happens during 40 Hz synchrony came with the realization that negentropic entanglement is possible in the intersection of real and p-adic worlds. The generation of negentropic entanglement between two sub-selves means that the corresponding mental images are fused [K106, K59]. The process is experienced by the fusing sub-selves as an expansion of consciousness whereas consciousness is lost when when bound state entanglement is generated. Also the meditative states begin with enchanged 40 Hz activity and the interpretation would be same. Quite generally, the generation of negentropically entangled neuron groups could be a correlate for the emergence of a new idea or a new holistic pattern emerging from a chaos. Synchronous firing would be a natural correlate for the synergic state resulting in this manner. The paradoxical looking reduction of the oxiditative metabolism associated with 40 Hz firing could be seen as a signature of reduced dissipation when dissipating ensemble of neurons forms a single quantum coherent system.

What could then be the interpretation of the 300-500 ms time scale and synchronous firing in TGD framework?

1. If one assumes that only brain is involved, one must answer whether the new percept emerges after such a long time period. One would naïvely expect that negentropic entanglement immediately gives rise to the percept. Negentropic entanglement however means that a quantum superposition of several alternative percepts is involved. In the beginning the new percept is present with only small probability so that one would only know that the moment of eureka is quite near (this is indeed the experience that one has) and in the final situation it dominates but not completely since it requires conscious effort to preserve the percept.

2. Also magnetic body should be involved in TGD framework. The natural question is "Why this synchronous neuronal firing?". The natural answer would be that it allows to communicate the new percept as a consequence of a generation of negentropic entanglement to the magnetic body. The frequency scale of 40 Hz corresponds to a time scale of 25 milliseconds and corresponds to a length scale involved is about $.75 \times 10^7$ m, a good candidate for the size of the part of the magnetic body involved. This time scale is much shorter than 300-500 seconds. If the layer of the magnetic body in question corresponds to the fundamental 100 millisecond time scale assignable to electron as is natural in case of sensory percepts, the time lapse could be essentially due to the communication. If one takes the time scale literally the value of Planck constant which is about 3 to 5 larger than its standard value would suggest itself. Of course, the development of the percept from a fuzzy inkling to the final eureka could involve several communication loops between brain and magnetic body so that the interpretation as a lapse due the slowness of communications need not be inconsistent with the first interpretation.

3. The time scale 300-500 ms could characterize the duration of negentropic entanglement but this is not necessarily the case since negentropic entanglement would be un-necessary after the percept has been represented symbolically so that one knows what is lurking behind the chaos.

10.4 Stochastic Resonance And Brain

This section begins with the review of the notion of the stochastic resonance. Also its applications to neuronal systems are reviewed. With motivations coming from conceptual difficulties of the proposed neuronal models, a reduction of the stochastic resonance to the quantum level, which is assumed to control the functioning of bio-systems, is developed by refining the quantum model

for nerve pulse generation by specifying the interaction with MEs. Another key idea described in detail in [K18] is that bio-systems correspond to flow equilibria for ions in the many-sheeted space-time with atomic space-time sheets having the role of a controlled system and super-conducting space-time sheets taking the role of the controlling system. The possibility that MEs generate by stochastic resonance soliton sequences associated with Josephson currents, is discussed.

10.4.1 Stochastic Resonance

Background noise is usually seen as a mere nuisance in communications but under certain circumstances it can in fact improve, rather than hinder the performance. The notion of stochastic resonance [D26] was originally put forward by Benzi and collaborators [D19] in seminal papers where they study the problem of the periodically recurrent ice ages. The same suggestion was raised independently by C. Nicolis and G. Nicolis [D67]. The planetary glaciation sequence has a period of about 10^5 years which happens to be same as the period of the planetary gravitational perturbations with a typical time scale of 10^5 years inducing an extremely small (of about .1 per cent) periodic variation of the solar constant which as such cannot explain ice ages. The system is modelled by a bistable potential in which the two potential wells represent the ice-covered Earth and the normal climate. Short term climate fluctuations are modelled by white noise and if the intensity of the white noise is correct, the weak periodic variation of Earth's temperature is amplified to a synchronized hopping between cold and warm climates.

The notion of stochastic resonance has been considerably generalized to include a number of different mechanisms. The unifying features are the increased sensitivity to small perturbations and phase locking for an optimal noise level. Stochastic resonance like features have been reported also for autonomous systems. Also the quantum version of the stochastic resonance taking into account quantum tunnelling has been studied. Stochastic resonance has been also generalized to coupled (that is higher-dimensional) systems and to excitable systems allowing only single stable state and meta-stable states. The interested reader can find references to the rich literature about stochastic resonance in [D26].

Stochastic resonance has been verified for a wide variety of system such as Schmitt trigger, bistable ring laser, electron paramagnetic resonance, and super-conducting quantum interference devices (SQUIDs) [D26]. An especially important application is to neuronal systems [D74].

10.4.2 Basic Model For Stochastic Resonance

The archetypal model of stochastic resonance involves a one-dimensional system equivalent with a particle with mass m moving in a double potential well

$$V(x) = -ax^2/2 + bx^4/2$$

under a friction force $\gamma dx/dt$ proportional to velocity, a weak periodic external driving force $A(t) = A_0 sin(\Omega t)$, and a random force which can be modelled as a white noise $\xi(t)$ with vanishing mean and correlation function

$$\langle \xi(t_1)\xi(t_2) \rangle = 2D\delta(t_1 - t_2) \ .$$

Here the parameter D characterizes the noise level.

The noise could be also a more general colored Gaussian noise with ultraviolet frequency cutoff. The fluctuation forces cause transitions between the potential wells with a rate given by the Kramers rate [D48]:

$$r_K \quad = \quad \frac{\omega_0\omega_b}{2\pi\gamma}exp\left[-\frac{\Delta V}{D}\right] \ . \tag{10.4.1}$$

Here $\omega_0^2 = V''(\pm x_m)/m$ is square of the frequency of small oscillations at the bottom of well and $\omega_b^2 = -V''(x_b)/m$ is an analogous quantity estimated at origin which correspond to the maximum of the potential. ΔV denotes the height of the potential barrier separating the two minima.

If a periodic spatially constant force is applied to the particle, it induces a periodic variation in the shape of potential. At a given well the minimum of the potential barrier occurs periodically

with frequency Ω and if the particle hops to second well when barrier height is minimum it experiences minimum height barrier in the second well after a half period. If the white noise is such that the rate r_K is twice the frequency Ω:

$$r_K \quad = \quad 2\Omega \ , \tag{10.4.2}$$

the rate for the jumps between potential wells is synchronized with the periodic variation of the external force. One can understand this relationship intuitively on basis of the previous simple observations.

Stochastic resonance is manifested as a phase locking of $x(t)$ to the external force and as maximum of the average amplitude as function of the parameter D characterizing the noise level when the resonance condition is satisfied. In linear response theory, which is appropriate when the condition $A_0 x_m << D$ is satisfied, the approximate expressions for the average amplitude and phase shift read as

$$\overline{x} = \frac{1}{m\gamma\omega\omega_b} \frac{A_0 \langle x^2 \rangle_0}{D} \frac{2r_K}{\sqrt{4r_K^2 + \Omega^2}} \ ,$$

$$\overline{\Phi}(D) = arctan(\frac{\Omega}{2r_K}) \ . \tag{10.4.3}$$

$\langle x^2 \rangle_0$ denotes the variance for the unperturbed noisy system. The distribution of time intervals between hoppings has characteristic peaks at $T = 2\pi/\Omega$ and its integer multiples.

The phase averaged power spectral density $S(\omega)$ defined as the Fourier transform of the correlation function $\langle x(t+\tau)x(t) \rangle$

$$S(\omega) \quad = \quad \int_{-\infty}^{\infty} exp(-i\omega\tau)\langle x(t+\tau)x(t) \rangle d\tau \ , \tag{10.4.4}$$

exhibits delta peaks at frequencies $(2n+1)\Omega$ superposed to a noise background $S_N(\omega)$ whereas even multiples of Ω correspond to dips. This reflects the reflection symmetry of the double potential well. The heights of the spectral spikes behave as A_0^{2n} and since the periodic perturbation is assumed to be weak, it is possible to restrict the consideration to the first spike ($n = 1$). In the linear response theory one obtains following expressions for the noise density $S_N^0(\omega)$, total spectral density $S(\omega)$, and signal-to-noise ratio:

$$S_N^0(\omega) = 4r_K \frac{\langle x^2 \rangle_0}{\sqrt{4r_K^2 + \Omega^2}} \ ,$$

$$S(\omega) = \frac{\pi}{2}\overline{x}(D)^2 \left[\delta(\omega - \Omega) + \delta(\omega + \Omega)\right] + S_N(\omega) \ , \tag{10.4.5}$$

$$SMR \equiv 2 \left[lim_{\Delta\omega \to 0} \int_{\Omega - \Delta\omega}^{\Omega + \Delta\omega} d\omega\right] / S_N(\Omega) = \pi(\frac{A_0 x_m}{D})^2 r_K \ .$$

10.4.3 Stochastic Resonance And Neuronal Systems

During the last decade stochastic resonance has become a well accepted paradigm in the biological and neurophysiological sciences [D74]. This despite the fact that neuronal systems are excitable systems with only single stable ground state and a short-lived excited state with lifetime of order millisecond which can be short as compared to the typical driving frequency. The simplest models effectively assume that neuron is a bistable system. The most obvious functions of the stochastic resonance in neuronal systems are the amplification of weak periodic signals (such as the noise produced by a predator) and temporal coding (say in auditory nerve).

In TGD framework the natural question is whether the stochastic resonance really occurs at the neuronal level or at a deeper control level. If the latter option is correct, the simplest paradigm of bistable system might be enough to model the system.

Empirical evidence for stochastic resonance in neuronal systems

The encoding of acoustic information on the primary auditory nerve of mammals has been studied for a half century. It has been known that, in contrast to the conventional theory, the information about the frequency of the stimulus is coded also to the inter-spike distribution of the spike sequence. This correlation between neuronal input and output is known as phase locking in neurophysiology and presents one particular form of temporal coding [**?**]. It is needless to emphasize that various forms of temporal coding and its reverse process are absolutely crucial in TGD based model of qualia.

Longtin, Bulsa and Moss [**?**] observed that inter-spike interval histograms of periodically stimulated neurons of a cat exhibit a remarkable resemblance to the return time distributions of a periodically driven noisy bistable system with Gaussian noise for which correlation function decays exponentially:

$$\langle \xi(t)\xi(t') \rangle = \frac{D}{\tau_c} exp\left(-\frac{|t-t'|}{\tau_c} \right) \quad . \tag{10.4.6}$$

Return time is defined as the time for the system to be kicked from one well to another and back again. With only one fitting parameter it was possible to achieve an excellent agreement. Neuron is definitely not a bistable system and this forces to ask whether the assumption about the underlying bistable system might make sense at some deeper, controlling level.

Moss and collaborators studied also the behavior of the mechanoreceptor cell of a crayfish [**?**] by stimulating it with an input consisting of a sum of single tone and noise. The spectral properties of the action potentials were analyzed, yielding a power spectrum typified by a background noise plus sharp peaks at multiples of the frequency of the stimulus. Also signal-to-noise ratio was studied and was found to resemble the shape of the corresponding curve for a bistable system although the resonance peak as function of the noise intensity does not decrease so fast as for stochastic resonance in a bistable system.

Stochastic resonance has been demonstrated to occur also in the hair cell of cricket [**?**]. In this case the function of the stochastic resonance is to help the detection of a weak periodic signal (a coherent motion of air created by say predator) from a huge noisy background.

Models of stochastic resonance based on standard neuroscience

Several phenomenological models reproducing the stochastic resonance for inter-spike interval distributions have been proposed.

1. Neuron firing and Poissonian spike trains

The simplest model is based on the idea that neuron emits uncorrelated sharp spikes at random times [**?**] The spiking rate $r(t)$ is however sinusoidally modulated and the specification of $r(t)$ defines the model. One can express the phase averaged spectral density $S(\omega)$ for the spike train as a sum of frequency independent white noise term $\bar{r}$ and sum of delta peaks at frequencies $\omega = n\Omega$:

$$S(\omega) = \bar{r} + 2\pi \sum_{n=1}^{\infty} |r_n|^2 \delta(\omega - n\Omega) \quad ,$$

$$r_n = \frac{1}{T} \int_0^T r(t) exp(-in\Omega t) dt \quad . \tag{10.4.7}$$

The rate theory for noise-induced barrier crossing in the presence of a periodic external force suggest the generalization of the Kramers rate formula for the hopping rate r_D between potential wells to

$$r(t) = \nu \times exp\left[-\frac{\Delta V}{D} - \frac{A_0 x_m}{D} cos(\Omega t) \right] \quad . \tag{10.4.8}$$

Here ΔV is the barrier height in absence of forcing, D is noise strength, A_0 is the amplitude of the periodic driving force, and the scale factor x_m characterizes the position of the potential well. The

pre-factor ν depends on the details of the process. This formula should make sense for sufficiently low frequencies Ω (adiabatic approximation).

By calculating the Fourier transform of $r(t)$ one obtains for the signal to noise ratio defined as the ratio

$$SNR = \frac{2\pi r_1^2}{\bar{r}} \simeq \frac{\pi x_m^2 A_0^2}{D^2} exp\left(-\frac{\Delta V}{D}\right) \quad . \tag{10.4.9}$$

Signal-to-noise ratio shows a behavior characteristic for stochastic resonance. The comparison with the data from the mechanically modulated mechanoreceptors of a crayfish shows qualitative agreement with this prediction although the decrease of SNR for large noise levels is overestimated by this model. The parameterization of $r(t)$ is based on the assumption that system is effectively bistable: this is of course not true at the neuronal level.

3. Integrate and fire model

Integrate and fire model assumes that the input of the neuron consists of a spike train $i(t)$ (cortical neurons) or a continuous signal (sensory neurons) [D26], [?]. The membrane voltage $u(t)$ is obtained by integrating the input $i(t)$ represented as a current through the membrane. By representing cell membrane as a capacitance C and resistance R the equation of motion for the membrane potential reads as

$$\frac{d}{dt}u = -\frac{1}{\tau_{RC}}u + \frac{i(t)}{C} + \frac{\xi(t)}{C} \quad . \tag{10.4.10}$$

Here one has $\tau_{RC} = RC$. Gaussian white noise with a zero mean is assumed. In the case of a perfect integrator ($1/RC = 0$) the Fokker Planck equation for the probability distribution for the potential values as a function of time reads as

$$\frac{\partial P(u,t)}{\partial t} = -\left[i_0 + A_0 cos(\Omega t)\right]\frac{\partial P(u,t)}{\partial u} + D\frac{\partial^2 P(u,t)}{\partial u^2} \quad . \tag{10.4.11}$$

The equation states that probability is conserved for the flow in the phase space defined by u and velocity variable $\partial_t u$. Initial values are $P(u = b, t) = 0$ at threshold stating that particle is absorbed at $u = b$. The rate for crossing is given by $r(t) = dP(u = b, t)/dt$.

The distribution function for the inter-spike intervals is given by the mean-first-passage time distribution ρ which is essentially the probability $P(b \to b)$ that the random walk in the external driving force leads from the point $u = b$ representing the threshold for nerve pulse generation ends up for the first time back to $u = b$. This probability can be calculated using Wiener integral for a particle performing random walk in the external force field defined by the periodic perturbation at the half-line $u \geq b$. The first passage distribution shows a multi-peaked structure with higher peaks suppressed exponentially. For a sufficiently large stimulus the peaks are located at $t_n = nT$, $T = 2\pi/\Omega$. The heights of the peaks decay exponentially. The peaks heights run through a maximum as a function of the noise strength D.

This model is unrealistic for several reasons. For instance, the phase of the sinusoidal stimulus is reset after every spike so that the coherence of the stimulus is eliminated.

4. Neuron firing and threshold crossing

One can improve the integrate and fire model by allowing the resistance to be finite and modify it by assuming that the phase, rather than being reset, does not change at all in the emission of a nerve pulse [D26], [?]. One can solve $u(t)$ from the previous equation in absence of the noise explicitly by assuming that the amplitude of the driving force is so small that the threshold is not crossed in the absence of the noise. This gives at large values of time

$$u_\infty(t) = i_0 R + \frac{A_0 R}{1 + \Omega^2 \tau_{RC}^2}sin(\Omega t - \phi_{RC}) \quad . \tag{10.4.12}$$

Here one has $tan(\phi_{RC}) = \Omega/t_{RC}$. The presence of the ohmic current induces the reduction of the threshold to $b - i_0 R$. Gaussian colored noise is assumed to cause the crossing and the generation of the nerve pulse, which is for simplicity idealized with a delta peak.

The problem of calculating the rate for the threshold crossing can be formulated mathematically as a random walk on half line $u \geq b$ in presence of an external force using a semiclassical approximation for the Wiener integral over all paths. This means a functional integration over small perturbations of an unperturbed solution to give the probability $P(t)$ that an arbitrary path of the particle leads to the threshold $u = b$ during time interval t. The rate $r(t)$ for the threshold crossing is given as $r(t) = dP(t)/dt$. In [**?**] $r(t)$ the threshold crossing rate is estimated for a colored Gaussian noise and one finds stochastic resonance also now. The formulas are not reproduced here: the interested reader can find them in [D26].

This model effectively assumes that the membrane potential is driven by an external driving force and that the phase of the membrane potential is not appreciably affected by the emission of the spikes. This is consistent with the idea that there is some deeper control mechanism giving rise to the stochastic resonance and that neural level is only the controlled level.

10.4.4 How Neuronal Stochastic Resonance Could Be Realized At Quantum Level?

There is no doubt that neuronal systems exhibit stochastic resonance. The excellent fit of the inter-spike interval distribution by a return time distribution for a bistable system in the case of the auditory nerve of a cat suggests that genuine bistable system might be somehow involved. It is however not at all clear whether it is possible to understand the emergence of the stochastic resonance without leaving the framework of the standard Hodgkin-Huxley theory.

1. Neuronal systems are excitable media rather than bistable systems and it is not at all obvious whether excitable media allow stochastic resonance.

2. The time scale for the return of a neuron to the resting state is of order milliseconds and can be much shorter than the period of the driving external force. Thus the intuitive picture behind stochastic resonance need not make sense at neuronal level. Perhaps one should turn the attention to a more fundamental level, and interpret nerve pulse activity as a result of quantum control with the bistable system to be identified acting as a control system.

The previous model for sensory receptor applied to hearing suggests that perhaps a plausible model of stochastic resonance could be obtained by including besides neurons also a system able to represent sensory input as evoked potentials giving rise to cognitive and/or emotional representations in the manner discussed. This system could be sensory receptor such has hair cell or an aggregate of glial cells (the possible role of astrocytes for brain functioning has been discussed earlier in [K48]).

As found, periodic signal and white noise affecting bistable system are the key factors in the stochastic resonance. Astrocytes would induce the spiking of nearby neurons whereas spike activity and/or microtubular input would generate perturbations of the astrocyte membrane potential which might perhaps allow idealization as white noise. In the case of sensory receptor the source of white noise could be neuronal and/or microtubular back projection.

The basic prediction is that the frequency of the stochastic resonance has an exponential sensitivity to $1/D$, where D characterizes the intensity of the white noise assumed to be generated by the neural activity. The noise level should correlate with the average firing rate if neurons are responsible for the white noise. Also microtubular white noise could be induced by the neuronal firing. The intensity of the white noise should be under automatic or conscious control so that important frequencies could be spotted out from the sensory input by "tuning to the correct wavelength" by varying the level of (possibly neural) noise. The reduction of the resting potential generates higher level of spontaneous firing so that the level of alertness would correlate directly with the value of the spotted frequency for neural noise option.

In the case of sensory organ the oscillatory signal would be contained in the sensory input represented as an evoked potential. In the case of astrocytes the oscillatory signal would be contained to the sensory signal mediated by microtubuli inducing oscillating evoked membrane

potentials V. For hearing V could represent electric counterpart of a sound wave with a well-defined frequency. V would modulate Josephson frequency since it would appear as an additive component in membrane potential besides membrane voltage.

Stochastic resonance should transform a frequency associated with the sensory input V to a peak frequency in the autocorrelation function for spikes so that spike interval distribution would reflect the frequency of the sensory input and its harmonics. For sound frequencies sufficiently below kHz this is easy to understand since the membrane potential oscillates in the same rhythm as the sound wave. Above kHz frequency rate coding does not make sense.

If neuron is Josephson junction it could serve as a system allowing bistability and stochastic resonance. Josephson junctions are indeed known to allow stochastic resonance [D16] but this situation applies to small oscillations of the phase difference Φ over the junction with regions $\Phi > 0$ and $\Phi < 0$ identified as the analogs of the two potential wells. The two state should correspond to firing and non-firing states of the neuron and the model for nerve pulse and EEG identifies the resting state as a state in which Josephson junction is mathematically analogous to a rotating pendulum but with so low a rotation velocity that small reduction of the rotation velocity leads to an oscillation mode. The reduction of membrane potential below the critical value for nerve pulse generation would reduce the rotation velocity and would reduce the rotation to oscillation and induce nerve pulse. The return to the original state would be automatic. The transition between the two states (no firing induced or firing induced) would be induced by the neuronal noise with Kramer rate equal to two times the frequency of the periodic stimulation.

Astrocyte system could control the level of the neural noise acting like a listener of the radio turning the knob to find the station. The position of knob would be replaced with the level of the neural noise. A feedback loop between the two systems would make possible to find the optimal noise level. Glutamine-glutamate cycle for astrocyte-neuron interaction could make this system possible.

10.5 Temporal Codings

An impressive evidence exists for the temporal coding [**?**] despite the fact that the dominant view has for long time been that rate coding is all that is involved. The vision about MEs as quantum holograms suggests that nerve pulse patterns are coded to the pulse patterns of the light-like current along ME. The hierarchy of Planck constants and the model of EEG in terms of Josephson radiation suggests a quite precise realization for the brain as orchestra metaphor with frequency modulation used as the basic tool to represent information.

10.5.1 Basic Structure Of EEG In TGD Framework

It is known that EEG decomposes to sum of two parts: the part consisting of relatively few fundamental frequencies and their harmonics and the quasi-continuous part, "noise". Both the amplitudes of harmonics and fundamental frequencies fluctuate.

Josephson current of particular ion is proportional to $sin(Q_{eff} \int (V_0 + V_1 + V_{noise})dt)$, V represents fundamental frequency, V_1 to spike contribution, and V_{noise} to the neural noise. The current and thus also Josephson radiation can be decomposed by basic trigonometric formula to the sum

$$sin[Q_{eff} \int (V_0 + V_1)dt] \times cos[Q_{eff} \int V_{noise}dt] + cos[Q_{eff} \int (V_0 + V_1)dt] \times sin[Q_{eff} \int V_{noise})dt] \ .$$

The integral over the noise is small so that one has $cos[Q_{eff} \int V_{noise}dt] \simeq 1$ and $sin[Q_{eff} \int V_{noise}dt] \simeq Q_{eff} \int V_{noise}dt$ giving a representation which might be consistent with the observations.

What is new that the noise level is amplitude modulated. If the frequency of the stimulus is high as compared to the Josephson frequency, the neuron automatically performs variation of the noise level in order to find ideal noise level for stochastic resonance during the period. This is like automaticized periodic turning of the knob back and forth to identify the correct wave length.

The fluctuation of the frequencies would be due to the fluctuation of the membrane potentials and the fluctuation of the amplitudes due to the intensity of Josephson currents.

Due to the fact that the neuronal membrane is near to the threshold for firing the treatment of the noise as something small is justified only if the amplitude of the noise remains low enough. Indeed, stochastic resonance becomes possible and leads to neuronal firing in the rhythm defined by external perturbation.

10.5.2 TGD Based Overall View About Temporal Codings

The following is a summary about TGD inspired attempt to build an overall view about temporal codings.

Brain as orchestra metaphor

1. The prevailing neuro-scientific view is that the resonance frequencies of EEG can be assigned to resonances in neural circuits. In TGD inspired picture nerve circuits are not necessary and there are reasons to believe that this kind of resonances are too wide to explain kHz resonances frequency or even sharp EEG resonances. Rather, EEG frequencies are reduced to Josephson frequencies assignable to the effective cell membrane potential and are proportional to the membrane potential. The energies of corresponding dark photons are in visible and UV range and their decay gives rise to either EEG photons or bio-photons. The spectrum of frequencies is dictated by the spectrum of the preferred Planck constants and the scale of spectrum depends on ion and value of membrane potential.

   Singing whale provides a good metaphor for how EEG codes for the information carried by neuronal activity since the small perturbations of the membrane potential and even nerve pulse induce frequency modulation of the fundamental frequency. Depending on the character of perturbation the situation corresponds to singing or speech (when recorded speech is represented slowly it becomes clear that also now frequency modulation is involved). If preferred Planck constants come as powers of to dictated by Mersenne hypothesis then also brain as orchestra metaphor becomes surprisingly precise.

2. The interference of perturbations of the membrane potential from presynaptic cells means that membrane potentials are summed up so that rate coding is only partial description and it is indeed known that emotional aspects of speech cannot be produced using only this information. At the level of brain an attractive hypothesis is that the signals from neurons are transferred to glial cells as small perturbations and communicated to the magnetic body therefrom.

   "Note" and "phoneme" representations (song and speech) defining emotional and cognitive representations would be realized as temporal patterns of evoked potentials at the level of sensory receptors and glial cells. Genetic or even memetic code could be realized in case of speech like representations. The hierarchy of Planck constants allows very complex hierarchy of frequency modulations induced by the interaction of nearby neurons and glial cells and by spike activity. The aggregates of glial cells could be in the role of highest level in the representational hierarchy. Orchestras have soloists and one can wonder whether soloists are now analogs of Grandma neurons or groups of neurons or glial cells producing especially intricate frequency modulation patterns. Features include also spatial modulation patterns.

4. That neural transmitters and modulators control resonance frequencies in neural circuits is also a natural hypothesis in neuroscience context. In TGD framework neural transmitters and modulators can affect average firing rates and also the intensity of neural activity by controlling the resting value of the membrane potential and sensitivity for the firing. Glial cells might also participate on this control in accordance with idea that they take the role of conductor.

Codings

Several kinds of codings reducing basically to frequency modulation can be considered and also here orchestra metaphor helps to imagine various options. First kind of could would rely on nerve pulse patterns and the perturbations induced by these.

1. The cortical representation of audible frequencies above 1 kHz requires representations using evoked potentials of glial cells and the transfer of sensory input as Josephson radiation along sensory pathway and/or as acoustic/electric oscillations of microtubuli to the glial cells is a necessary prerequisite of this representation. The cortical feedback via outer hair cells expands the audible frequencies above 1 kHz in the case of mammals and makes possible the representations of EEG frequencies as frequency modulations of the Josephson frequencies for the aggregates of glial cells. This representation would emerge in frontal lobes.

2. Also the coding of (say sound) frequencies based on spike interval statistics is supported by experimental findings and is possible for frequencies below 1 kHz. This representation might be induced from the above discussed representation at the level of glial aggregates and sensory receptors via stochastic resonance. Periodic signal and white noise affecting bistable system are basic elements of stochastic resonance. Astrocytes induce the spiking of nearby neurons whereas neuronal noise affects astrocytes. Suppose that astrocytes receive also sensory signals mediated by microtubuli inducing oscillating evoked membrane potentials V of astrocytes.

   Stochastic resonance would transform V to a peak frequency in the autocorrelation function for spikes. Glutamine-glutamate cycle for astrocyte-neuron interaction could define the neuron-astrocyte interaction with astrocytes taking the role of radio listener tuning the neurons to a specified wavelength by using the level of noise as a knob.

3. Rate coding defines the roughest coding and would relate to the perturbations of resting potentials of glial cells induced by spike patterns. For the rate conding the temporal pattern of spikes does not matter.

4. The proposal that nerve pulse patterns could realize genetic or even memetic code is one of the earliest TGD inspired conjectures. The time scales of CDs assignable to electron and d quark provide additional support for this idea. In the proposed framework the realization would be in terms of frequency modulation patterns induced by spikes and in principle could realize genetic code by allowing maximum flexibility. 10 Hz alpha rhythm would specify uniquely the time intervals containing the genetic codons. The discrete value of the firing rate expressed as the number of spikes per period of 10 Hz alpha wave would realize genetic codon as an integer $n \leq 63$. One can however argue that memetic code looks somewhat too rigid a representation to be used by a musician.

   The hint about what might be involved comes from the fact that music is also recorded and nowadays the recordings are digital. Millisecond and 100 ms time scales characterizing nerve pulse activity and features correspond to the standard value of $\hbar_0$. Maybe genetic and memetic code representations result via the interaction between large $\hbar$ space-time sheets with space-time sheets with the same time scale of CD but different Planck constant and p-adic prime. $\hbar_0$ space-time sheets would represent the lowest level of this interaction hierarchy. Mersenne hypothesis indeed relies on this interaction transforming dark weak bosons to their lighter counterparts with a lower value of Planck constant. This interaction would produce something analogous to a binary representation of music piece as a CD able to regenerate to the original experience to some degree and might be of special relevance for long term memory and cognition. The model for the sensory receptor provides a concrete representation for how this transformation could take place [K35].

Objections against temporal coding can be circumvented in TGD framework

There are several objections against temporal coding which all involve in an essential manner the relationship between subjective and geometric time. If t=constant snapshot represents the reality, as believed in standard quantum physics, the inclusion of frequencies and temporal patterns does not make sense except phenomenologically. In TGD approach the problem disappears since quantum states are quantum histories. The quantum jump sequence represented by a nerve pulse pattern corresponds to subjective time development as hopping between geometric time developments characterized by EEG patterns. Each nerve pulse affects slightly the EEG pattern.

This raises the question whether EEG record represents the EEG spectrum associated with the space-time surface generated in the last quantum jump or whether it is some kind of an average

over the EEG spectra over quantum jumps. If the recording of EEG is completely automatic process, it is updated in every quantum jump and represents EEG at the space-time surface generated in the last quantum jump and, rather paradoxically, is therefore changing all the subjective time. The experiments of Radin and Bierman support this view [**?**]. Also the experiments related to the timing in active aspects of consciousness suggest that the EEG of the past changes in the interval which is a considerable fraction of second [**?**] and long time scale compared to the millisecond time scale of nerve pulse patterns.

10.5.3 As If Time Really Mattered

Not only physics, but also neuroscience is plagued by the tensions caused by the erratic identification of the subjective time with the geometric time. There are two views about how nerve pulses patterns code for the sensory data. The first, and still dominating, view is that firing frequency codes for the intensity of the sensory experience. Competing view is that temporal patterns of nerve pulses code for the sensory information (fore a review see [**?**]).

In TGD framework first approach can be seen as emphasizing the dynamics with respect to subjective time whereas temporal patterns with respect to geometric time are neglected. Both memetic code and spectroscopy of consciousness rely crucially on temporal patterns with respect to geometric time. Hence these approaches are in conflict with the standard view about time. The approach based on temporal coding in the framework of the classical field theory forgets the dynamics with respect to subjective time and concentrates on the dynamics with respect to the geometric time. One however ends up with philosophical paradoxes circulating around time-frequency uncertainty relation: it is difficult to understand how communication is possible at all in deterministic classical world.

Quantum jumps between quantum histories view fuses both of these approaches to a more general unified description. The excellent review article "As if time really mattered: Temporal strategies for neural coding of sensory information" by Peter Cariani about temporal coding will be referred to several times in the following discussion. This article also reviews the difficult problems of frequency coding approach [**?**].

10.5.4 Rate Coding Contra Temporal Coding

Rate coding is the dominating view about the representation of the sensory data in neuroscience and most neural net models rely on this approach. The approach is based on three assumptions.

1. Rate coding is the whole story: the average rate of firing defined by an interval with duration of ten to few hundred milliseconds codes the intensity of the sensory input.

2. Everything is ultimately coded into spatial patterns and spatial rate differences somehow code all relevant sensory information. The standard coding relies on rate-place scheme: average firing rate increases along one-dimensional axis. In TGD this hypothesis is generalized in the sense that brain is assumed to build miniature virtual world model of the space-time and that magnetic transition frequencies code for the values of the spatial and temporal coordinates.

3. A further element is connectionism: in some manner the architecture of the neural pathways gives rise to qualia associated with it.

Geometric time is completely absent from rate-coding based model of brain. This is what mere quantum statistical determinism neglecting the notion of quantum history and the physics of the classical em fields associated with them would leads to. In particular, EEG is mere epiphenomenon in this approach. What makes the situation so problematic is that neural net models describing information as purely spatial patterns can always reproduce the observed behavioral patterns by brute force by introducing a sufficiently complex neural network. From modelling perspective this might be nice but need not have anything to do with how Nature does it. The situation has been however changing during the last decade. The observations about the correlations of EEG patterns with conscious experience, the successes of neurofeedback [**?**], the realization of the potential importance of 40 Hz coherent oscillations in binding, and a rigorous experimental

proof for the temporal coding of odors [**?**], are forcing the view about brain as a system in which classical em fields are important.

Temporal coding provides alternative and much more general approach but, as already noticed, has also its problems which relate to the fundamental confusions about the relationship between geometric and subjective time. There is empirical evidence for the occurrence of temporal coding in virtually every sensory system [**?**] . One can imagine many temporal coding mechanisms but the most important ones rely on spike interval statistics and latency-place representations.

Temporal coding provides solutions to the three basic difficulties of the rate coding paradigm: contrast degradation problem, pattern recognition problem and multiple object problem or "superposition catastrophe". Contrast degradation implied by the saturation of the firing rates at high stimulus intensities. Good example of pattern recognition problem is related to the perception of pitch. Same pitch can be generated in very many ways: by monochromatic sound; by a sequence of clicks; or even by a superposition of multiples of fundamental frequency not involving the fundamental frequency itself as in the case of periodic pitch phenomenon. It is very difficult to understand how the stimulus coded to a spatial representation based on mere firing rates could even contain the information needed to decode the pitch. For temporal coding these problems are almost trivial [**?**]. Superposition catastrophe is identity problem for different objects of perceptive field. For instance, how it is possible to identify the sound of a familiar person in large crowd of people or distinguish transparent object from a nontransparent one, and how it is possible to group sensory inputs to form objects of perceptive field? In temporal coding approach common temporal structures allow to define objects of perceptive field: for instance, points of perceptive field moving in the same direction or behaving synchronously belong to the same object.

10.5.5   Spike-Statistics Coding In TGD Framework

The idea about temporal coding by spike-interval distributions or by some other distribution of time scales associated with the nerve pulse patterns (say intervals between spike bursts) resonates strongly with the spectroscopy of consciousness idea.

Spike-interval statistics and EEG

Spike interval statistics is rather successful. For instance, the information provided by single nerve fiber is enough to reproduce recognizable speech. The correlation of EEG with contents of consciousness experience could be understood by the effect of spike sequences on EEG waves. In the standard framework EEG waves are assumed to be excited by neuronal loops at subcortical level.

Several experiments described in [**?**] however suggest that spike-interval coding could occur also at subcortical level which supports the view that the necessary information is present already at the level of sensory receptors as indeed assumed in TGD inspired model. In TGD framework nerve pulse patterns would stimulate frequency modulations of EEG waves with frequencies identified as Josephson frequencies and since EEG waves transfer information about sensory data to the magnetic body, the success of the spike interval statistics can be understood.

Multiplexing and broadcasting

Multiplexing means the possibility of transmitting several messages simultaneously as superpositions of different harmonics. In TGD context this means frequency modulations coming as superpositions of this kind and are coded to the EEG waves directly. In the case of small oscillatory perturbations one can apply the product formula to the Josephson current to obtain an approximate linear superposition at the level of Josephson current.

Josephson radiation should affect also neurons and glial cells - in particular regeneration of sensory quale could be possible [K35] - and the attractive possibility is that resonance like situation occurs when the period of the oscillatory perturbation co-incides with the average Josephson frequency of the receiving cell and leads to a selection of only this particular contribution from the signal.

This mechanism makes also possible broadcasting is possible: the same message or superposition of messages can be send as Josephson radiation propagating along axonal flux tubes or

larger flux quanta at which axonal flux tubes are topologically condensed. This allows mass communications and depending on Josephson frequency of receiving cell, only part of the message is received.

This kind of communication mechanism -if it involves radiation at larger space-time sheets-would provide a mass media type communication mechanism depending only weakly on the connectivity of the neural circuitry. Brain as a neuron society metaphor indeed supports the view that besides neural chatting also mass communications are important. In particular, mass communications might be involved with the synchronous firing of the neuron groups. Combined with the possibility of simultaneous superposition of various data in EEG pattern, broadcasting mechanism replaces the rather poorly defined problem of computing the representation of the external world from spatial firing rate patterns by direct experiencing. The computational problem is transformed to understanding how experience of, say, motion is represented by magnetic quantum phase transitions. Of course, the very assumption that computation gives rise to conscious experience is completely ad-hoc hypothesis.

The role of transmitters and modulators in generating correct EEG frequencies?

The recovery periods for neurons vary from milliseconds to seconds. Recovery time can be affected by neurotransmitters as well as neuro-modulators. Many axons [?] show triphasic recovery period consisting of refractory period, super-excitable phase and depression phase. Clearly, neuron favors inter-spike intervals for which the next spike arrives in neuron during super-excitable phase. Many-levelled hierarchy of neuronal pathways could thus serve as a sequence of sieves selecting preferred frequencies. Emotions are known to affect strongly the information processing in brain but not to alter the information content and peptides as molecules of emotion expresses the importance of these molecules as correlates of the emotional state.

Josephson radiation is absent during recovery period. During the refractory period the Josephson frequency would be higher, during refractory period low, and depression phase presumably higher again. This would allow to code information about the state of the neuron in terms of the pitch of the neuronal song.

Neurotransmitters and neuro-modulators control among other things the value of the resting potential. Besides small scalings of the resting potential also phase transitions changing the value of Planck constant and leading to a new octave could take place. Neither of these changes afffects the information but could code for the emotional state. For instance, alpha and 40 Hz bands could relate by this kind of scaling and the TGD inspired model for EEG during sleep assumes that a phase transition increasing the value of Planck constant by a factor of two occurs twice [K35]. It is known that "hippocampal theta frequency" varies in wide limits [?] and that its value correlates with the state of arousal [?]. This could be due to both $\hbar$ changing phase transitions and smooth change of the resting potential.

Resonant generation of complex motor activities?

There is also the fascinating possibility that a characteristic EEG pattern induces complex self-organization patterns giving rise to the basic building blocks of motor actions or even patterns of them. If this is really the case, then characteristic EEG patterns could serve as names for self-organization processes. This idea is of course not new and is expressed eloquently already by Ernst Mach [?] .

Multiplexing and mass communications based on the selective receival by resonance mechanism indeed makes possible for single temporal pattern to carry very complex superposition of EEG frequencies with each frequency coding for a particular spatiotemporal position in the virtual world of brain and exciting neuron in that particular position and leading to to a generation of a complex spatiotemporal pattern amplified to motor action by puppet in string mechanism.

10.5.6   Applications Of Spike Interval Coding

Spike interval statistics codes information in the temporal pattern. This information can be information about the temporal or spatial pattern of the sensory stimulus (audition, vibratory sense)

or about the non-geometric quale (this might be the case in the case of color vision, tastes and odors).

Empirical data support following type of spike-interval coding. The dominating time interval ΔT in the spike sequence codes for the heard frequency below kHz: $f = 1/\Delta T$ in the case of audition. The intensity of experience is measured by the ratio of the power in dominant interval to the power in non-dominant intervals [**?**]. This relationship holds true generally. This code gives frequency coding by averaging.

The nice feature of temporal coding mechanism is the possibility of multiplex coding: same nerve pulse pattern can contain simultaneously several messages represented by spike patterns which are mutually orthogonal with respect to the inner product defined by Fourier transform. For instance, information about color, shape and temporal pattern of illumination might be coded as a superposition of nerve pulse patterns. In the following some well established examples about this mechanism [**?**] are discussed.

Hearing

Hearing involves both spatial coding of frequencies in the sense that special points of cochlea are especially sensitive to frequencies around the center frequency. This is not however the whole story. Rather, it would seem that this frequency serves only as a carrier frequency for amplitude modulated messages generated by the pattern of nerve pulses. The spike sequences for nerve fibers specialized to a given center frequency contain spike intervals which code for various qualities of sound like pitch, timbre and phonemic identity. Rather remarkably, the spike distribution of single nerve fiber contains enough information about speech to make possible speech recognition [**?**] .

One problem related to the pitch quale is that nerve pulse rates are able to code only for the frequencies considerably below kHz and one must understand the coding of frequencies above kHz. Coding of the frequency by the modulation frequency of Josephson radiation provides a solution to the problem. One could even assume that there is a resonance in the sense that the modulation frequency of the frequency equals to the frequency itself [K79] so that the Josephson current decomposes into harmonics of the fundamental frequency. This would mean that EEG patterns would be analogous to harmonics sounds produced by music instruments. Of course, also non-harmonic sounds can be considered.

In the phenomenon of periodic pitch superposition of the harmonics of fundamental frequency, which is not itself present in the superposition, generates experience of pitch at the fundamental frequency. Periodic pitch has also visual counterpart which can be understood as coding of the visual textures along lines to temporal patterns by scanning. Periodic pitch can be understood if one assumes coding of the temporal patterns to spike patterns. The point is that any superposition of Fourier components not containing constant term is periodic function with a period determined by the fundamental frequency and must have at least one zero in the period since the integral of this function vanishes and must therefore change its sign at least once in the period. Thus sensory stimulus vanishes at least once during the period which means that threshold crossing occurs periodically and generates spike train. This periodicity in turn implies that also EEG contains the fundamental frequency.

In TGD framework also the feedback from cortex via outer hair cells to the inner hair cells is needed to generate fundamental frequency as an artificial auditory input.

Two visual/auditory/tactile stimuli are experienced as separate if the time interval between them is longer than 25 ms/.01 ms/5 ms. For hearing the time interval is by a factor 1/100 shorter than the millisecond time scale of nerve pulse which suggests that nerve pulse patterns cannot code for the high frequency part of the auditory stimulus. The representations of the auditory stimulus as evoked potentials at hair cells and glial cells inducing frequency modulations of Josephson frequencies would resolve the problem.

One cannot avoid the temptation to understand these time scales in the framework provided by Mersenne hypothesis involving the Planck constants $r = 2^{k_d}$ with preferred values of k_d and the time scale hierarchy assignable to CDs. 25 ms corresponds to the CD time scale (secondary p-adic time scale) $T(125)$, 6.25 ms corresponds to $T(123)$ and to the time scale of CD assignable to u quark and .012 ms to $T(112)$. The values of k_d for these scales come from $T(k_d) = 2^{k_2} 1/f(2 \ eV)$ are $k_d \in \{45, 43, 35\}$. They are all odd whereas the allowed values of k_d are even for the most stringent form of the Mersenne hypothesis. The corresponding p-adic length scales are 5.12 m,

2.56 m, and 32 cm, which corresponds to the size scale of head.

Tactile senses

Humans can perceive vibrations applied to skin in the range $5 - 1000$ Hz. The so called rapidly adapting receptors code for 5-100 Hz frequency range whereas Pacinian corpuscle receptors code for 30-1000 Hz. There is evidence that this ability relies on or at least involves spike statistics coding. The temporal patterns of the vibratory stimulus are evident in the temporal discharge patterns of all units at all stations in the ascending somatosensory pathway. In TGD framework the spike patterns would reflect the deeper coding in terms of glial evoked potential patterns.

It is known that the ordering of the inter-spike intervals is disrupted by jitter along neural pathway to cortex. Note that the loss of information about temporal ordering is not important for our sensory experience which is temporal average over quantum jumps over time interval of at least .1 seconds as suggested by the fact that temporal resolution of sensory experience is about .1 seconds. If the time separation between visual, auditory, or tactile stimuli is above 20 ms, their temporal ordering can be perceived correctly. It could be however that the reaction to the sensory input is associated with some lower level self and that at our level averaging over longer time scale occurs.

Spike interval codes has also been reported for pain, touch, temperature and nociception (for more details and references see [**?**]). These modalities are highly emotional which suggests that the temporal interference patterns of Josephson radiation code for the emotional content.

Chemical senses

Odor discrimination relies on spatiotemporal coding of odors [**?**]. The facts about olfaction and gustation does not fit well with the hypothesis that connection structure of the neural pathway somehow codes for the quale. This hypothesis requires that the connection structure should be more or less static. Both taste buds and olfactory neurons have limited lifespans. Cells of taste bud move from center to boundary during the life cycles and are innervated by different axons during their life cycle. In TGD framework these problems disappear.

Taste discrimination experiments [**?**] have demonstrated that electrical stimulation using the spike patterns stimulated by odorant reproduce the emotional expressions following the perception of the real odor. When temporal pattern is changed by keeping the firing rate same, emotional response disappears. This is consistent with the assumption that "emotional" representations experienced by us are realized at the level of glial cells and that neuronal spike patterns are enough to excite the frequencies involve with these representations. Second type experiments demonstrate that electrical stimulation of an individual taste bud generates taste experience. This would suggest that the frequency giving rise to taste quale is excited automatically by the sensory stimulus and that each cell of taste bud generates it own primary taste.

Vision

In the case of vision there is psychophysical evidence for the temporal coding of color, texture and form. Color sensations can be produced using achromatic temporal patterns. Any color can be induced by the appropriate pattern of luminal changes. Benham's top is a famous device used to achieve this [J6]. Also electric stimulation of retina can directly induce color sensations. In TGD framework the color sensation in the case of Benham's top should result from the back projection from glial cells to the sensory receptors induced by the achromatic temporal pattern communicated to glial cells and would involve genuine generation of photons which could be also dark photons. The stimulation would take place by dark photons with energies in visible region but frequencies much lower than those of ordinary visible photons: 80 Hz frequency associated with retina is a good candidate for this frequency (this frequency corresponds to a dark p-adic length scale of 1.8 m).

Also ordinary visible photons could be transformed to dark photons before the arrival to the photoreceptors. It is known that photoreceptors are obscured by three or four coats of neurons. This has been traditionally represented as an example of not so intelligent design. One should be however rather cautious before making this kind of statements. It has turned out that these cells act as optical fibres [**?**]. One can however still wonder why this complex manouvre is needed.

The possible answer is that in this manner communications from both brain and external world to retina are optimized. Optic fibres could also induce the leakage of these photons to dark space-time sheets.

In TGD framework color qualia could be seen as coding spatial gradients of the illumination at a particular wavelength (in consistency with the color constancy phenomenon) to subjective experience. The saccadic motion of the eye would code a spatial change in the illumination to a subjecto-temporal gradient represented by the increments of appropriate color quantum numbers in quantum jump. This phenomenon is related to the color sensations stimulated by suitable frequency patterns of achromatic illumination [**?**]. What would happen that some colors present in the achromatic illumination would be amplified more than others. How precisely the coding of spatial illumination gradients to color qualia occurs is a challenge for TGD approach but it seems obvious that classical color gauge fields accompanying always classical electromagnetic fields must be an essential element of this coding.

Scanning and saccadic motion suggests itself as a fundamental mechanism generating at neuronal level temporal maps of the surface texture. Each line of the perceptive field scanned by the saccadic motion could give rise to spikes at those moments when the line is crossed by the saccadic line. Neighboring neurons would in turn code the direction of the line to the direction of a line in space-time-plane: line would be like space-time orbit of particle. There is empirical evidence for multiplex coding of information about visual form and color (for more detail and references see [**?**]). Also information about changing illumination seems to be coded into spike-statistics.

10.5.7 Latency-Place Representations

Latency-place representations use relative time-of-arrival differences to code information about the intensity of the sensory stimulus. Since latency typically decreases with intensity, the contrast degradation problem is circumvented. As absolute latencies decrease, so do the variances of latency distributions. Latency differences can be amplified more centrally by lateral inhibition since the impulses can excite inhibitory units which can inhibit regions surrounding the region with the shortest latency. This mechanism might be involved with the generation of space-time sheets representing objects of perceptive field. Variants of the latency-place representation can be involved with vision (motion perception), electroception, auditory, somatosensory, olfactory and gustatory systems.

Co-incidence detection is basic mechanism related with the formation of latency-place representations for position or direction. There is evidence that pyramidal neurons in cortex apply co-incidence detection [**?**]. In the case of hearing, which is the most studied case, co-incidence detection occurs in brain stem. In many vertebrates, inter-aural time differences are used to deduce the azimuthal direction of the sound source at frequencies above kHz whereas at lower frequencies phase differences between waves entering into separate ears are used for this purpose. The general mechanism uses pathways from corresponding positions of right and left ear to an array of co-incidence detectors in brain stem such that the length difference for the pathways varies linearly with the array coordinate. Only that part of array fires for co-incidence for which the delay caused by the length difference between right and left pathways compensates the time lapse between signals to separate ears. The time difference for the arrival times of the signal to two ears is thus coded to spatial coordinate and this coordinate represents information about azimuthal angle characterizing the direction of the sound source.

It is interesting to notice that music metaphor reflects itself also at the level of brain anatomy [**?**]. Brain resembles piano in that distances along axes coding different temporal or spatial frequencies depend logarithmically on frequency ratios: this guarantees the invariance of the sensation with respect to the scaling of frequencies. It might have also something to do with the hallucinatory states in which objects of the external world are perceived as gigantic or miniature sized: perhaps hallucinatory state leads to anomalous frequency-scales for some objects of the perceptive field.

In TGD the comparison of parallel supra-currents representing sensory inputs to be compared makes possible co-incidence detection at quantum level. When two identical supra currents flowing in parallel super conductors and forming Josephson junctions enter at same time they are in the same phase, resonant Josephson current is generated and wakes up sub-self giving rise to mental image about co-incidence and also generates nerve pulse activity giving rise to further

experiences.

10.5.8 Do Brain Areas Correspond To Particular EEG Resonance Frequencies?

The scaling law of homeopathy inspires the guess that the information processing hierarchy, which starts from the primary sensory organs and contains besides sub-cortical nuclei also primary, secondary, etc... sensory areas, corresponds to a hierarchy of increasing EEG resonance wavelengths. This is consistent with the idea that primary, secondary and higher sensory areas of the cortex correspond to the periods of the periodic table in increasing order such that gamma band corresponds to the primary areas. Similar hierarchy should be realized at the motor areas.

This hierarchy should be realized dynamically by resonantly amplifying the EEG MEs with fundamental frequencies near the resonance frequency associated with a particular brain area. Neural circuits generating nerve pulse patterns, whose autocorrelation function contains the resonance frequency, could form a part of the mechanism. Alfven resonance could be even more important. If the magnetic flux loops associated with the magnetic body of a given brain area have a particular length L, one expects that the ELF MEs passign around the magnetic loop acting as a wave guide are amplified, when the fundamental frequency of the ELF ME satisfies certain resonance condition. This passage might involve several reflections but one might hope that only single curvilinear ME parallel to the magnetic flux loop acting as an Alfven wave guide is needed. In this case the length L of the magnetic flux tube would correspond to the resonance frequency $f = c/L$.

The generalization of this argument to the case of super-symplectic resonance frequencies would suggest the following scenario.

1. Primary sensory areas correspond to tertiary excitations of $k = 5_2^3$ algebra with the fundamental frequency of 40 Hz to primary excitations of $k = 251$ with fundamental frequency of 28 Hz. It is also possible that $k = 83_3$ excitations with frequency 56 Hz are associated with primary sensory areas and subcortical areas.

2. Secondary sensory areas correspond to secondary excitations of $k = 127$ with fundamental frequency of 10 Hz, average frequency in alpha and fundamental frequency associated with memory.

3. Tertiary association areas turn correspond to $k = 2^8 = 256$ with fundamental frequency 5 Hz belonging to theta band.

4. Unimodal association areas correspond to $k = 257$ with fundamental frequency of 3.5 Hz, the upper end of delta band.

5. Multimodal association areas would correspond to secondary excitations of $k = 131$ with fundamental frequency .63 Hz.

Of course, one could shift the positions of p-adic length scales along cortex but the assignment of 40 Hz to primary sensory cortex suggests that the identification could be correct. The mirror mechanism of long term memories suggests that an analogous hierarchy is realized at much lower frequency scales in terms of MEs and magnetic flux loops.

10.6 Scaling Law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. I ended up with the scaling law much before the realization that sensory representations could reside outside the brain and have same sizes as EEG MEs. The hypothesis that scaling law relates the sizes of the magnetic flux tube structures outside the body serving as a magnetic canvas to the sizes of the sensory representations inside brain implies that the view about hierarchy of magnetic body becomes rather quantitative. The scaling law has several forms and the latest of them is based on the hierarchy of Planck constants.

10.6.1   Various Forms Of Scaling Law

Scaling law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of possibly astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L_e(k)$ and $L_e(k(next))$. Scaling law is of form

$$L \quad = \quad \frac{v}{f} = \frac{v}{c}\lambda \ , \tag{10.6.1}$$

and relates ELF self size characterized by ELF frequency f (wave length λ) to the self size L and to the effective phase velocity v of the EEG wave.

With the discovery how non-episodal/declarative long term memories could be realized, came the realization that the scaling law could also relate the sizes of magnetic loops involved with positive frequency MEs propagating with sub-luminal effective phase velocity v along magnetic flux tubes and negative frequency MEs propagating with light velocity along much larger flux loops. Quite generally, it would seem that it is magnetic structures associated with positive and negative energy MEs, whose sizes are related by the scaling law.

The input from the work of Cyril Smith [I14] led to a variant of the scaling law stating the existence of imprinted frequency pairs (f_h, f_l) such that the presence of f_h implicates the presence of f_l and vice versa and satisfying

$$\frac{f_h}{f_l} \quad \simeq \quad 2 \times 10^{11} \ . \tag{10.6.2}$$

Also other values for the ratio can be considered. Scaling law in this form is discussed in the chapters [K42] and [K48]. One can interpret this scaling law in terms of $L = v/f_l$ law if one identifies the ratio of frequencies as velocity $v = f_l/f_h$.

The hierarchy of Planck constants leads to a further development in the understanding of the scaling law. For dark matter hierarchy the scaling law relates the time scale defined by Josephson frequency f expressible as

$$f \quad = \quad rf_0 \ , \quad L = \frac{\sqrt{r}}{f_0} = \sqrt{r}\lambda \ ,$$
$$r \quad \equiv \quad \frac{\hbar}{\hbar_0} \ . \tag{10.6.3}$$

The second form of the scaling law corresponds to

$$\frac{f_h}{f_l} \quad = \quad \sqrt{r} \tag{10.6.4}$$

with $r = 4 \times 10^{22} \simeq 5 \times 2^{75} = .944 \times 2 \times 10^{11}$. The error is 6 per cent. Note that the value of Planck constant would correspond to a ruler and compass integer but would be more general than allowed by Mersenne hypothesis. The imprinting process associated with the water memory would correspond to phase transitions changing the value of Planck constant. One of them transforms large $\hbar$ dark photons to ordinary photons with same energy having interpretation as bio-photons and also the reversal of this transformation is possible. Second one transforms large $\hbar$ photons to bunches of photons of generalized EEG photons with the same frequency and probably does not have reversal.

If one assumes also the first form of the scaling law, one can conclude that there is a velocity parameter given by the expression

$$\frac{v}{c} \quad = \quad \sqrt{\frac{1}{r}} \ . \tag{10.6.5}$$

This velocity could have several interpretations. It could correspond to the velocity of nerve pulse conduction, of propagating EEG wave, or of Ca^{++} wave. The velocities of the latter waves vary in extremely wide range. If EEG corresponds to Josephson radiation then the effective velocity of EEG wave could correspond to the disturbance of the propagating soliton sequence induced by the resting potential, which is most naturally at rest in the rest system of the soliton sequence. Hence the propagation of EEG wave could be interpreted as the conduction velocity of the solitons sequence or equivalently that of the nerve pulse.

If this interpretation is correct, the value of the Planck constant assignable to a given neural pathway are glial cell cluster could be measured. Nerve pulse velocities vary in the range 1-100 m/s and increase with the radius of axon. One would have $r \in \{2^{43}, 3 \times 2^{55}\}$ and $r \simeq 10^{14}$ would correspond to 5 Hz EEG frequency. The corresponding frequency range would be 80 Hz-.032 Hz. The latter scale corresponds to .51 minute period for the generalized EEG. These bounds look realistic.

If v corresponds to a velocity of EEG wave (it is not clear whether they indeed propagate), one can deduce the corresponding value of Planck constant and frequency from v as well as the size scale of the body part involved. This gives the consistency condition

$$\frac{f}{f_0} \quad = \quad r = (\frac{c}{v})^2 \tag{10.6.6}$$

allowing to test the hypothesis. Here f_0 is the photon frequency (around 2 eV for -50 mV resting potential: see the tables of [K35]) defined by the energy of the dark Josephson photon and is proportional to the membrane potential and thus varies with certain limits. The right-hand side is constant so that the Josephson frequency must be proportional to EEG and different ions must correspond to different brances of generalized EEG. If EEG waves are assumed to propagate with the same velocity as EEG waves the hypothesis reduces to the above case, which seems to be consistent with what is known about the range of EEG frequencies.

The phase velocity of the soliton sequence can be either $v < c$ or $v = c^2/V > c$, $V < c$ and this suggests that these velocities correspond to two kinds of EEG waves. $v = c^2/V > c$ gives standing solitons at the limit $V \to 0$: in practice even $v = c$ gives effectively standing waves. The phase velocities larger than light velocity would formally correspond to the values of Planck constant smaller than the standard value. Physically these waves would correspond to the firing of the entire axon simultaneously and are excluded.

If one accepts the identification of velocity in terms of Planck constant completely generally and allows only sub-luminal velocities, then only integer valued Planck constants are possible because otherwise the velocities could exceed light velocity. Hence only singular coverings of CD and CP_2 would be allowed. Once the value r of Planck constant is known the coverings of CD and CP_2 correspond to different decompositions of r to a product of integers for this option. If singular factors spaces are allowed, an infinite number of decompositions are possible.

10.6.2 Scaling Law For The Qualia About Brain Structure Of Given Size Scale

The classical fields associated with MEs are expected to code information about the contents of conscious experience at various levels of self hierarchy. EEG represents one level in this hierarchy. This coding is crucial for the realization of declarative memory as classical communications from the geometric past. p-Adic length scale hypothesis to estimate how wide the range of frequencies responsible for coding information about conscious experience at given level of self hierarchy is. The model makes a prediction for the number of EEG harmonics representing information about conscious experience at a given level of self hierarchy, and suggests a general law telling what transition frequencies correlate with experiences conscious-to-us.

Relationship between self size and EEG frequency

Scaling law in its basic form reads as

$$
\begin{aligned}
v &= \lambda f \ , \\
L &= \lambda \ .
\end{aligned}
\tag{10.6.7}
$$

Here v denotes the effective phase velocity associated with the EEG wave, λ corresponding wavelength, and f EEG frequency. L denotes the size of the sub-self and is assumed to be multiple of the effective wavelength associated with the EEG wave. The sub-self in question can give rise to a sensory mental image at the level of primary sensory organs or to a symbolic or cognitive representation at the level of brain.

In TGD Universe effective EEG phase velocities correspond basically to the effective phase velocity for MEs drifting along the relevant brain structure or a closed magnetic loop. The sub-luminal phase velocity results because positive energy ME tends to hop towards geometric future in quantum jump with some average rate while the space-time sheet representing environment is stationary. This velocity can be super-luminal for negative energy MEs if they dissipate since dissipation in this case would mean gradual shifting of ME backwards in the geometric time. Whether the dissipation really occurs significantly is not at all clear. If the frequency of the negative energy ME corresponds to an energy above thermal energies, the probability that negative energy can be absorbed is very low. This makes negative energy MEs ideal for generating time-like quantum entanglement, which is the prerequisite for the sharing of mental images. This process is the key element of long term memory, and even of the ordinary sensory experience and motor activity.

TGD based model for nerve pulse and EEG relates effective EEG phase velocities to the effective phase velocities of MEs moving along axon and generating the nerve pulse and also cell membrane oscillations [K80]. The dropping of ions to the magnetic flux tubes of the Earth's magnetic field during the process generates positive energy EEG MEs propagating along magnetic flux tubes of the personal magnetic body with sub-luminal phase velocity and representing in their modulation pattern information about the contents of sensory experience presumably crucial for declarative long term memories.

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. In this case the process would occur coherently for all particles. 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.

1. Ordinary states of consciousness and scaling law

One can argue that for the states of consciousness deriving only from ordinary sensory data by information processing in CNS, L cannot be larger than brain or body size for normal states of consciousness. The reason is that ELF self gains the sensory information from nerve circuits when it scans the relevant brain region and it does not make sense to scan regions much larger than brain size. This obviously implies $v < c$.

A stronger hypothesis making sense for ordinary states of consciousness encouraged by the empirical data [**?**] is that apparent phase velocity is actually equal to the conduction propagation velocity of the nerve pulses in the neural pathway involved:

$$
v = v_{cond} \ .
\tag{10.6.8}
$$

2. Transpersonal states of consciousness and scaling law

One could argue that transpersonal levels of consciousness (during sleep perhaps) provide sensory information from several brains simultaneously. Also states of transpersonal consciousness and even cosmic consciousness are difficult unless one allows self sizes much larger than brain size. That this kind of experiences might be possible is suggested by out-of-body experiences in which person sees her own body in eyes of outsider.

1. The first guess was that transpersonal states of consciousness correspond by $L = v/f$ law super-luminal effective phase velocities $v = c^2/V > c$ associated with the Lorentz boosts of time-like soliton sequences. The soliton sequences can be assigned with the possible existing Josephson junction structures connecting parallel super-conducting magnetic flux tubes. The potential differences associated with the junctions are extremely weak and correspond to the EEG frequencies via the formula $\omega = Q_{eff}eV/\hbar$.

2. The second guess is that they correspond to negative energy MEs for which EEG frequencies predict length of the order of the Earth's circumference. Negative energy MEs are indeed natural correlates for the generation of the bound state entanglement and the generation of macrotemporal quantum coherence accompanied by experiences of "one-ness". Negative energy MEs make also possible telepathic sharing of mental images. Episodal (sensory) long term memories would involve negative energy MEs with ultra low frequency scale. The generation of negative energy MEs could also provide metabolic energy by buy now-let others pay mechanism and might explain the claims about the ability of yogis and meditators to survive with minimum nutrition.

It might be that negative energy MEs associated with semitrance mechanism (semitrance mechanism is described in chapters [K89] and [K90] and possibly also with the initiation of motor actions. Positive energy MEs would in turn be involved with long term declarative memories involving classical communication with a sub-luminal phase velocity along closed magnetic loops of size $L = v/f$. These communications could be more or less automatic and the active memory recall could only mean a decision to receive the signal. Hippocampus and amygdala are good candidates for the parts of brain responsible for generating the positive energy MEs responsible for inducing the non-episodal memories.

Memory circuits could be also indirectly responsible for the generation of long term episodal memories. It is indeed known that removal of these structures leads to a loss of, say, hallucinations induced by say LSD [?]. In [K82] the mechanism of synesthesia is discussed with the cautious conclusion that the activity in the hippocampal region indirectly induces the generation of long term episodal memories. The over-activity in the memory circuits would induce a "starvation" in certain cortical regions. In order to get metabolic energy these starving regions would apply buy now-let others pay mechanism and generate negative energy MEs inducing a time-like entanglement with the geometric past and a sharing of mental images resulting in episodal memories.

Maximal number of harmonics at given level of p-adic hierarchy

The general vision is that we can have experiences mediating information about several levels of the p-adic length scale hierarchy associated with body. Both primary and secondary and even higher p-adic length scales are allowed in this hierarchy. The sharing of mental images made possible by negative energy MEs and classical communications made possible by positive energy MEs are the main mechanisms involved. Classical communications involve some code translating information to the shape of the classical fields and/or vacuum currents associated with positive energy ME propagating with sub-luminal phase velocity.

To build a model one can make more detailed technical assumptions.

1. For a given p-adic length scale $L_e(k)$ the self sizes between $L_e(k)$ and $L_e(k_{next})$ contribute to the experiences about that level. $v = Lf$ law in turn allows to estimate for a given fundamental transition frequency f how many harmonics contribute to the classical field of ME in question at level k. The number of harmonics determines the maximum information content of the experience generated by the classical signal carried by ME at that level.

2. For a given transition frequency and nerve pulse velocity v_{cond}, which could be for definiteness assumed to be equal to EEG phase velocity, there is some minimal p-adic prime $k(min)$ nearest to the length scale v_{cond}/f:

$$L_e(k_{min}) \leq \frac{v_{cond}}{f} \quad . \tag{10.6.9}$$

The minimal p-adic length scale does not in general allow maximal sensory acuity since v/f is not in general infinitely near to $L_e(k_{min})$.

The next k: s can however give maximal number of transition frequencies corresponding to $[k_{next} - k]/2$ octaves if the spectrum of self sizes is maximal. The frequency band for a given k is filled by starting from the frequency corresponding to the lowest possible "bodily self" size $L_e(k)$, which is the largest possible frequency for that k, and proceeding to smaller frequencies corresponding to larger values of self size. This means that the hierarchy of p-adic length scales coming as octaves of the basic scale very precisely corresponds to the hierarchy of conscious experiences about various length scales. Every p-adic length scale is like music instrument producing $[k_{next} - k]/2$ octaves of musical notes.

Scaling law leads to rather strong predictions when combined with the formula identifying self size as the apparent wave length associated with EEG waves.

For instance in the case of $k = 199$ characterizing the size of brain, there are 6 octaves of frequencies between $L_e(199)$ and next primary p-adic length scale $L_e(211)$. Rather interestingly, the range $1.5 - 90$ Hz of EEG frequencies spans also 6 octaves. ELF self can have also experiences about what it is to be brain hemisphere ($k = 197$): this is possible for suitably tuned drift velocity range of ELF self, in this case the maximal frequency range would be 2 octaves. Amygdala would presumably correspond to $k = 193$ and in this case three octaves of EEG frequencies are possible. One must also consider the possibility that secondary and higher p-adic length scales are involved. In this case $L_3(67) = 32$ cm corresponds the p-adic length scale next to $L_e(199) = 16$ cm.

Communication between different levels of the self hierarchy and fractal scalings

Communication between different levels of p-adic hierarchy means mapping of various functions representing sensory information from a given level p to another level p_1. The obvious manner to realize this mapping is simply to scale by the ratio $p_1/p = 2^{(k_1 - k)/2}$. Music piece is transposed to $(k_1 - k)/2$ octaves higher. For instance, actual EEG pattern corresponding to virtual motor activity would be simply its fractally scaled version containing virtual nerve pulse pattern as a repeated command (*"Do this- do this-..."*). It is known that motor neurons indeed serve as low pass filters [B15] noticing only low frequencies and this might correspond to this kind of fractality. Unconscious fine structure of motion could result from unconscious-to-us processing by this kind of fractal scaling. This kind of temporal scaling fits nicely with the paradigm of 4-dimensional brain.

Super Virasoro frequency scales $f(n_1, k_1)$ and $f(n_2, k_2)$ discussed in [K39] differ from each other by power of 2 when both n_1 and n_2 are even or odd. This means that for a given prime super-symplectic transition frequency spectrum is fractal and contains the frequency spectra associated with shorter p-adic length scales as sub-spectra and thus can generate resonantly Super Canonical transitions in shorter p-adic length scales. Similar fractality might be realized for magnetic frequencies. The scaling law $B \propto 1/L^2(k)$ for magnetic field strengths suggested by p-adic fractality would imply that magnetic transition frequency scale scales as $f(k) \propto 1/L^2(k)$.

Is there a correlation between brain size and apparent EEG phase velocity?

A natural assumption is that self sizes at level k are in the range $[L_e(k), L_e(k_{next})]$. $L_e(k_{next})$ can be also secondary or even higher p-adic length scale such that brain size is in the range $[L_e(k), L_e(k_{next})]$. This would give

$$\frac{v}{f} \quad \in \quad [L_e(k), L_e(k_{next})] \quad . \tag{10.6.10}$$

An interesting possibility is that there is correlation between brain size and nerve pulse conduction velocity in the neural pathways contributing to consciousness:

$$\frac{v_1}{v_2} = \frac{L_e(k_1)}{L_e(k_2)} \quad , \tag{10.6.11}$$

k	191	193	97_2	197	199	67_3	101_2	103_2
L_p/m	.01	.02	2.8	.08	.16	.32	.45	1.8

Table 10.1: p-Adic length scales $L_e(k,n)$ possibly relevant to consciousness and life at length scales relevant to human brain and body. k characterizes p-adic prime via $p \simeq 2^k$ and $n = 1, 2, 3$ tells whether primary, secondary, or higher p-adic length scale is in question. $n > 3$ n-ary scales are assumed to be un-important.

where $L_e(k_i)$ are the p-adic length scales associated with the brains of the organisms 1 and 2 and v_i are velocities in corresponding neural pathways. If this assumption holds true then the maximal information content of the field pattern of ME depends only weakly on the size of the brain since the frequency ranges are more or less the same. That velocity of conduction should increase with the size of organism sounds rather natural since axons get thicker.

It is possible to make definite estimates about conscious qualia for given species using information about nerve pulse velocities involved and about brain size. There is indeed some evidence for the correlation between brain size and inverse of the peak frequency of EEG [**?**]. For instance, it is known that in the case of dog intracranial phase velocities of alpha waves are in the range $.3 - 1.2$ m/s [**?**]. These data suggests that the sizes of alpha wave selves for dog are in the range $3 - 12$ cm so that dog's alpha consciousness would correspond to $L_e(197) = 8$ cm, which is the length scale associated with single brain hemisphere for humans. The result supports the view that the sizes of self correlate with brain size. Large animals like whales could have in ordinary wake-up state sensory input from p-adic length scales above $L_e(199)$ [$L_3(67) = 32$ cm, $L_2(101) = 45$ cm, $L_2(103) = 180$ cm].

If the phase velocity of the alpha waves is same along the entire magnetic flux loops associated with the magnetic body, the values $.3 - 1.2$ m/s *resp.* 14 m/s for the phase velocities of dog *resp.* human would mean that the time span for the long term non-episodal memories would be at least by a factor $1.2/14$ shorter for dogs than for humans. This would roughly conform with the dog/human life time ratio.

Consider some examples illustrating what this hypothesis predicts assuming that the velocity range $(v_l, v_u) = (3, 7)$ m/s applies to EEG waves associated with the entire brain and that the doubled velocity range $6 - 14$ m/s applies to single brain hemisphere. **Table 10.1** helps to get overall view about the important p-adic lengths scales.

1. For $k = 199$ corresponding to entire brain the maximal self size L_m, when identified as the next p-adic scale, is $L_3(67) = 32$ cm if tertiary p-adic length scales are allowed. Otherwise L_m is $L_2(101) \simeq .45$ meters. By $v = L/f$ law the ratio $L_m/L_e(199)$ should be smaller than the ratio $v_u/v_d = 7/3 \simeq 2.3$. $L_2(101)/L_e(199) = 2\sqrt{2} \simeq 2.8$ is larger than the ratio $7/3 \simeq 2.3$ whereas $L_3(67)/L_e(199) = 2$ satisfies the constraint so that $k = 67$, which corresponds to rather closely to the length scale of head, is favored.

2. The EEG frequency ranges correlating with qualia conscious-to-us are predicted to be $9.4 - 21.9$ Hz for $k = 67$ and $6.7 - 15.6$ Hz for $k = 101$. The frequency range associated with $L_e(199)$ is $19.0 - 43.8$ Hz.

3. For $k = 197$ corresponding to brain hemisphere one has $L_e(k_{next}) = L_e(199)$ and frequency range corresponding to the velocity range $7 - 14$ m/s is $43.8 - 102$ Hz and for $L_e(197)$ the range is $87.6 - 204$ Hz.

Lower bounds for "bodily" self sizes from the range of nerve pulse conduction velocities

The range for nerve pulse conduction velocities associated with EEG waves does not correspond to the entire range of nerve pulse velocities in somatosensory system ranging from .5 m/s to 120 m/s [B15]. Thus our brain anatomy could allow much wider spectrum of sizes for mental images than allowed by the rather narrow range $3 - 14$ m/s of propagation velocities for alpha waves.

$v/(m/s)$	$.5-2$	$5-30$	$35-75$	$80-120$
$L_e(1,e)/\mu m$	.8-3.2	8-48	58-125	133-200
$L_e(1,p)/mm$	$.27-1.0$	$2.7-5.9$	$19-41$	$44-66$
$L_e(1,Li_+)/cm$	$.1-.5$	$1.2-7.1$	$8.3-17.9$	$19.0-28.6$
$L_e(1,Ca^{++})/dm$	$.3-1.2$	$2.9-17.1$	$20-43$	$46-69$
$L_e(1,Co_+)/m$	$.1-5$	$1.2-7.0$	$8-17$	$18-28$

Table 10.2: Table gives the length scales below which electron, proton and ionic consciousness is possible assuming that the nerve pulse velocities vary in the ranges associated with somatosensory system.

Nerve pulse conduction velocity as a function of the axon thickness obeys the approximate law [B15]

$$v = kv_0 \times \frac{d}{d_0} \ , \quad v_0 = 1 \ m/s \ , \quad d_0 = 1 \ \mu m \ .$$

The value of k is about 6 for thickly myelinated axons and between 1.5 and 5 for thinly myelinated axons. The variation ranges of conduction velocities in somatosensory (!) system are in ranges $80-120$ m/s, $35-75$ m/s, $5-30$ m/s and $.5-2$ m/s for unmyelinated axons. Conduction velocity varies in rather wide range $(.5-120)$ m/s: "quale key" can vary in a range of almost 8 octaves. The lowering the conduction velocity of nerve pulses by reducing myelinization or thickness could make it possible for us to have qualia about length scales of brain nuclei.

It is interesting to look for the lower bound $L_e(min)$ of self sizes assuming that 90 Hz is upper bound for transition frequencies representing experiences possibly conscious to us. The values of L_{min} are.89 m for $80-120$ m/s range;.39 cm for $35-75$ m/s range; 5 cm for the range $5-30$ m/s and.5 mm for the range $.5-2$ m/s associated with the unmyelinated axons.

Table 10.2 gives the length scales below which electron, proton and ionic cyclotron consciousness is possible assuming that the nerve pulse velocities vary in the range described above. These ranges of nerve pulse conduction velocities are associated with somatosensory system and actual "phase velocities" of EEG waves seem to vary in much narrower ranges.

From **Table 10.2** one finds that electronic cyclotron consciousness is possible in p-adic length scales $L_e(173) = 20 \ \mu m$ and $L_e(179) = 160 \ \mu m$ but not above this length scale. Also the length scale $L_e(169)$ might be possible. Protonic cyclotron consciousness is possible at all length scale above $k = 169$ up to $k = 193$.

10.6.3   Scaling Law And Evolution

Scaling law, when combined with general ideas about consciousness, allows to build speculative models for the evolution of consciousness at both biological and cultural level. What would be new and nontrivial would be the strong correlation between cultural and electromagnetic evolution (strictly speaking, also the evolution field bodies is involved). Cultural evolution could be perhaps seen as evolution of memes with memetic code playing the role of genetic code. There are good reasons to believe that the intronic portion of DNA codes for memes represented dynamically as field patterns associated with MEs [K41]. The portion of the introns in genome is indeed large for humans (99 per cent).

Scaling law contra biological, cultural, and spiritual evolution

One can distinguish between two kinds of developments of individual: the neural development of child in the p-adic length scales relevant to body and the evolution of magnetic body and of communications between magnetic body and biological body. Besides the personal magnetic bodies also the magnetic body of Earth, magnetosphere, is expected to carry sensory, cognitive and symbolic representations resulting through entanglement with various organisms. Negative energy MEs in EEG range are natural in this respect. These representations would give rise to

multi-brained magnetospheric selves [K53]. The development at ELF frequency range corresponds by *ontogeny recapitulates phylogeny principle* to the evolution of civilization.

There are good reasons to believe that brain anatomy has remained more or less the same in time scales much longer than the evolution of civilization from bicamerality to modern man. This would mean that the evolution of our consciousness and civilization is basically electromagnetic rather than genetic evolution and corresponds to the evolution of EEG and ZEG during ontogeny. The evolution of magnetospheric consciousness might be a crucial factor in this development. These evolutions are not completely independent since $L = v/f$ ($v < c$) relationship correlates these developments to each other.

1. Scaling law and the relationship between cultural and biological evolution

A fascinating challenge would be to understand the detailed relationship between cultural evolution and the evolution of field body. In particular, there are many interesting questions related to the relationship between self-hierarchy and Freud's ideas. Is super ego above EEG length scales or above the body length scale? Could one regard the counterpart of Id as a species consciousness, some kind of biological superego, in length scales larger than body size but considerably below ELF length scales representing cultural aspects of consciousness? Can one speak of cultural superego? Is the time scale of the phenomenon direct measure for the p-adic length scale of the corresponding self?

It is important to notice that $v = Lf$ relationship defines mapping $k \to f(k)$ between the biological and electromagnetic length scale hierarchies such that ELF self at particular p-adic level has sensory experiences about experiences of particular self at bodily level? Very roughly this mapping would correspond to the scaling

$$L_e(k) \to [\frac{c}{v} L_e(k)] \equiv L_e(f(k)) \ \ ,$$

where $[L]$ is shorthand for the nearest p-adic length scale below length scale L. More explicit manner to define this mapping would be as

$$k \to [k + log_2(c/v)] \ \ ,$$

where $[k]$ now denotes the nearest power of prime below k. If this kind of mapping is involved then the evolutions at these two widely different length scales might correspond to each other rather closely.

Evolution at the level central nervous system

The natural implication of the proposed picture is that the biological (as also electromagnetic) evolution of the central nervous system (CNS) proceeds from shorter to longer p-adic scales. Jump in the evolution correspond to emergence of new p-adic length scale when the size of self becomes equal to next p-adic length scale.

This vision about evolution of central nervous system can be tested immediately. Magnetic spectroscopy of consciousness predicts that there are seven levels between $k = 169$ level of neuron and brain and they correspond to the primary p-adic length scales associated with $k = 173, 179, 181, 191, 193, 197, 199$. Central nervous system indeed has 7-levelled hierarchy corresponding to spinal chord, medulla, pons, midbrain, diencephalon, brain hemisphere, brain and higher levels of this hierarchy have indeed emerged one-by-one during evolution. The eight levels of the hierarchy (perhaps it is worth to notice the amusing connection with the eight-fold way of Buddhism and the idea of Lily about eight levels of consciousness) would correspond to the next level of bio-consciousness $k = 211$ which might be already present at delta and theta frequencies.

Geometric consciousness at the level of spinal chord geometric consciousness should at least correspond to multiples of electron cyclotron frequencies. Electronic consciousness is not possible at higher levels. This picture explains why the activities of autonomous nervous system is more or less unconscious to us. Hypothalamus and thalamus and presumably also many other brain nuclei would correspond to the level $k = 193$ in the hierarchy. Their sizes are indeed above 2 cm and below 8 centimeters. Thus autonomic nervous system should correspond to lower level of the p-adic hierarchy of selves so that the contribution to our consciousness would involve several

averageings. Note that protonic cyclotron consciousness is still possible at at this level but not at higher levels for typical conduction velocities of nerve pulses.

Scaling law and ontogeny

During the early development neural pathways myelinize gradually [**?**] and this means gradual increase of the conduction velocities $v = Lf$. This suggest that various versions of quale about given p-adic length scale $L_e(k)$ labelled by the harmonics of the fundamental frequency emerge gradually one by one as nerve pulse propagation velocities in neural pathway increase. First pops up $n = 1$ version of quale, then $n = 3$ version, etc.. One could visualize this as drift of various versions of quale from shorter to longer p-adic length scales.

This predicts that the sensory acuity of infant increases in stepwise manner at critical values of the nerve pulse propagation velocity making possible new harmonic of EEG pattern representing particular quale. The critical values of the nerve pulse propagation velocity for secondary experiences about events at level k are given by

$$v(n) \quad = \quad nf \times L_e(k) \ . \tag{10.6.12}$$

This applies also to motor expression which in TGD framework is very much like virtual sensory experiencing amplified to macroscopic motor activity by puppet-in-string mechanism. For instance, coordination and control of motor activities improves and emotional expression in speech becomes more refined.

This option is not the only one that one can imagine. Also EEG develops during the development of individual. The fact that the peak frequency of EEG moves gradually from delta band to alpha during the first ten years allows to consider the possibility that the sizes L of mental images, stay more or less constant during maturation. This requires that both that nerve pulse velocity and the harmonic of the fundamental frequency giving the dominating contribution to the quale gradually increase. An interesting possibility is that the sizes of selves correlate with body size or with the size of relevant body part during development of individual.

$$L = \frac{v}{f} = k \times L_e(body\ part) \ .$$

This would mean that all ions correspond to the same self size for given value of nerve pulse conduction velocity.

Transition from bicamerality to modern consciousness

TGD based vision about the evolution of civilization relies on *ontogeny recapitulates phylogeny principle* stating that the development of child's electromagnetic body is fractally scaled version of the development from bicamerality to modern consciousness. In particular, the hypothesis has been that this development meant the emergence of higher level emotion and cognition and of the semitrance mechanism in which collective self gave commands and advices to the bicameral.

The proposed model for the evolution of qualia concretizes this general vision considerably. The picture about what might have happened in the transition might perhaps look like follows.

1. Semitrance mechanism

Semitrance mechanism made possible for the collective higher level ELF self to communicate commands and advices to the bicamerals. This higher level ELF self presumably had also higher level sensory experiences about entire social group in some p-adic length scale larger than body size. $L_e(211) = 10$ meters and $L_e(223) = 640$ meters are the most obvious length scales involved. The emergence of new ELF frequencies to EEG meant also that the sensory and emotional acuity of bicameral man improved. It is not absolutely clear whether semitrance is communication of higher level selves to us or sensory experiencing of transpersonal levels of consciousness or both. The predicted lifetimes of transpersonal selves are however measured in years which suggests that they are closely involved with long term memories.

2. Development of speech

The emergence of modern man involved the development of speech faculty. This evolution must have been proceeding in two directions. We have self-narrative in rather long time scales and someone must tell it to us: this implies that ELF MEs corresponding to $k = 127_2, 2^8, 257, 131_2, 263,$ $89_3, 269, 271, 137_2, 277, 139_2, ...$ should have emerged gradually. This could have also meant development of amplitude modulation hierarchy and increasingly complicated linguistic structures. Note that the time scale starting from .1 seconds ($k = 127_2$) and ending up to 6.1 seconds ($k = 139_2$) contains especially many primary, secondary and tertiary p-adic time scales. This also meant development of increasingly refined linguistic structures in short time scales: words decomposed to syllables and syllables to phonemes presumably identifiable as memetic codewords at $k = 127_2$ level and this made possible development of written language.

In conflict with the standard beliefs about our position in the hierarchy of consciousness, this picture suggests that to some extend both speech and internal speech are speech of higher level self. It is indeed well-known that it is almost impossible to speak fluently if one tries to control what one is saying: one must simply let it go. Also body unconscious-to-us language can be interpreted as talk of higher level self using limbic brain as instrument of expression: this would explain why we express emotional reaction before becoming conscious about the emotion.

3. Emergence of long term memory

What Jaynes believes could be translated to the statement that the transition from bicamerality to modernity involved the emergence of the long term memory and its evolution from a direct sensory memory to declarative memory [**?**]. Sensory memory means direct re-experiencing by the sharing of mental images made possible by time-like entanglement. Declarative memory would be based on a symbolic representation of the data, and would be communicated classically (communication would be ultra-slow!) from the geometric past as a response to the shared mental image representing the desire to remember.

A possible model for long term declarative memories is based on the generalization of the frequency representation of the memetic code. What is presumably coded, are perhaps not details of particular experience but sequence for names of "program modules" realizing particular kind of experience. Thus very high level coding would be in question. In this model long term memories could perhaps be represented as a modulation of the carrier frequency of "hippocampal theta frequency" varying in the range $4 - 12$ Hz [A4] by multiples of some lower ELF frequency representing higher level of self hierarchy.

The large range of variation for hippocampal frequencies suggest that they could correspond to magnetic transition frequencies of various ions subject to homeostatic regulation. It is indeed known that the state of arousal correlates with the hippocampal frequency. The modulating level would correspond naturally to the ELF self associated with multimodal association regions which project via entorhinal cortex to hippocampus. If the tertiary time scale associated with $k = 251$ (28 Hz) corresponds to primary sensory areas, this region must correspond to $k = 131$ and frequency of .63 Hz and cycle of 1.6 seconds which sounds sensible. If this is the case, long term memories should have natural time unit of 1.6 seconds.

The motion of the peak frequency of child's EEG from delta band to alpha band during the first ten years looks paradoxal against the idea that lower frequencies correspond to higher levels of consciousness. One interpretation for the presence of low frequencies is that the child is in a semitrance state and that the presence of the low frequencies reflects control from the higher levels of self hierarchy. A second interpretation allowing to get rid of the paradox is that the carrier frequency evolves gradually from delta to alpha band while fundamental modulation frequencies stay constant. This would mean that the number of multiples fundamental frequency which can appear in the modulation increases and information storage capacity increases.

This kind of coding is not the only possibility and it is quite possible that entire fractal hierarchy of codings are involved such that single codeword at higher level corresponds to an equivalence class of codewords at lower level. For instance, hippocampal theta period could define the duration for the codeword of a lower level code realized by modulation using gamma frequencies. There is evidence for temporal coding in the sense that the relative temporal shift of the spike sequence with respect to the "hippocampal theta frequency" codes for the position of moving rat [**?**]. This would mean the coding of rat's position to the overall phase of the complex Fourier components representing $n > 1$ harmonics of the memetic codeword ($n = 1$ would correspond to "hippocampal theta frequency") and can be understood if the motion of rat is coded to periodically

occurring nerve pulse patterns inducing reset of theta oscillator.

4. Schizophrenic as a modern bicameral?

Schizophrenic is regarded by Jaynes as a modern bicameral. According to Jaynes, schizophrenics seem to have amazing ability to tolerate pain and to work hardly for long times without experiencing fatigue. For instance, catatonics can stay in same bodily posture for hours. Perhaps this is due to the fact that they do not experience pain in same sense as normal persons do. Jaynes also explains by this the architectural feats of ancient civilizations impossible for modern man using the primitive tools available for bicamerals.

Our emotions are partially generated by the feedback loop in which the lower level emotions expressed by the limbic brain are perceived by the cortical levels and amplified and in turn affect limbic brain. If this loop is not working properly (say due to the inhibited emotional expression), nociception is not accompanied by the experience of pain. If the transition to modernity meant also evolution of emotions and their expression, the emotional expression of bicamerals must have been primitive so that this loop cannot have been so effective as it is in the case of modern man. One can also consider the possibility that bicamerals spent a considerable fraction of time in semitrance in which regions of the emotional right brain were entangled with higher level selves or with large selves and were thus unconscious and unable to feel pain. The myth about exile from paradise would reflect that the newly developed ability to experience strong emotional pain.

Schizophrenics have often also unusually high sensory acuity: this is probably due to the weakened sensory censorship eliminating from sensory landscape unessential features. The fact that the attention of schizophrenic is more easily distractable is also consistent with this.

5. Child as a small bicameral?

Scaling law suggests that child is during the first years of her life more or less the modern counterpart of the bicameral man of Jaynes [**?**] receiving commands and advices of the higher level selves as sensory, in particular auditory hallucinations as suggested in the chapters [K89] and [K90]. Semitrance hypothesis is consistent with the fact that REM occur during wakefulness and sleep. REM is also found to occur few moments after an infant begins to engage in nutritional sucking. Even modern man has day dreams with the same 90-120 minute period as he has REM period during sleep. That small children comment their activities from third person view (*"Now John is going to do this"*) is consistent with semitrance hypothesis.

Delta wave dominance of EEG (see below) is indeed consistent with the hypothesis that child spends long times at transpersonal levels of consciousness seeing her body with eyes of outsider. The fact that the speech of child however lacks much of the emotional component present in the speech of adult is consistent with the idea that emotional expression develops gradually more refined when also generalized sensory experience about state of body becomes more refined. It has been indeed noticed already by Rousseau that child's speech lacks much of the emotional color involved with the speech of adults.

It is known delta band dominates during childhood and that the EEG intensity in delta band is reduced during ageing. A possible interpretation is that the attention is during childhood more directed to transpersonal levels and gradually shifts to more bodily level (perhaps for the simple reason that the unpleasant side effects of ageing require more and more attention to the state of body!). This would suggest that ageing could but need not mean spiritual degeneration. The shift to higher frequencies could mean that higher harmonics of the cyclotron frequency in delta band begin to dominate. On the other hand, sensory acuity gets poorer when individual gets older. This could have purely anatomical reasons but could also involve gradual increase of the average cyclotron frequency associated with the quale so that also harmonics of low cyclotron frequencies responsible for high sensory acuity tend to disappear from EEG. Also the timing accuracy of the temporal patterns of nerve pulses could become worse during ageing. As a consequence, the frequencies of EEG waves would not be sufficiently near to the harmonics of low cyclotron frequencies anymore.

6. The role of Earth's magnetic field in the evolution of civilization?

The fundamental frequencies associated with exotic super-symplectic representations are constants of Nature. As far as the proposed role of these frequencies is considered, this is very satisfying feature. Many basic frequencies associated with exotic super-symplectic representations

in EEG range are however very near to Schumann frequencies (inversely proportional to the circumference of Earth) and to important cyclotron frequencies proportional to Earth's magnetic field. This suggests the possibility of a resonant interaction so that the value of Earth's magnetic field could have played important role in the evolution.

During last thousand years Earth's magnetic field has reduced by a factor of one half. For instance, the cyclotron frequency of Co^{++} ion (probably closely involved with 10 Hz bio-clock in pineal gland), which is 10 Hz for present value of about $.5 \times 10^{-4}$ Tesla of Earth's magnetic field, has reduced by a factor two during this period. The considerations of the chapter [K53] raise the question whether the reduction of the magnetic field might have something to do with the exponential evolution of the civilization during this period.

10.6.4 Scaling Law And Sensory Maps

The vision about sensory maps realized using magnetic canvas outside the body inspires the hypothesis about a hierarchy formed by the primary and secondary sensory organs inside brain with levels labelled by the p-adic length scales. The radius of the approximately spherical structures from which the radial magnetic flux tubes serving as magnetic canvas emanate should be roughly given by the relevant p-adic length scale L. ELF MEs define the projection of the sensory image from the (possibly secondary) sensory organ to the magnetic canvas by place-frequency coding. This requires that the thickness of the magnetic flux tube depends weakly on the distance from the projecting sensory organ. A stronger assumption is that the magnetic structure serving as a sensory canvas has the same size as EEG MEs: $L_e(magn) \sim L_e(EEG)$. Hence sensory images would be magnetic giants in TGD framework whereas in standard neuroscience they would be miniatures defined by the cortical neural activity patterns.

By scaling law the sizes $L_e(EEG)$ of ELF selves relate to the sizes L of brain structures: $L_e(EEG) = (c/v)L$. Here v is the velocity of motion of EEG ME along axon, or equivalently nerve pulse conduction velocity, and f is the EEG frequency. The consistency with the scaling law is achieved if secondary sensory organs, which could be approximately spherical structures analogous to eyeball, have radii $L \sim v/f$ approximately given by various p-adic length scales $L = L_p$. As will be found later, the resulting sensory hierarchy correlates nicely with the brain anatomy, with the band structure of EEG and with the structure of the periodic table.

It is of interest to apply the scaling law at the level of eye. Amazingly, the sizes of the lense (about $L_e(191) \simeq 1$ cm) and retina (about $L_e(193) \simeq 2$ cm) are just at the lower bound of the p-adic length scale range allowing the EEG frequency to be in the range of cyclotron frequencies in Earth's magnetic field. For $v = 3$ m/s, which is the lower bound for the velocities of alpha waves, $f = v/L$ gives proton cyclotron frequency $f_c = 300$ Hz for lense size $L \sim 1$ cm and deuterium cyclotron frequency $f_c = 150$ Hz for retina size $L \sim 2$ cm or more naturally proton cyclotron frequency for a two times larger value of Planck constant. Note that higher harmonics cyclotron frequency are possible even if the lowest one is not and could thus allow deuteronic cyclotron consciousness. For retina $v = 6$ m/s gives proton cyclotron frequency for retina. He_4 consciousness would require $v \sim 1.5$ m/s, which is possible only for unmyelinated axons: the axons from retina are myelinated.

Thus it seems that the lowest level or perhaps even two lowest levels of visual consciousness could be possible at the level of lense and retina. The size of the pupil correlates with the state of consciousness. An interesting question is whether these two levels of retinal consciousness could correlate with the size of pupil. For instance, the velocity of nerve pulse conduction in the axons from retina could correlate with the size of the pupil. Contracted pupils might correspond to the most primitive form of retinal consciousness and dilated pupils to consciousness with the value of Planck constant which is two times larger. The projection to the exterior world would be determined by the input from the next level of the visual hierarchy and would be directed backwards rather than to the visual field of the retina. Retinal visual selves could thus represent the lowest level of the visual self hierarchy above EEG and would be unconscious to us as also 40 Hz visual consciousness at the primary sensory areas seems to be. What is encouraging is that the size of retina fits nicely with the general vision about hierarchy of visual selves starting already at the level of the primary sensory organ.

The lowest level in the hierarchy of the sensory consciousness would correspond to electron with cyclotron frequency $f_c \simeq 6 \times 10^5$ Hz in Earth's magnetic field. The size of the projecting organ would be about 5 micro–ns for the minimal value of $v = 3$ m/s of alpha wave velocity. This would

k(bio)	191	193	97_2	197	199	101_2 (67_3)
$L_e(k(bio))/cm$	1	2	2.8	8	16	45 (32)
$k(ELF)$	2_2^5	251	127_2	$2^8 = 256$	257	131_2
$f(k, n)/Hz$	40.0	28.2	10.0	5.0	3.5	.63
sensory area	I	I	II	III	IV	V
EEG band	gamma	beta	alpha	theta	delta	delta
period	He	He	Ne	Ar	Kr	Xe

Table 10.3: Table gives the correspondence between biological and ELF length scales suggested by $v = L_e(k)f$ relationship assigning to the "biological" length scale $L_e(k(bio))$ (not larger than body size) ELF frequency $f(k, n)$ and corresponding "cultural" p-adic length scale, which is of order of Earth circumference for 8 Hz EEG frequency. Also the proposed assignments of the sensory areas of neocortex to these length scales are given. The lower index associated with the exponent k tells whether the scale is secondary or tertiary in the case that it is not primary (one has $p \simeq 2^k$ by p-adic length scale hypothesis).

suggest that even neurons can represent sensory input on the magnetic canvas and have senses just as we do. TGD neurons would be considerably more complex creatures than the fire-doesn't fire neurons of computationalist. This is of course what fractal self hierarchy predicts on completely general grounds. From the scaling law the size of the neuronal sensory image represented by electronic magnetic transitions would be of order 10^4 meters. A possible test for this view is whether radiation at electron's cyclotron frequency or its multiples has direct effects at neuronal level.

10.6.5 Does The Structure Of Neocortex Correlate With TheHierarchy Of P-Adic Frequencies?

p-Adic frequencies differing by appropriate scalings by a power of square root two would correspond naturally to the brain structures and organizational hierarchy of brain and CNS. The nice aspect of this hypothesis would be universality and prediction of the cognitive codes.

The $v = Lf$ scaling law described earlier implies the existence of a mapping

$$L_e(k(bio)) \to L_e(k(ELF))$$

between biological length scales $L_e(k(bio))$ and cultural length scales $L_e(k(ELF))$. The mapping means that ELF self characterized by $k(ELF)$ receives sensory input from corresponding biological length scale $L_e(k(bio))$ and presumably has corresponding biological selves as sub-selves. This mapping is illustrated in the table below. For instance, the selves at length range 8-16 cm corresponding to the size of brain hemisphere and to tertiary sensory areas are scanned by ELF selves at theta frequencies.

By $L = v/f$ correspondence the structures of neocortex correspond to definite ELF selves containing at least the p-adic length scales $L_2(2^5)$, $L_e(251)$, $L_2(127)$, $L_e(2^8)$, $L_e(257)$, $L_2(131)$, ... with fundamental Super Virasoro frequencies $f(k, n)$ equal to 40 Hz, 28.2 Hz, 10 Hz, 5.0 Hz, 3.5 Hz, .63 Hz, ... Note that the fundamental frequencies correspond to gamma, beta, alpha, theta and delta bands. The table below provides a concise summary of the proposed correspondences. The length scale $L_3(83)$ corresponds to $f(1,0) = 56$ Hz contained also in the EEG range and is not given in the table.

10.7 Consciousness As A Phenomenon In The Operational Architectonics Of Brain Organization: Criticality And Self-Organization Considerations

I received an interesting article by brothers Fingelkurts (Andrew and Alexander) and Carlos Neves to be published in Chaos, Solitons & Fractals [**?**]. The title of the article is *Consciousness as a phenomenon in the operational architectonics of brain organization: Criticality and self-organization considerations.*

Already on basis of the title it is clear that article is interesting also from the point of view of Topological Geometrodynamics (TGD) (see `http://tinyurl.com/yccb73gq`) (for overview see "Topological Geometrodynamics: an Overview" at `http://tinyurl.com/y7v6z4vm`) [K116], especially the part II), where quantum criticality replaces thermodynamical criticality as a basic characteristic of the Universe dictating uniquely the dynamics fixing the geometry of the "world of classical worlds" (WCW [K20], see `http://tinyurl.com/ycqyk49f`) consisting of 3- surfaces in certain 8-dimensional space-time. Quantum criticality is also central in TGD inspired theory of consciousness and the basic picture is roughly the same as in OA model. The chapter Comparison of TGD Inspired Theory of Consciousness with some Other Theories of Consciousness (see `http://tinyurl.com/yaq75hg6`) [K23] might help to get an overview about TGD inspired theory of consciousness.

Quantum self-organization (see `http://tinyurl.com/y8wcl3lm`) [K16] is second key element of TGD inspired theory of consciousness and corresponds to a cascade of quantum jumps proceeding from level of given causal diamond (CD) defined as intersection of future and past directed light-cones of 4-D Minkowski space to shorter scales (sub-CDs, their sub-CDs, etc..). Quantum jump corresponds to a state function reduction at either boundary of CD and have interpretation as sensory perception and motor action (time reversed sensory perception). CD is identified as geometric correlate for "spotlight of consciousness".

In the following I summarize the basic concepts and ideas of the article and compare them with TGD approach to consciousness. There is also a section devoted to quantum criticality in TGD Universe. The approach is certainly TGD centred and I can only apologize this.

10.7.1 The Model For Operational Architecture Of Brain (OA)

In the following I summarize my understanding of OA model by comparing in with TGD approach to consciousness.

Basic philosophy

Concerning physics, the proposed model is necessarily conservative. Non-physicist - and I am afraid that also physicist - proposing theory of consciousness hardly has any other option. The model is basically thermodynamical: no quantum effects are considered although the general structure of the model can be considered also in quantum framework by allowing macroscopic quantum effects and replacing criticality and self-organization with their quantum counterparts. The vision is roughly the following.

1. *Spatiotemporal separability stating that two regions with space-like separation are un-correlated.* This assumption is natural if one believes that classical physics is all that is needed. In quantum field theory (QFT) this corresponds to micro-causality and assumption of point-like particles. In quantum theory entanglement challenges this assumption. This assumption does not make easy to understand the unity of consciousness and the coherent behaviour of living organisms.

   TGD approach differs here from the proposed one. Point like particle is generalized to 3-surface and the notion of topological field quantization brings in the notions of field body and magnetic body. Magnetic body becomes the intentional agent using biological body to its purposes. Magnetic flux tubes serve as correlates for directed attention and for negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig.** **??** in the appendix of this book) and bind disjoint systems to single quantum system in some degrees of freedom.

2. *The neuro-physiological state of brain (extracellular electric fields reflecting themselves via EEG)* is in 1-1 correspondence with the contents of phenomenal consciousness. Therefore the approach is materialistic. Phenomenal consciousness is not however doomed to be illusion (whatever this could mean) and is even allowed to have causal powers. Strong emergence (system has qualities not directly traceable to those of component systems) seems to be the philosophical characterization of their approach. Therefore the main criticism that can be made against the theory of Fingelkurts *et al* is that both phenomenal consciousness and causal powers emerge in miraculous manner as Revonsuo puts it. In TGD Universe the space-time sheet containing the smaller space-time sheet is something which does not reduce to the properties of the smaller space-time sheets.

   Macroscopic quantum effects are not considered, which I take to mean that quantum statistical determinism holds true. In this framework it is difficult to understand the non-determinism accompanying the causal powers of consciousness. The proposal seems to be that thermodynamical phase transitions are the source of causal powers.

   Even classical thermodynamics assigns to thermodynamical fluctuations at thermodynamical criticality certain kind of non-determinism: the motivation is the simple fact that experimentally this seems to be the case. Theoreticians must be in this kind of situation slightly illogical! Quantum non-determinism in microscopic scales might explain the non-deterministic features of critical systems extremely sensitive to fluctuations, even quantum fluctuations. If hidden macroscopic quantum coherence assignable to dark matter is present, the reduction to quantum level looks even more plausible. In TGD Universe dark matter identified as a hierarchy of phases with arbitrarily large effective value of Planck constant might be therefore also behind the long range fluctuations at thermodynamical criticality. Certainly these phase are crucial for biology in TGD Universe.

3. *Consciousness is localized to brain.* This includes also sensory qualia. This identification has well-known problems. First, the term "consciousness" is problematic since strictly speaking "-ness" implies that "consciousness" refers to a property of system: this leads to problems unless one is ready to accept materialism (in TGD approach consciousness is in quantum jump, between two worlds rather than in the world or a property of the world). Secondly, the localization of conscious experience in space-time is a problematic assumption: a weaker assumption is that the contents of conscious experience *is about* some region of space-time (causal diamond in TGD approach). Thirdly, even the localization of contents of conscious experience to brain only is problematic (sensory qualia). A weaker assumption is that only reflective consciousness consisting of recognition of objects of perceptive field and naming them and producing a representation of the external world and self in this manner is *performed* by brain (and by magnetic body in TGD context). Brain could be seen as a manufacturer of standardized mental images - representations - and phenomenal consciousness would correspond to sensory qualia. In TGD framework it is also possible to assume that sensory receptors are the seats of sensory qualia: neurons could serve as seats of qualia not conscious-to-us since selves form a hierarchy.

   One can consider even the possibility that sensory organs generate quantum entanglement with the target of attention by reconnection of flux tubes of the magnetic bodies so that perceiver and perceived form a single quantum coherent system. This would explain among other things the 3-D character of sensory perception requiring complicated neural computation if strictly 2-D data at retina is used to build the perception as a virtual world representation of the external world.

4. *Consciousness consists of a discrete series of mental images assignable to sharp phase transitions between thermodynamical far from equilibrium states.* There is a neuro-scientific support for this belief and the pleasant news is that it is just what TGD predicts via the identification of quantum jump as a moment of consciousness.

Basic ingredients of the model

Consider now the basic ingredients of the model.

1. *Living matter as open self-organizing thermodynamical system.* Energy flows through the system and gives rise to self-organization patterns with dissipation serving as a Darwinian selector taking care that very many initial states lead to the same final self-organization patterns. Second law translating to minimization of free energy is the essential element of the model.

    In TGD framework self-organization is replaced by 4-D self-organization for quantum superpositions of space-time sheets leading to asymptotic spatio-temporal rather than only spatial patterns accompanied by standardized mental images. EEG pattern would be one example of this. The 4-D self-organization has also 3-D counterpart since space-time evolution represents space-time correlate for dissipation. The new prediction is that the arrow of embedding space geometric time of the resulting zero energy state is opposite in subsequent state function reductions at opposite boundaries of given CD.

    Negentropy Maximization Principle (NMP) [K59] states that the information contents of conscious experience is maximal. This requires a more detailed explanation.

    (a) In TGD framework state function reduction taking place in quantum jump means a measurement of subsystem density matrix leading to an eigen-space of density matrix. Hence the final state density matrix is $N \times N$ unit matrix with a degenerate eigenvalue $P = 1/N$ giving entanglement probabilities. These probabilities are rational numbers belonging to the intersection of reals and p-adic number fields Q_p. One can therefore assign to the resulting entangled state information measure that I call number theoretic entanglement entropy obtained from Shannon entropy by replacing logarithms of probabilities with p-based logarithms of the p-adic norms of probabilities. If the p-adic prime p divides N, the entropy is negative and maximum for the largest prime power factor of N: this assigns a unique p-adic prime to the final state.

    (b) The proposal is that quantum jumps between real and p-adic states creating cognitive representations correspond to transitions transforming real state to p-adic one with this particular p-adic prime to satisfy NMP [K59]. The interpretation is that the state pairs in the superposition of state pairs represent instances of a rule. This negative entropy should not be confused with thermodynamical entropy which characterizes the lack of information about a member of ensemble.

    (c) The systems with degenerate density matrix are clearly very special systems - quantum critical in well-defined sense- and the proposal is that the hierarchy of effective values $\hbar_{eff}/\hbar = N$ of Planck constants corresponds to this kind of systems. This hierarchy would be identifiable in terms of N-furcations of space-time surface made possible by the failure of the strict determinism of Kähler action serving as the variational principle dictating the dynamics of space-time surfaces.

    (d) Clearly, several ideas are unified: quantum criticality as a presence of N degenerate states realized by space-time sheets of N-furcation, negentropic entanglement with N-fold degeneracy, hierarchy of Planck constants $\hbar_{eff}/\hbar = N$, and the idea about life as something in the intersection of real and p-adic worlds ($p = 1/N$ is rational number). Furthermore, the measurement of density matrix automatically leads to exact criticality. In dynamics without state function reduction criticality is approached only asymptotically. Note that in self-organized criticality [B2] the criticality corresponds to a minimum of potential with some flat directions in which the situation is non-deterministic at criticality.

    Second law holds true also in TGD framework for (ordinary) matter, which is not negentropically entangled and is implied by the non-determinism of state function reduction at the level of thermodynamical ensemble. NMP however governs the quantal behaviour of dark matter crucial for the generation of negentropically entangled systems responsible for various representations as approximate invariants under quantum jumps (by NMP) and here negentropic entanglement enters the game. For some years ago I considered the pessimistic scenario (see `http://tinyurl.com/ybg8qypx`) [L6] in which the negentropy assignable to negentropic entanglement is compensated by thermodynamical ensemble entropy. Experimentally the situation remains open since we do not have yet experimental methods to detect dark matter

- and certainly not dark matter in the sense of TGD. At this moment only the evolution of intelligence and science itself could be seen as a support for optimistic scenario saving the Universe from eventual heat death.

2. *Renormalization group principle.* Thinning of degrees of freedom means reducing the measurement resolution and forgetting the un-necessary details. This gives rise to abstraction at the level of cognitive and sensory representations characterized by cognitive resolution. The higher the abstraction level, the more un-necessary details are dropped from the representation. This means that reflective consciousness has a hierarchical structure.

   In TGD framework causal diamonds (CDs) within CDs define this kind of hierarchy characterized by spatial and temporal scales defining embedding space correlate for the self hierarchy. Many-sheeted space-time serves as a geometric correlate for the hierarchical structure of consciousness.

   p-Adic length scale hypothesis makes the hypothesis quantitative and means that continuous renormalization group evolution is replaced with a discrete p-adic coupling constant evolution. Finite measurement resolution implies effective discretization at space-time and embedding space level.

   Discretization is also forced by the notion of p-adic manifold (see `http://tinyurl.com/ydxw3zvm`) [K120], whose definition forces the introduction of finite length scale and angle resolutions having number theoretic interpretations. The common rational (or even some algebraic) points of real and p-adic space-time surfaces define the discrete cognitive representations at space-time level. One can say that life resides in the intersection of reality and various p-adicities.

3. *Self-organized criticality (SOC).* The sensitivity of sandpile to avalanches serves as an illustration for self-organized criticality (see `http://tinyurl.com/65bo4k`) (SOC [B2])). A very elegant characterization of SOC is as a critical point which is an attractor but such that the matrix defined by the second order partial derivatives of potential function has non-maximal rank being thus non-invertible.

   SOC inspires the notion of neuronal avalanche. Neuron groups form synchronically firing structures which end up to criticality. At criticality a fast increase of entropy takes place (the reduction of free energy per time is maximal: eat the food as fast as possible so that others do not steal it!). After this the system uploads the entropy to environment and generates negentropy for a while later compensated by entropy. There is evidence that a sequence of neural avalanches self-organize to avalanches in longer time scale. Temporal sequences of associations representing memories and predictions would be possible interpretation.

   In TGD framework this picture has interpretation in terms of the basic fractal structure of quantum jump. In quantum jump negentropic entanglement is generated: NMP dictates this. After this follows a cascade of quantum jumps (state function reductions for sub-CDs unless they are mutually negentropically entangled) and this generates ensemble entropy because the outcome of state function reduction for ordinary entanglement is random and takes entanglement entropy to zero. The process continues and certainly ceases when all sub-CDs have internal negentropic entanglement so that nothing can happen. At least after this the state function reduction to the opposite boundary of CD occurs. Whether second law is satisfied remains an open question as already noticed.

Operational architectonics of brain

This picture combined with the decomposition of local EEG to quasi-stationary segments leads to the notion of Operational architectonics of brain.

1. *Operational architectonics of brain (OA).* The hypothesis is that neuronal avalanches represent the primary building bricks of more complex brain activities. These more complex activities are constructed as operational modules (OM) from the elementary neuronal self organization patterns. This however requires synchronous firing of neurons and the challenge is to understand how this is physically possible if one assumes that disjoint regions of 3-space do not have any correlations.

The spatiotemporal patterns of extracellular electric fields are assumed to be in 1-1 correspondence with phenomenal experiences. Authors introduce also the notion of operational space-time (OST) assumed to exist within internal physical space-time (IPST). These notions remain somewhat fuzzy in the framework of classical physics.

The proposed architectonics is 4- rather than 3-dimensional. The notions of 4-D brain and causal diamond (CD) as 4-D spotlight of consciousness define the counterpart for OA in TGD framework. In TGD framework OST and IPST bring in mind p-adic and real variants magnetic body and the topological light rays parallel to them.

Braiding of the short portions of flux tubes connecting bio-molecules (say tubulins and axonal membrane) serve as a geometric correlate for negentropic entanglement and negentropically entanglement subsystems give rise to various representations as "Akashic records", which are experienced consciously.

The original view, which is *not* consistent with the recent view formulation of TGD inspired theory of consciousness, was that "Akashic records" could be read by interaction free measurement modified so that one obtains holographic representation of the data readable by using reference beam [K23] (see `http://tinyurl.com/yaq75hg6`).

The recent view is that only bit representations of memories can be read by interaction free measurements. The detectors in interaction free measurement correspond to the hologram substrate analogous to excitable lasers. The cyclotron Bose-Einstein condensates of dark matter with large value of $\hbar_{eff}/\hbar$ at the "long" portions of flux tubes and large flux sheets (with size scales exceeding even the Earth's radius) carry sensory and other representation as analogous of lasers excited in the reading of the representations.

2. *The decomposition of local EEG to quasi-stationary segments.* The proposal is that the sequences correspond to self-organization patterns for neuronal assemblies and serve as correlates simple qualia. The transitions between the quasi-stationary segments are sharp and the interpretation is as correlates for the above described phase transitions: they care referred to as rapid transitional processes (RTPs).

   In TGD framework EEG (see `http://tinyurl.com/yavjeosp`) [K95] serves as a control and communication tool for magnetic body using biological body as sensory receptor and motor instrument. There is a strong temptation to assign the quasi stationary segments of EEG to self-organization patterns assignable CDs with frequency scale in 1-1 correspondence with the scale of CD (discrete). The amplitude- and frequency modulation of the Josephson radiation emitted by cell membrane acting as Josephson junction would map neural activity to temporal patterns of EEG.

3. *Neuronal synchrony binding neuron groups to operational modules.* Authors have introduced the notion of operational synchrony (OS) to describe the needed synchrony. This synchrony should be visible in EEG channels as correlations of the quasi-stationary segments.

   In TGD context OMs would be formed and destroyed by the reconnection of magnetic flux tubes building different quantum coherent structures formed from neurons. For instance, patterns defining objects of the visual field could correspond to this kind of quantum coherent units. This process would take place in all living matter and ATP-ADP transformation could generate standardized reconnection and negentropic entanglement between distant biomolecules. The basic function of metabolism would be production and modification of negentropic entanglement

10.7.2 About The Notion Of Criticality In TGD Framework

Criticality is one of the basic notions in Finglekurts *et al*'s model and has quantum criticality as TGD counterpart. As a matter of fact, quantum criticality is a fundamental physical principle of TGD dictating the classical and also quantum dynamics so that it deserves a separate discussion. The value of Kähler coupling strength - the only parameter of theory - is fixed as the analog of critical temperature. In order to characterize the critical degrees of freedom one must say something about the Kähler metric of WCW. .

Very roughly, WCW can be seen as a generalization of the loop space of string models or of the super-space of Wheeler consisting of 3-geometries. WCW consists of all 3-surfaces in the 8-D embedding space $M^4 \times CP_2$. Holography due to 4-D general coordinate invariance implies that one can speak about WCW also as a space of 4-D space-time surfaces with space-time surface being analogous to Bohr orbit. The challenge is to generalize Einstein's geometrization of physics program and geometrize quantum physics by providing WCW with so called Kähler geometry for which the metric is characterized by single function, so called Kähler function. There are excellent hopes that this geometry is unique since already for loop spaces this is the case. The mere mathematical existence of this geometry requires infinite-D symmetries and for 4-D space-time one can indeed generalized the conformal symmetries of super string model and achieve these symmetries. WCW becomes a union of infinite-dimensional symmetric spaces for which all points are geometrically equivalent. The zero modes labelling the symmetric spaces have interpretation as non-quantum fluctuating classical variables needed in quantum measurement theory.

Consider now what criticality means in this framework.

1. The matrix defined by the second order derivatives of Kähler function with respect to WCW coordinates is degenerate as is also the WCW Kähler metric defined by a subset of these derivatives ($G_{K\overline{L}} = \partial_K \partial_{\overline{L}} K$ is the defining formula of Kähler metric in complex coordinates in terms of Kähler function K).

   The reason for the degeneracy is that WCW metric depends on real zero mode coordinates, which do not appear as differentials in the line-element. These coordinate directions of WCW correspond to non-quantum fluctuating classical degrees of freedom not contributing to WCW Kähler metric. The proposed generalization of quantum measurement theory assumes that zero modes are analogous to classical variables defining say the position of a pointer of a measurement instrument and that they are in 1-1 correspondence with the outcomes of quantum measurements in quantum fluctuating degrees of freedom and give rise to quantum classical correspondence.

2. Quantum criticality would corresponds to a situation in which maximum of Kähler function (defining most probable space-time surface in their quantum superpososition) corresponds to a Kähler metric for which some elements of Kähler metric approach zero so that the rank for the matrix defined by the non-vanishing components of the Kähler metric is reduced. The resulting degrees of freedom would be effectively zero modes inside the critical manifold but not elsewhere. The criticalities would define an infinite hierarchy analogous to the finite hierarchy of criticalities for finite dimensional catastrophes Thom's catastrophe theory (see `http://tinyurl.com/fpbsm`) [A12]: cusp catastrophe is the simplest non-trivial example.

3. At the level of conformal symmetry algebras (see `http://tinyurl.com/ycqyk49f`) [K110] defining the infinite-dimensional symmetries of TGD Universe - call them with generic name A - this hierarchy could have very elegant representation. The elements of conformal algebra are labeled by integer plus other quantum numbers so that one can write the element of algebra $a_{n,\alpha}$. Critical sub-manifolds woud correspond to sub-spaces of WCW for which the elements $a_{nk,\alpha}$ of sub-algebra A_n (k is integer) annihilate the states or creates zero norm f states from them. Here n is a non-negative integer characterizing the critical manifold. Critical manifolds would be in 1-1 correspondence with non-negative integers n. If n_1 divides n_2, the critical manifold Cr_{n_2} belongs to Cr_{n_1}.

4. In the phase transitions between different critical manifolds some quantum fluctuating degrees of freedom become local zero modes in the sense that their contribution to WCW metric at a given point of WCW vanishes at criticality. Also the reverse transformation can take place.

There are some interesting questions to be answered.

1. Criticalities form a number theoretic hierarchy and primes define "prime criticalities". Does this mean that the primes dividing integer n define the possible p-adic topologies assignable to criticality defined by n?

2. The hierarchy of effective Planck constants is labelled by integers and giving integer n corresponds to n-furcation made possible by the failure of strict determinism for Kähler action.

Could this integer correspond to the integer defining the criticality? Criticality is indeed accompanied by non-determinism realized as long range fluctuations.

3. Causal diamonds have size scales coming as integer multiples of CP_2 scale. Does this integer relate to the integer defining criticality?

4. The condition that the n characterizes finite measurement resolution in the sense A_n annihilates the physical states everywhere would de-localize the critical states outside the critical manifold. Does this mean that also finite measurement resolution is characterized by integer.

5. How the 4-D spin glass degeneracy due to the huge vacuum degeneracy of Kähler action implying breaking of strict determinism relates to quantum criticality?

These connections together with those suggested by NMP suggest that integer arithmetics is coded directly to the hierarchy of criticalities and is also basic characteristic of consciousness. This would give additional piece of support for the vision about physics as a generalized number theory (see `http://tinyurl.com/y86lo57g`) [K67].

<div align="center">Acknowledgements</div>

Chapter 11

EEG and the structure of magnetosphere

11.1 Introduction

Roughly 15 years ago I proposed the idea that Earth's magnetosphere could serve as a sensory canvas in the sense that biological systems, in particular the vertebrate brain, could have sensory representations realized at the "personal" magnetic body (MB) closely associated with the magnetosphere of the Earth [K53, K51]. EEG would make communications to and control by MB possible [K35, K83].

During fifteen years a considerable progress has occurred. At that time I did not have yet the idea about the number theoretical realization of hierarchy of Planck constants $h_{eff} = nh_0$ in the framework of adelic physics fusing the physics of sensory experience and cognition [L51, L52]. This hierarchy is crucial for understanding the basic aspects of living matter such as metabolism, coherence in long scales, correlates of cognition, and even evolution.

Also the concept of zero energy ontology (ZEO) [L86] forming now the basis of the quantum TGD was missing although there was already the about communication to past using negative energy signals. ZEO is now central role in the understanding of self-organization [L83] - not only the biological one. The new view about time predicting that time reversal occurs in ordinary state function reductions (SFRs) allows to understand homeostasis as self-organized quantum criticality [L160].

For these reasons it is interesting to consider the notion of sensory canvas from the new perspective.

11.1.1 Some basic ideas of TGD inspired quantum biology

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

1. Many-sheeted space-time allows the interpretation of the structures of macroscopic world around us in terms of space-time topology. Magnetic-/field body (MB) acts as intentional agent using biological body (BB) as a sensory receptor and motor instrument and controlling the BB and inheriting its hierarchical fractal structure. The quantum coherence of MB in turn induces the coherence of biomatter.

   That MB receives sensory input motivates the idea that MB serves as a kind of sensory canvas [K53, K51]. This idea generalizes: the information received can be also more abstract information and the layers of the MB could define a hierarchy of increasingly abstract representations of the sensory data [L98, L164].

   Fractal hierarchy of EEGs and its variants can be seen as communication and control tools of MB. Also collective levels of consciousness have a natural interpretation in terms of MB.

   MB 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. MB carrying dark matter as $h_{eff} = nh_0 > h$ phases of the ordinary 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.

   MB is identified as intentional agent using biological body as sensory receptor and motor instrument [K76, K74]. EEG and its fractal variants are identified as a communication and control tool of the MB 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 [K3, K2, K114]. The model of DNA as topological quantum computer is one application. In ZEO the braiding actually generalize to 2-braiding for string world sheets in 4-D space-time and brings in new elements.

3. ZEO makes possible a p-adic description of intentions and cognitions and their transformations to action. Time mirror mechanism (see **Fig. https://cutt.ly/DcDKyTj**) 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.

5. One can also understand genetic code. 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 way and vertebrate genetic code as correspondence between DNA and amino-acids emerges naturally [L29, L73]. This suggests that genetic code is realized at the level of dark nuclear physics. The chemical realization would provide only a secondary representation of the code.

   The recent findings support the view that the genetic code is actually universal and realized at the fundamental level in quantum TGD. Hitherto unknown realizations in living matterare suggestive [L120]. Second realization of the genetic code would be associated with communications using dark photons. It would be in terms of dark photon triplets defining 3-chords of light and realized in terms of icosahedral and tetrahedral Hamiltomnian cycles giving rise to a set of bio-harmonies having interpretation as correlates of emotions at the molecular level [L12, L100, L120]

11.1.2 Some questions

MB has roles as both sensory canvas and controller of the ordinary matter with standard value $h_{eff}0nh_0 = h$ using EEG and its fractally scaled variants for these purposes. This raises some questions.

Could magnetosphere be a living and metabolizing organism?

h_{eff} is a measure for algebraic complexity and analogous to IQ. h_{eff} tends to be reduced spontaneously. Metabolic energy is needed to preserve the distribution of h_{eff} and also to drive self-organization.

Could one think that MB is a higher level organism utilizing energy arriving from the Sun. Could solar radiation and solar wind provide metabolic energy to the Earth's magnetosphere (MS) accompanied by "personal" MBs. Could MB also receive metabolic energy produced by photosynthesis at the surface of the Earth?

Could the rotating inner MS transfer energy from solar radiation and transfer it to the night-side of the Earth. Could also solar wind provide energy to magnetopause, plasma pause, plasma sheet and neural sheet which are self-organizing highly dynamical structures? Could these regions of the MS serve as a sensory canvas?

Could the anatomy of the magnetosphere be regarded as a scaled variant of the anatomy of a vertebrate?

The anatomy of the MS (see the illustrations of `https://cutt.ly/kcDKzqL`) resembles that of a vertebrate. The TGD Universe is fractal and this inspires the question whether there is something deeper behind this resemblance: could the anatomy of the MS be scaled up anatomy of the organism? This would be natural if the "big" part of the personal MB assignable to the MS serves as a sensory canvas.

The correspondence need not be a strict scaling. Conformal transformations define a more general correspondence and the correspondence respecting only topology is even more general correspondence.

Could one gain useful insights by formulating this idea quantitatively? Could the scales of the body parts of the vertebrate(say human)body and MS correspond to each other at the order of magnitude level? Could the ratios of scales for the corresponding parts of the MS and human body be nearly the same?

The sensory canvas idea is discussed earlier at the level of the brain in [**?**, K51] but restricting the consideration to the cyclotron frequencies for magnetic fields involved with various parts of the MS. The distance of the part of the MS gives an upper bound for the frequencies involved with the communications between it and the biological body. Could one associateEEG bands with the parts of the MS? The frequency scale correspondence indeed predicts frequencies in EEG range and it is possible to assign EEG bands to the parts of the MS.

11.2 The structure of the magnetosphere of Earth

It is interesting to try to relate the model for sensory representations to the structure of Earth's MS. To achieve this, I will provide a brief novice's overview about the structure of MS. I will use partially TGD based language in which magnetic field lines are replaced by magnetic flux tubes and the formation of the plasma corresponds to the leakage of the supra currents from the magnetic flux tubes.

I will also briefly consider TGD based qualitative models for the phenomena, many of which are not well understood in Maxwellian theory. Examples of such phenomena are Alfven waves which are not proven to result from Maxwellian theory, and magnetic dynamo of Earth whose working mechanism is not really understood. Also the mechanism of auroras becomes very concrete when field lines are replaced with flux tubes [K18].

11.2.1 Magnetosphere

Solar wind [F5, F14, F13] determines the large scale structure of the magnetic field of Earth to a high extent. The basic structural components are transition regions and regions between them.

1. At the bow shock the solar wind arriving at a supersonic velocity of 500 km/s encounters Earth's magnetic field and is transformed to a subsonic flow and dissipates energy inside magnetosheath where the plasma is denser and hotter than in the solar wind. The distance of the bow shock is roughly 12-14 R (R denotes Earth's radius).

2. The shocked solar wind cannot penetrate Earth's magnetic field and a cavity called MS is formed. Interplanetary magnetic field and MS is separated by a transition region called magneto-pause, which is accompanied by a plasma mantle. At the day-side magneto-pause is at a distance of about 10 R but when the solar wind is particularly strong, it can move down to 6-7 R. At the night side MS is stretched into long cylindrical magneto-tail of length about 1000 R and radius about 20 R.

MS consists of clearly separated regions with widely different densities and temperatures. The main division is into the inner and outer MSs. In the inner MS (also known as plasma sphere) magnetic field lines are co-rotating with the Earth: in the outer MS they are stationary.
Boundaries are the regions at which self-organization typically occurs.

1. Magneto-pause contains an ionic current determined by the discontinuity of the magnetic field and orthogonal to it. This region is highly dynamic.

2. The boundary between inner and outer MSs is known as plasmapause. Also this region is dynamical and its shape and size varies as response to solar wind. The analog is liquid is the boundary between two compressible liquid flows: other flow is rotating and other flow stationary.

3. Outer MS consists of a plasma sheet, which is between magnetic lobes carrying magnetic fluxes, which have opposite directions and are bounded by the magnetopause. In the plasma sheet the magnetic flux flows between the northern and southern lobes to give rise to closed field lines. Neutral sheet is in the equatorial region and starts at $10 \pm 3R_E$. Also this region is dynamic.

Both magnetopause, plasma pause and neutral sheet are expected to be highly dynamical self-organizing regions and are especially interesting from the point of view of magnetospheric consciousness.

11.2.2 Outer magnetosphere

Magnetic lobes

The outer MS at the night side, magneto-tail, consist of northern and southern magnetic lobes which are cavities having very low ionic density of about .01 ions per cubic cm. The low density can be understood as resulting from the absence of the solar wind in this region. By Maxwell's equations the magnetic field is approximately constant in the region where the flow lines are parallel (if sources can be neglected). According to [F4] the value of the magnetic field is about 30 nT in the interior of the lobes. The relatively strong magnetic field inside lobes serves as a magnetic energy battery feeding energy to the plasma sheet.

Magneto-tail is a cylindrical structure with radius of order $R_m = 20R$. Magnetic lobes extend up to $r \sim 1000R$. The magnetic field lines remain actually closed. In the TGD framework this means the existence of a closed supra-current circuitry formed by the magnetic flux tubes.

Plasma sheet and magneto-pause

Magnetic lobes are separated by a plasma sheet in the equitorial plane consisting of hot (5×10^6 K), low density plasma (.3-.5 ions/cm^3 as opposed to .01 ions/cm^3 inside lobes) with magnetic field ~ 10 nT. Plasma sheet extends from $8R$ to about $60R$ and has thickness of order few R, and gets thinner with increasing distance. Plasma sheet disappears at the so called neutral point, where the magnetic field vanishes. In the plasma sheet the magnetic flux from the southern lobe flows to the northern lobe. Near the Earth plasma sheet reaches the high latitude auroral ionosphere. The value of the magnetic field immediately above the magnetic sheet is 20 nT.

In the TGD framework the plasma sheet can be seen as resulting from the leakage of the supra currents from the magnetic flux tubes of Earth's magnetic field to a larger space-time sheet. This supra-current leakage would be caused by the inertia of the ions and electrons in the region where the magnetic flux tubes are highly curved. The leakage occurs also in the magneto-pause, where the tangential component of the magnetic field is discontinuous and a surface current orthogonal to B generating the discontinuity flows.

In the magneto-pause the magnetic flux tubes of the inner and outer region are parallel. The reconnection of the parallel flux tubes of the magnetic fields of Earth and Sun allows the transfer of the ions of the solar wind to the MS. Magneto-pause is accompanied by a plasma mantle, which could be partially due to the leakage of ions to a larger space-time sheet accompanying the reconnection process.

There is a convective flow of ions towards the plasma sphere along the plasma sheet. In the TGD framework this motion must take place at a larger space-time sheet or involves a hopping between magnetic flux tubes: in both cases a breaking of the propposed super-conductivity is implied.

Plasma sheet also has a boundary layer in which the tangential component of the magnetic field is discontinuous. This requires a surface current orthogonal to the axis of the sheet. This current would result as the ions from the magnetic flux tubes leak out from flux tubes to a larger space-time sheet by their inertia in the highly curved portion of the flux tube caused by the tangential discontinuity.

Cusps

Southern and northern cusps are funnel-shaped regions which on the day side consist of closed highly compressed flux tubes of dipole field and on the night side of almost open flux tubes stretched deep into the magnetospheric tail. In this funnel magnetic field is orthogonal to the magneto-pause and the magnetic flux tubes of the solar magnetic field can penetrate the MS. This implies that solar plasma contained in the solar magnetic field lines penetrates deeply into the magneto-tail by reconnecting with the field lines of Earth's magnetic field near poles. This gives rise to auroras [F15].

Reconnection can be seen as resulting from the penetration of the solar magnetic flux tubes at the upper boundary of the magneto-pause along the plasma sheet to highly stretched flux tubes along the boundary of the plasma sheet. The transformation to open flux tubes can happen only if the solar flux tubes reconnect with the flux tubes of the solar magnetic field penetrated into the plasma sphere. Thus auroras can be seen as a phenomenon involved with the boundary between plasma sheet and lobes.

Cusps, and to some extent also plasma mantle, serve as a channel along which the solar wind feeds "magnetometabolic" energy to the MS needed to run the geodynamo system [F2] (the notion of super-conducting geodynamo will be introduced later). The dipole field generated solely by the convective currents in Earth interior would die out in a few thousands of years. The field inside lobes serves as a storage of magnetic energy and is recharged by the energy of the solar ions leaking into the magnetic tail in the reconnection process. One could see the cusps also as a communication channel between solar and Earth's magnetic structures, kind of magnetic "ears" of magnetic Mother Gaia.

11.2.3 Basic structure of the inner magnetosphere

Inner MS is a toruslike structure whose extension varies between 4R (day side) and 8R (night side). In the inner MS the typical density is about 1 ion per cubic centimeter.

Inner MS is bounded by a transition layer of thickness of $\sim R$ (magneto-pause). In this region the density of the ions drops rapidly.

Inner MS contains plasma sphere whose radius varies in the range 2R-4R at day side and 2R-6R at night side. Plasma has an ionospheric origin. The density of the cold plasma consisting mainly of protons ($T \sim 1$ eV) sphere varies in the range $10 - 10^3$ ions/cm^3, whereas the temperature is $\sim 5 \times 10^3$ K. The cold, dense plasma of the plasma sphere is frozen around magnetic flux lines which co-rotate with Earth.

In the TGD framework this means that flux tubes co-rotate and thus change shape. In the equatorial plane the density of the plasma sphere drops sharply down to ~ 1 ions/cm^3 at $r = 4R$. This transition region is known as a plasma pause. During magnetic storms the outer radius decreases since the pressure of the solar wind compresses the plasma sphere. The day-night variation of the shape of the plasma sphere is rather small. Within this region the magnetic field in a reasonable approximation has dipole shape with radiation belts forming an exception.

11.2.4 Radiation belts and ring currents

Plasma sphere (i.e. inner magnetosphere) contains the inner and outer van Allen radiation belts [F3] (extending from $2R$ to $4R$ at the day side and from $2R$ to $9R$ at the night side).Inner radiation belt extends from distance $.2R_E$ to $2R_E$. Outer radiation belt extends from distance $3R_E$ to $10R_E$ and is regarded as part of non-rotating outer MS. Both the inner and outer belts extend up to latitude of 60 degrees. The boundaries of the belts follow magnetic field lines except at the Northern and Southern tips. This region contains ring currents.

One of the functions of the radiation belts is to prevent the penetration of the biologically harmful high energy cosmic rays to the ionosphere. In fact, the inner protonic belt results from the decay of the cosmic ray neutrons to protons. Second function (in TGD universe!) is to act as a part of a controlled dynamo system giving rise to the MS of Earth (for the standard theory of geodynamo see [F2]).

It has been found that the energies of the ions in the radiation belts are much higher than one might expect [F6]. This might be understood if part of the ions runs as supra currents along the magnetic flux tubes. Super-conductivity is broken only by the leakage of the supra currents from the magnetic flux tubes. This could explain the success of magnetohydrodynamics based on the assumption of effective super conductivity.

Inner radiation belts

There are actually two separate inner radiation belts: the one containing protons and the one containing electrons. Protons in the inner belt have energies at 10-100 MeV range and readily penetrate space crafts. The inner radiation belts are concentrated around the equator in the range $(1.1 - -3.3)R$ (these numbers depend on the conventions used and should not be taken too literally). In the protonic belt the maximum of the flux density is at $2R$: in the electronic belt the maximum flux density is at about $1.4R$. The inner belts are relatively stable and there is no night-day difference. The inner belts feel magnetic storms and vary with the 11 year period of solar activity.

What is interesting is that the inner belts are also sensitive to human technology. The inner belt has lowered above the East Coast of US from 300 km to 10 km [?]: this process is associated with power transmission along magnetic field line and the usage of the ionosphere-resonance frequency 60 Hz as the frequency of household current.

During the last decade two new belts have formed inside inner belts [F5], [?]. The new electronic belt has maximum electron flux at $r \sim 2R$ (earlier flux maximum was at $r \sim 1.4R$). The second newcomer consists mostly of O^+ ions but contains also He^+. This process has been seen as a part of magnetic re-self-organization process occurring in the scale of the entire helio-magnetosphere implying rapid changes of planetary MSs [?].

Outer radiation belt

Outer belt contains mainly electrons with energies up to 10 MeV and is produced by the injection of charged particles during geomagnetic storms. This makes the outer belt much more dynamical than the inner one. The cross section of the outer radiation belt is banana shaped. The outer belt ranges from 3R to 6R (at night side). The maximum for the density of electrons above MeV energy occurs at 4R.

Ring currents

Radiation belts contain ring currents. Electronic ring current rotates in the same direction as Earth whereas protonic current runs to the opposite direction. In the outer belt only electronic current is present. Quiet time ring current in the inner electronic *resp.* protonic belts consist mainly of hydrogen ions resp. electrons but during magnetic storms also O^+ ions are present (note however the presence of the new O^+ belt). Ring current has the effect that the magnetic field gets stronger at the outer side of a given belt and weaker at the inner side.

11.3 Frequency scales associated with the magnetosphere

11.3.1 Cyclotron frequencies in magnetic lobes and plasma sheet

The values of important magnetic transitions frequencies in various regions of the MS are crucial if one wants to construct a general vision about sensory and motor representations at the magnetic sensory canvas. In the inner MS dipole approximation allows to estimate the spatial dependence magnetic transition frequencies.

In magnetosheath and magnetolobes the average values of the magnetic field are 10 nT and 30 nT respectively. Immediately above the magnetosheath the value of the magnetic field is 20 nT. Magnetosheath could thus allow place coding by the magnetic transition frequency scale whereas magnetolobes are not taylor made for this purpose. Note that the thickness of the magnetic flux tubes in the field of 10 nT $= 2^{-9}B_E$, $B_E = 5 \times 10^4$ nT is from the quantization of magnetic flux equal to about 55 μm and thus corresponds to a biological length scale. This length scale corresponds to the p-adic length scale $L(11, 16)$ $(L_p(n) = p^{(n-1)/2}L_p)$. Already this encourages to think that plasma sheet might be involved with bio-control.

The strength of the interplanetary magnetic field depends on the intensity of solar wind and varies between $.2 - 80$ nT and has average of 6 nT. Interestingly, the maximum value 80 nT corresponds to the p-adic length scale $L(173) = 20$ μm.

1. Proton

In the case of proton there are three especially interesting frequencies to be considered: cyclotron frequency $f_c = eB/2\pi m_p$, spin flip frequency and the frequency of combined spin flip and $\Delta n = 1$ transitions. The frequencies of these transitions in magnetic field of $.5 \times 10^{-4}$ T are $f_c = 300$ Hz, $f_{flip} = 838$ Hz, $f_1 = 532$ Hz and $f_2 = 1138$ Hz. In a field of 10 nT the values of the transition periods $T = 1/f$ are $T_c = 16.7$ sec, $T_{flip} = 6$ sec, $\tau_1 = 9.3$ sec, and $\tau_2 = 4.4$ sec. For a field of 30 nT the values are obtained by dividing by three. Plasma sheet contains also He^{++} and He^+ ions and for these the cyclotron times are 2τ and 4τ. For O^+ ion which is also present cyclotron time varies between 1 min 20 s and 4 minutes. All these time scales are typical time scales of human consciousness. For the interplanetary magnetic field protonic cyclotron times are 13.9 min, 27.8 sec, and 2.1 sec for the minimum, average, and maximum respectively.

2. Electron

For electrons the cyclotron frequency is 282 Hz for 10 nT so that electronic cyclotron transitions cannot represent ionic cyclotron transitions in brain (if they occur at the flux tubes of Earth's magnetic field!). Spin flip combined with cyclotron transition represents however an important exception. In this case the non-vanishing transition frequency is due to the anomalous magnetic moment of electron and the frequency in the reference field of $.5 \times 10^{-4}$ T is 2255 Hz. This gives $T(e) = 2.24$ sec. Note that also $n = 3$ protonic cyclotron transition gives rise to nearly the same period.

It is interesting to notice that these time scales are important time scales of human consciousness and that both protonic spin flip time scale and $T(e)$ nearly half of the 5 second time scale associated with the Comorosan effect [I57, I17] discussed in [K122]. If Earth's magnetic field is accompanied by dark flux sheets in entire MS carrying field $B_{end} = 2B_E/5$, then the value of $T(e)$ would become $T(e) = 5$ seconds for $B_E = 11.2$ nT.

To sum up:

1. The average magnetic field in plasma sheet corresponds to a definite p-adic length scale.

2. The mysterious time scale of the Comorosan effect pops up as a basic magnetic transition time in magnetic lobes and plasma sheet and is related to bio-control by enhancing catalytic rates: it is however essential that the "dark" counterpart $B_{end} = 2B_E/5$ of B_E associated with living matter is in question.

3. Plasma sheet is found to be a complex self-organizing system with the velocity distribution of ions representing complex features (such as "eyes" and "wings" !) [F9].

These findings force to seriously consider the possibility that plasma sheet and magnetopause and perhaps even magnetic lobes might perform high level bio-control utilizing MEs and

Region	R/R_E range	f/Hz range	EEG bands
plasma sheath	...-1000	...-0.049 (20 s)	
inner MS	1-10	49.0-4.9	$\theta, \alpha, \beta, \gamma$
plasmapause	4.0-5.0	12.5-10.0	θ, α
inner van Allen belt	.2-2.0	75.0-7.5	θ, β, γ
outer van Allen belt	3.0-10.0	5.1-1.5	δ
day-side magnetopause	8.0-10.0	6.25-4.9	θ
night-side magnetopause	10.0-200.0	4.9-.2 (5 s)	δ
plasma sheet	10.0-60.0	4.9-.82	δ
neutral sheet	7.0-13.0	7.0-3.8	δ

Table 11.1: The frequency scales f assignable to the size scales R of various regions of the MS (MS)

supra-currents along magnetic flux tubes forming the extension of the endogenous magnetic circulation to the entire MS.

11.3.2 Estimates for the natural frequency scales assignable to various parts of the magnetosphere

The part of MS having distance R from the center of Earth corresponds naturally to frequency scale $f = 1/R$. This allows a rough estimate for the frequencies needed for the communications between various parts of MS. What is highly non-trivial is that these scales are in EEG range and that one can even assign EEG bands to the regions of MS.

The basic correspondence is given by the formula $f = 1/R$: favored frequencies are harmonics of this fundamental frequency. Takin the Schuman resonance frequency 7.8 Hz as reference and Earth radius as length unit, one has

$$\frac{f}{Hz} = \frac{R_E}{R} \times 2\pi \times 7.8 = \frac{R_E}{R} \times 49$$

Table 11.1 summarizes the frequency scales assignable to the size scales of various regions of the MS.

Some remarks are in order.

1. Plasmapause corresponds to frequency range 10-12.5 Hz containing alpha band and also frequencies often included in theta band.

2. Neutral sheet corresponds to the range 3.8-7.0 Hz above delta band.

3. The outer van Allen belt corresponds to delta band in EEG. Therefore also the delta band of EEG dominating during deep sleep appears naturally also at the day-side. Note that outer van Allen belt belongs to the non-rotating outer magnetosphere.

4. Night-side magnetopause and plasma sheet contain frequencies in delta band which dominates during deep sleep.

5. The lower bound for frequencies from the size of magnetopause at night-side corresponds to the period 5 s assignable to the Comorosan effect [I57, I17] [K122].

6. Day-side regions of the MS correspond to θ, α, β and γ bands.

These findings encourage to ask whether the communications between the brain (and possibly also other parts of body, at least central nervous system) and MS could be in terms of EEG.

Region	$y = R/R_E$ r	r
Earth	1.0	3.5 mm
plasmapause	4.0-5.0	1.4-1.7 cm
inner van Allen belt	0.2-2.0	.84-7.4 mm
outer van Allen belt	3.0-10.0	1.3-4.2 cm
day-side magnetopause	8.0-10.0	2.8-3.6 cm
night-side magnetopause	10.0-200.0	3.6-80.0 cm
plasma sheet length	10.0-60.0	3.6 cm-21.5 cm
plasma sheet thickness	5.0-10.0	1.8 cm-3.6 cm
neutral sheet	7.0-13.0	2.4-4.6 cm

Table 11.2: The scaled down radii $r = .5 \times 10^{-9} R = y \times 3.5$ mm for various regions of the MS (MS) with radius $R = yR_E$

11.3.3 Could one regard magnetosphere as a scaled variant of biological body?

Sensory canvas hypothesis allows two options. MS could be the sensory canvas for the brain or for the entire nervous system and body. The structure of the MS suggests that it could correspond to a sensory map of the entire body.

1. Inner MS could be the sensory canvas for the brain or part of it and Earth perhaps to some nucleus, say pineal gland.

2. Magnetopause would correspond to skin and magnetic lobes would correspond to to the interior of the body. Plasma sheet would correspond to the interior of the body and the neutral sheet at which the direction of magnetic field changes to the spine.

3. Left and right body parts would correspond to northern and southern magnetic lobes.

4. The inner MS could correspond to the part of the nervous system assignable to the head and neck and involve cranial nerves associated with vision, hearing, and smell. Outer MS could correspond to tactile senses.

5. The neutral sheet at the night side of the outer MS could correspond to the spinal cord, which has dorsal and ventral parts which could correspond to flux tubes with opposite fluxes.

6. Plasma sheet would contain the spinal nerves leading to the magnetopause as the counterpart of the skin.

The frequency-distance correspondence suggests a rather detailed correspondence between EEG bands and magnetospheric regions. Delta band dominating during deep sleep should correspond to the magnetopause, plasma sheet, and neutral sheet.

A quantitative formulation for this hypothesis is in terms of fractality. The scales of the body and corresponding parts of the MS should be in constant proportion and the ratios of the corresponding scales should be the same for body and MS.

Magnetopause has thickness $D \simeq 1000$ km. Magnetopause corresponds to skin and the first guess is that the ratio of smallest and largest length $L = 200R_E$ associated with the MS has same value as the corresponding ratio for human body. One has $D/L = 1340$. The ratio the human body length $l \sim 1$ m of the human skin thickness $d \simeq .5$ mm is $l/d = 2 \times 10^3$. The order of magnitude is same. $D/L = 2 \times 10^3$ would give a perfect fit.

$R_E = 6.37D$ and the ratio $x = d/D = .5 \times 10^{-9}$ allows to scale down various scales $L = yR_E = 6.37yD$ of MS to $xL = y \times 3.5$ mm to see whether they are consistent with the corresponding scales of body suggested by the above intuitive considerations.

Table 11.2 summarizes the scaled down length scales for various regions of the MS.

Using these scaled down estimates one can try to identify the correspondence between body parts of human body and parts of MS.

Region	d	R
DNA codon	1.0 nm	29 cm
lipid layer cell membrane	2.5-5.0 nm	.73-1.45 m
tubulin	10.0 nm	2.9 m
cell nucleus	1.0 μm	290 m
cell	2.5-25.0 μm	.73-7.3 km
neuron	2.5-100.0 μm	.73-29.2 km

Table 11.3: The scaled up size scales $R = .29 \times 10^9 d = y \times 29$ cm for basic biomolecules, cells, and neurons with size scale $d = y$ nm

1. Pineal gland has radius 3.7 mm which is not far from the size scales 3.5 cm assigned to Earth.

2. Most scales correspond to the scales of brain nuclei which have diameter of 5 cm. Apart from pineal gland these structures of MS are expected to appear as pairs associated with Northern and Souther magnetic lobes.

3. Night-time magnetopause would correspond to a structure with radius .76 m and could correspond to the entire body. Plasma sheet corresponds to size scales in the range $3.6 - 21.5$ cm, perhaps the upper limit corresponds to brain size scale.

One can also ask whether the length scales of DNA and proteins, cell membrane thickness, size scale of cell nucleus, and the range of size scales for cells and neurons could have counterparts at the level of MS and whether one might identify possible candidates for the counterparts for these structures.

Given the size scale d of the molecular or cellular structure the scaled up system should have size scale $R = .29 \times 10^9 d$. System with size 1 nm - roughly the size scale of the DNA codon - corresponds to a system with a size scale 29 cm not far from the size of the brain hemisphere. DNA letter with size scale .33 nm corresponds to scale 9-7 cm. Could the interpretation of the counterpart of the DNA codon as brain hemisphere make sense? Could the brain consisting of three parts be seen as a counterpart of the genetic codon with 3 letters?

The assignment of genetic codon with the brain does not seem to make sense but here an old idea about a hierarchy of codes is suggestive. Ordinary genetic code would correspond to Mersenne prime $M_7 = 2^7 - 1$ and have 2^6 codons. Memetic code assignable to Mersenne prime $M_{M_7} = M_{127} = 2^{127} - 1$ would have 2^{126} codons representable also as sequences of 21 ordinary genetic codons. One could say that one has an abstraction hierarchy in which genetic code corresponds to 64 statements and memetic codons to statements about these statements.

Individual brains do not certainly give rise to analogs of DNA sequences. Here however the notion of magnetic body (MB) providing an abstracted representation of the brain and the biological body is suggestive. The images of neurons at MB near to each other at MB need not be near to each other at the brain level: it is enough that they are functionally similar. This would realize the analog of RAM.

Pietch [?] found that the shuffling of the neurons of the salamander brain does not lead to the loss of its functionality. This supports the view about the brain as an analog ofRAM. In an analogous way human and perhaps also other than human brains could serve as analogs for the codons of memetic code mapped to the MB to form linear or even higher-dimensional analogs of the genome. Cultural evolution could mean the emergence of the memetic code.

One can also consider other size scales. **Table 11.3** summarizes the scaled up size scales for basic biomolecules, cells, and neurons.
From the table one finds that the lipids of the lipid layers of cell membrane still correspond to human size scales. This inspires the crazy idea that perhaps humans and possibly other higher animals correspond at the level of MB to analogs of lipids for cell membrane like structures. Larger structures - such as cell and neuron - could correspond to social structures reponsible for collective consciousness generated in the cultural evolution.

11.4 The model for h_{eff} preserving communications based on variable value of β_0

Nottale's gravitational Planck constant $\hbar_{gr} = GMm/v_0$ contains the velocity parameter v_0 as the only parameter. In the perturbative expansion of the scattering amplitudes $\beta_0 = v_0/c$ appears in the role of fine structure constant.

There is however a problem.

1. The model for the effects of ELF radiation on vertebrate brain inspired by a generalization of Nottale's hypothesis by replacing the total mass M in the case of Earth by $M_D \simeq 10^{-4} M_E$ suggests that in this case the dark particles involved couple only to a part of mass identifiable as dark mass M_D.

2. Since only GM appears in the basic formulas, the alternative option is that the value of G is reduced to G_D. This conforms with the fact that in the TGD framework CP_2 length is the fundamental parameter G is a prediction of the theory and therefore can vary.

3. A further option is that the parameter $\beta_0 = v_0/c \leq 1$ is variable and equals to $\beta_0 = 1$ or to a value not much smaller than 1, say $\beta_0 = 1/2$.

These three options are discussed in [L130]. The cautious conclusion is that the third option is the most plausible one. In the sequel I will develop a model for the communications between dark matter phases with $h_{eff} = nh_0$ satisfying $h_{eff} = h_{gr}$ based on the third option. One can consider two options for the communications depending on whether the value of h_{eff} changes as (for instance) in the communications between dark and ordinary matter or whether it is preserved.

1. If the value of h_{eff} can change, energy conservation for $E = h_{eff}f$ allows energy resonance whereas the frequency changes. The simplest option is that the dark photon transforms to say ordinary photon with the same amplitude

2. If the value h_{eff} is preserved, one has both energy and frequency resonance. In the case of cyclotron radiation, the simultaneous occurrence of energy and frequency resonances poses strong conditions on the values of the magnetic fields, the values of charged particle masses, and the parameter β_0 at the ends of the communication line.

11.4.1 Conditions for frequency - and energy resonance

The condition that the frequency is the same at both ends implies for cyclotron frequencies $f_c = ZeB/2\pi m$ the condition

$$\frac{Z_1 B_1}{m_1} = \frac{Z_2 B_2}{m_2} \quad . \tag{11.4.1}$$

For $h_{eff} = h_{gr}$ the condition that the cyclotron energy $E_c = GMZeB/v_0$ at both ends is same implies

$$\frac{Z_1 B_1}{v_{0,1}} = \frac{Z_2 B_2}{v_{0,2}} \quad . \tag{11.4.2}$$

Together these conditions give

$$\frac{m_1}{m_2} = \frac{Z_1 B_1}{Z_2 B_2} = \frac{\beta_{0,1}}{\beta_{0,2}} \quad . \tag{11.4.3}$$

For instance, if the two particles are proton and electron, one obtains

$$\frac{\beta_{0,1}}{\beta_{0,2}} \simeq \frac{m_e}{m_p} \quad .$$

This ratio is is consistent with the values $\beta_{0,2} = 1$ and $\beta_{0,1} = 2^{-11}$ in the accuracy considered. Is this a mere accident?

11.4.2 Resonance conditions for communications from the Earth's surface to the magnetosphere?

The simplest option is that the interacting particles have the same values of mass and β_0 and magnetic fields are identical. This is achieved if the flux tubes have constant thickness. Whether this is the case is not clear.

However, the idea that the flux tube picture about magnetic fields is locally consistent with the Maxwellian view inspires the question whether also the magnetic field strength at the flux tubes of B_{end} behaves like $B_{end} \propto 1/r^3$ as B_E in dipole approximation behaves.

B_{end} is by flux conservation proportional to $1/S$, where S is the area of the flux tube. sOne would have $S \propto r^3$. The constancy of B_{end}/m would suggest $m \propto 1/r^3$. If the charged particles are ions characterized by the A/Z ratio.

This would suggest that the regions of tubes/sheets in frequency resonance are at distances

$$\frac{r}{r_0} = (\frac{Z}{Z_0})^{-1/3}(\frac{A_0}{A})^{-1/3}$$

for ions Z_0, A_0 at the surface of the Earth. The heaviest ions would be nearest to the surface of Earth. Energy resonance condition

$$B_{end}(r)/\beta_{0,2} = B_{end}(R_E)/v_{0,1}$$

would give the additional condition

$$\frac{\beta_{0,2}}{\beta_{0,1}} = (\frac{R_E}{r})^3 = \frac{Z}{Z_0} \times \frac{A_0}{A} \quad .$$

β_0 would be quantized and would decrease with the distance.

11.4.3 Magnetosphere as sensory canvas

TGD leads to a model of the "personal" magnetic body (MB) as being associated with the Earth's MS. Different regions of the body and brain would be mapped to regions of the MS, which would give rise to sensory representations at the personal MB [K53, K51]. Personal MB, which would have size scale of at least of the Earth's MS, would also control biological body.

1. An interesting finding relates to the values of the magnetic field $B_{end} \simeq 2B_E/5$ (perhaps identifiable as the monopole flux part of B_E) and the value of $B \sim 10$ nT in the magnetotail at the night-side of the Earth.

   One has $B/B_{end} \sim 2^{-11}$ so that for dark proton-dark electron communications between the Earth's surface and this region of outer MS the resonance conditions would be satisfied for $\beta_0 = x$ and $\beta_0 = 2^{-11}x$, where $x < 1$ not far from unity.

2. Could the parameter β_0 characterize particles and act as a tunable control parameter allowing to achieve energy resonance? Also the values of B are tunable by changing the thickness of the flux tubes as a kind of motor action of MB.

   This idea can be applied to the h_{eff} preserving communications between biological body and the MS of the Earth.

1. The quantum coherence condition suggests that the communications are optimal when the wavelength of dark photon is larger than the distance considered: $\lambda > r$ or equivalently the frequency satisfies $f \leq c/r$ (one has $c = 1$ in the units used). If the structure of the MS has distances from the Earth's surface below r_{max} then the frequencies $f \leq 1/r_{max}$ are optimal.

2. Given the distance r_{max} and assuming $B = B_{end}$ at the surface of Earth, one obtains for the cyclotron frequencies the condition

$$f_c = \frac{ZeB_{end}}{2\pi m} \leq \frac{1}{r_{max}} \quad .$$

For instance, EEG frequency 10 Hz corresponds to 3×10^7 m. The cyclotron frequency of DNA sequence does not depend on its length and composition since DNA has constant charge per unit length. One has $f_c \simeq 1$ Hz so that the corresponding distance is $r = 3 \times 10^8$ m, that is $r = 46.9 R_E$.

Remark: B_{end} probably has a spectrum. Music experiences relies on frequency scale and if the audible frequencies correspond to cyclotron frequencies then eB_{end}/m is variable. This suggests that the spectrum of B_{end} covers at least the range of the audible frequencies spanning roughly 10 octaves [K79].

11.5 Further observations making bells ringing

There are direct observations suggesting that magnetosphere at the level of MB could be a quantum coherent system.

11.5.1 Magnetosphere as self-organizing system

ZEO is now in a central role in the understanding of self-organization [L83]. The new view about time predicts that time reversal occurs in ordinary ("big"") state function reductions (BSFRs) occurring for dark matter at MB whose quantum coherence controls ordinary matter. This has several implications.

1. Dissipative processes occurring in reversed time direction looks like self-organization in the standard time direction. The dissipation of the time reversed system looks like extraction of energy from the environment - an active gain of metabolic energy.

2. Quantum criticality has a description in terms of quantum fluctuations with $h_{eff} > h$ and homeostasis can be understood as self-organized quantum criticality. Dissipation makes possible for the system to stay near criticality contrary to what criticality means by definition.

3. A further implication is that BSFRs look in all scales for an observer with standard time direction like time averages of classical deterministic time evolutions leading to the final 3-D state of BSFR and associated with the final zero energy state. Hence the Universe looks classical in ZEO and the question about the scale in which quantum behavior transforms to classical becomes obsolete. The findings of Minev *et al* [L75] support this picture [L75].

The view that MS is a self-organizing system is supported by the observations accumulated about the magnetic self-organization of the solar system during the last decades reviewed in [**?**]. According to this report we are living a period of transition basically due to a penetration of highly charged material from the interstellar space into the interplanetary space from an interstellar plasma structure containing various kinds of magnetic structures.

This energy feed is inducing various kinds of processes affecting not only the atmo-, iono-, and MSs of Earth but also solar and other planetary MSs. Also interplanetary transmitting properties are affected. The Schumacher-Levy comet, which for few years ago collided with Jupiter and among other things a induced plasmoid train and had dramatic effects on Jupiter's MS, is referred to as a "Comet" SL-9 in [**?**]. I am not sure whether "Comet" was meant to suggest that SL-9 was actually a plasma magnetic structure from the interstellar space. There is also evidence that we are moving to a similar temperature instability that occurred about 10.000 years ago and which might have initiated the development of the bicameral society in turn leading to the modern society much later.

This process could be also seen as a re-self-organization and evolution of consciousness in solar length scale as a reaction to the encounter of heliospheric and interstellar magnetic intelligences. The penetration of interstellar plasmoid like structures to the interplanetary space through the solar magneto-pause could be interpreted as a failure of the magneto-immune system of the helio- MS. The interaction of the planetary MSs with these intelligent (benevolent?) plasmoid like structures would in turn induce the re-self-organization. Needless to say, the interaction of the two intelligences might have far-reaching consequences for the evolution of ordinary life.

11.5.2   Connection with the Comorosan effect

Comorosan effect means that the irradiation of living manner by visible light over a period which is a multiple of $\tau_C = 5$ seconds implies enhanced catalytic activity [I57, I17]. According to private communication, this effect is not restricted to living or even organic matter. TGD explains the effect [K122] but the deeper explanation of the time scale of $\tau_C = 5$ seconds has remained a longstanding challenge.

The 5 second time scale associated with Comorosan effect is the spin flip time scale associated with proton's $\Delta n = 1$ cyclotron transition in the field of $B_{end} = 13.32$ nT (which could correspond to the value of $B_E = 5B_{end}/2 = 33.3$ nT in magnetic lobes). τ_C is also associated with proton's $\Delta n = 3$ cyclotron transition and the electronic cyclotron spin flip in the field of $B_{end} = 2/5B_E = 11.2$ nT (plasma sheet). Lungs contain magnetic particles giving rise to ~ 10 nT magnetic field and thus for $B_{end} = 2B_E/5$ to $n = 3$ protonic cyclotron transitions and electronic cyclotron spin flips in 5.5 second scale, which is very near to τ_C. Perhaps the Comorosan effect is used by the outer MS to affect the behavior of living matter and lungs are involved with this process.

11.5.3   Plasma sheet as a "microchip"

Plasma sheet should be a seat for magnetospheric sensory representations in theta and delta bands and among other things provide a model of magnetospheric self. If the plasma sheet has this kind of role, it should manifest itself in its properties. The plasma sheet should be self-organizing, complex structure rather than a system near thermal equilibrium. In the TGD framework, the plasma sheet could also perform bio-control.

There is a fascinating finding about the "memory chip" character of the organization of the ionic velocity distribution in the plasma sheet [F9]. The belief was that the distribution is a Maxwellian thermal distribution but a complex organization of the number of ions as a function of speed and direction relative to the direction of the local magnetic field has been detected [F9]. By coloring the bins representing small volumes of the velocity space, one finds that 3-dimensional features like "eyes" and "wings" appear! The proposed interpretation is that these features code for the history of ionic currents.

One cannot exclude the possibility that these ionic currents could reflect even our sensory experiences. The prediction is that also other transition regions (in particular magneto-pause) should exhibit similar complex self-organization patterns. The simplest possibility is that the velocity patterns of ordinary electrons reflect the underlying pattern of dark matter at the dark magnetic flux tubes forming perhaps some kind of sensory representations.

11.6   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 [D28]. Pure silicon is very rare in nature and appears in the forms of Si oxides, silicates, in particular SiO_2 (see this). Quartz crystals and glass consist of silicon dioxide. In the experiment involving a silicon wafer the globules are divided into two groups: those having sizes in the range .2-.8 mm (high voltages) and .8-1.4 mm (low voltages). The sizes of ball lightning vary from a few millimeters to about 100 cm.

In DC voltage, the wafer decomposes to globules of various sizes. They can last as long as 6-8 second unlike sparks. The proposed explanation is that the 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 [D47].

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 [D52] (see this) is formed as the lightning strikes on the soil and SiO_2 crystals evaporate and transform to Si and Oxygen. There is support for this from direct observations of the spectrum of ball lightning containing spectral lines assignable to the elements in the soil. The spectra associated with ordinary lightning do not contain similar lines. How the chemical reaction producing Si and O_2 ions from SiO_2 ions could take place is far from clear. A lot of energy is needed for this process to occur. Where does this energy come from?

There is also the so-called microwave theory of ball lightning. Microwave wavelengths vary in the range of 1 mm-30 cm as also the sizes of ball lightning. The ball lightning would correspond to microwave cavities with a dynamical size and shape.

In the sequel a TGD inspired model for the ball lightning-like structures in silicon and for the real ball lightnings is developed relying on the TGD view of space-time predicting fractality and inspiring the hypothesis that biosphere could be regarded as a system analogous to neuronal membrane and that lightnings could be analogous to nerve pulses, the identification of dark matter as phases with non-standard value of Planck constant allowing quantum coherence in arbitrarily long scales, the TGD view of quantum gravitation and its role in quantum biology [L138, L135], and the TGD inspired model of nerve pulse [L156].

11.6.1 TGD view of lightnings

The background for the TGD based model of lightnings and ball lightnings is provided by the TGD view of magnetosphere [K53, K51] [L119] that I have developed during the last decades. The magnetic bodies (MBs) of living systems and even the MB of the biosphere would be controlling agents. These MBs are predicted to have a hierarchical onion-like structure [L151, L152] (monopole flux tubes inside monopole flux tubes). They would carry dark matter as phases of the ordinary matter labelled by the value of effective Planck constant having a number theoretic interpretation. 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 [K80] and its up-to-date version [L156] 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 [K53, K51] [L119]. The magnetic bodies (MBs) of living systems and even the MB of biosphere would be controlling agents. Tbese MBs would have a hierarchical onion-like structure [L151, L152].

1. The Earth ground-atmosphere pair is analogous to the cell interior-cell exterior pair. The surface of the Earth is negatively charged and analogous to the cell interior. This negative charge creates an electric field of strength 100-300 V/m (see this). The height h for the clouds varies in the range .5-16 km. For a cloud at height of 10 km this corresponds to an electrostatic energy $.1 - .3$ MeV and for h=16 km one has .48 MeV. In the case of electrons with rest mass of .5 MeV, these energies are relativistic and could relate to the observed relativistic energies associated with the lightning.

2. The thunder cloud (see) has a positive charge near the top of the cloud and negative charge in the middle to lower part of the thunder cloud. At bottom there is a small positive charge known to be important. The negative charge of the cloud repels the negative charge at ground so that ground becomes positively charged below the cloud. Does this induce a local depolarization of the ground-cloud system as the analog of cell membrane?

   This raises an objection against the idea that dark protons are at gravitational monopole flux tubes and that their energies are of the order of the gravitational binding energy in the gravitational field of Earth of order .5 eV. If dark protons experience the Coulombic force of Earth, their Coulomb energies are in the range .8-2.4 MeV below the ionosphere at height

$h_I = 80$ km, which defines the minimum height of the lower boundary of the ionosphere. The problem disappears since the dark protons at monopole flux tubes are at much larger heights, where the electric field of the Earth vanishes. However, the dark matter at parts of the MB at heights smaller than h_I the electric energy dominates and their role in biology should be very different.

3. Neuronal membrane is hyperpolarized and the nerve pulse is initiated when depolarization takes the membrane potential below a critical value. Could lightning be seen as an analog of nerve pulse induced when cloud-ground depolarization takes place? Thunder storm would be analogous to a conduction of a nerve pulse pattern.

TGD view of nerve pulse

The TGD based model of nerve pulse [L156] relies on the Pollack effect inducing a charge separation between cell interior/exterior and its MB.

1. Pollack effect [I40, L14, I67, I53] occurs in water in the presence of a gel phase. Also energy feed is required and in standard Pollack effect solar radiation provides it. The Pollack effect generates what Pollack calls the fourth phase of water. It has the effective stoichiometry $H_1.5O$ 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) [K123], 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 [L156]. 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 [L156]. 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 [K53, K51] [L119, L151, L152] are analogous to a cell membrane or even neuronal membrane or possibly a collection of basic units analogous to those of neuronal membranes. In the lightning strike, a charge separation between ground and its MB would transform to a charge separation between cloud and its MB. Lightning would be induced by the depolarization just as in the case of neuronal membrane.

    The assumption distinguishing sharply between TGD and standard physics is that the primary charge separation does not occur between cell interior and exterior but between interior/exterior and its MB.

2. In the initial, rather stationary situation, the Pollack effect at the ground has generated EZs and made the Earth surface negatively charged. The electric field of the Earth gives rise to the analog of the resting potential of 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 [K80] [L156].

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 [L156].

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 [K80].

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 [L151, L152], 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 $M_M \simeq 1.02 M_E$ of the Moon! [L156].

   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 $V = .05$ eV $\to V = 15$ 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 [L128], 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 $L(239)$.

11.6.2 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 [I40, L14, I67, I53] for the water at the soil has somehow generated EZs and SiO_2 ions from Si and water of the soil or atmospheric oxygen. This would explain the negative charge of the ground. The Pollack effect would not require energy feed now since the binding energy liberated in the formation of SiO_2 crystals would take care of energy conservation. A situation in which part of water corresponds to $H_{1.5}O$ 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, L135].

   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 [K32, K33] in a rather speculative spirit but starting from empirical facts published by professional biologists. There are reports that the crop circle formation occurs in presence of light balls analogous to ball lightning. The formation of crop circles can be understood in terms of the interaction of microwaves with crop stems causing effects similar to those taking place as one puts a tomato in a microwave oven. The size scale range for ball lightning conforms with the wavelength range for microwaves. Therefore the microwave theory seems to be consistent with the model based on the Pollack effect. The light ball would be an analog of the nerve pulse in the scale of the biosphere.

Meteorite iron is found at crop circles: they could arrive from the gravitational MB along gravitational flux tubes. Also small glass balls, encountered also on the Moon, are reported. They could emerge in the transformation of Si and O_2 to SiO_2 as the Pollack effect takes place.

What is fascinating is that crop circles look like intentional constructs expressing discrete geometric symmetries. Could the plasma balls be intelligent conscious entities, a new kind of life form and could they represent the primordial life forms, kind of proto cells? This kind of plasma balls are also reported in UFO encounters. Systematic observations of the plasma balls are performed in Hessdalen and the plasma balls are reported to behave like intelligent and intentional entities.

The gravitational MB of these entities would correspond to that of the Sun. Could this mean that their theoretical IQ, defined by the gravitational Planck constant of the Sun, is dramatically higher than ours? Probably this is not the case: the gravitational Compton frequency for the Sun is around 50 Hz. This is the cyclotron frequency of Lithium for $B_{end} = .2$ Gauss. It is known that too low Li depletion in the soil tends to induce depression and suicidal behavior. 50 Hz corresponds to EEG frequency so that life forms with EEG would interact with the gravitational MB of the Sun.

Are we silicon based life forms?

Computationalists tend to think that silicon based life will emerge in future. However, if the above considerations make sense, Si, chemically similar to Carbon and appearing as quartz in soil, could play a central role in life already now! Maybe the people claiming that quartz have very special effects on the state of consciousness, are right. In fact, I have had an opportunity to experience these effects myself.

Intriguingly, molten silica shows several characteristics observed in liquid water (see this) and the amorphous glass phase of silica resembles liquid in many aspects.

Interestingly, silicon di-oxide is used in MOSFETs. In [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 SiO_2. However, the idea about the local transformation of SiO_2 to Si and O_2 with Si in vapour phase by an analog of the Pollack effect does not look plausible since protons are not available now.

   Electrons should be transformed to dark electrons at the gravitational MB of Earth and the formation of SiO_2 would make possible energy conservation. The transformation of electrons back to ordinary electrons liberates energy and should induce the decay of SiO_2. The needed energy is few eVs. However, the gravitational binding energy for electrons in the field of Earth has an upper bound of order .25 meV. Note that the melting temperature of SiO_2 corresponds to the energy .134 eV. It seems that the only possibility that one can imagine is provided by dark variants of quantum coherent many-electron states.

Chapter 12

TGD Inspired Model for Nerve Pulse

12.1 Introduction

The model of nerve pulse has developed through several tortuous twists reflecting the development of the basic ideas of TGD inspired theory of consciousness and of bio-systems as macroscopic quantum systems, and is certainly not final yet. The chapters about EEG provide a necessary background for the model of nerve pulse. The chapter [K83] was written before dark matter revolution made possible a more detailed modelling of mew physics aspects of EEG. The newer chapter [K35] related to EEG provides a very general vision about the hierarchy of EEGs based on dark matter hierarchy and about its possible generalization to ZEG, WEG, and even GEB (Z, W and G denote for dark Z^0, W boson, and gluon fields with interaction range which can be arbitrary long at higher levels of dark matter hierarchy). This model derives from the model of bio-superconductivity [K77, K78] as quantum critical high T_c super-conductivity [K17, K18]. The consistency with the model of DNA as topological quantum computer [K2] poses additional strong constraints on the model. The findings of Gerald Pollack about fourth phase of water [L14] lead to additional strong constraints on the model of cell membrane as Josephson junction.

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse. One can imagine several way for how this could happen.

1. The first idea was that axonal membrane acts as a Josephson junction and that a soliton propagating along it induces the nerve pulse. The model for the high T_c electronic superconductivity allowed to construct a detailed model for this Josephson junction and "time-like" and possibly also space-like soliton sequences are indeed present. Time-like soliton sequences however represent oscillations at a frequency of order 10^{13} Hz. It is however clear that moving solitons cannot correspond to nerve pulses.

   Quite recently (2014), strong motivations for generalizing the notion of Josephson junction so that Josephson energy includes also the difference of cyclotron energies at the two sides of the junction has emerged. It is also possible to reduce cell membrane as Josephson junction to a collection of Josephson junctions defined by various transmembrane proteins such as pumps and channels.

2. The strange findings about ionic membrane currents discussed in [K77, K78] challenge the assumption cell membrane could be described in term of known biochemistry alone. Pollack's experiments [L14] demonstrate the existence of what he calls the fourth phase of water. This phase contains negatively charged regions - exclusion zones - serving in TGD Universe as candidates for prebiotic cells. The positive charge resides outside the exclusion region at the flux tubes of the magnetic body associated with the exclusion zones as dark proton strings defining dark nuclei realizing vertebrate genetic code [K42]. This vision leads to a generalization of the model of cell membrane Josephson junctions assignable to transmembrane proteins. Josephson energy becomes sum of Coulombic term and difference of cyclotron energies at the

two sides of the membrane. The thermodynamical model for cell membrane is replaced with its "square root" forced by Zero Energy Ontology, and means the replacement of Boltzmann weights with their square roots appearing in the wave functions for dark particles. The phase transitions changing Planck constant change the equilibrium distributions of ions and this process should be behind the generation of nerve pulse.

3. There exists also evidence that nerve pulse propagation is be an adiabatic process [**?, ?, ?, ?, ?**] (thanks to Ulla Mattfolk) and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. If h_{eff} changing phase transition changing the equilibrium ionic concentrations occurs, the phase transition in question should not absorb or liberate heat. Combining this input with the model of DNA as topological quantum computer (TQC) [K2] leads to a rather precise model for the generation of nerve pulse.

12.1.1   The Most Recent Model For The Generation Of Nerve Pulse

Quite recently I learned [**?, ?, ?, ?, ?**] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (TQC) [K2] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of TQC. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

2. During nerve pulse one pendulum would be kicked so that it would start to oscillate instead of rotating and this oscillation pattern would move with the velocity of kHz soliton sequence. The velocity of kHz wave and nerve pulse is fixed by periodic boundary conditions at the ends of the axon implying that the time spent by the nerve pulse in traveling along axon is always a multiple of the same unit: this implies kHz synchrony. The model predicts the value of Planck constant for the magnetic flux tubes associated with Josephson junctions and the predicted force caused by the ionic Josephson currents is of correct order of magnitude for reasonable values of the densities of ions. The model predicts kHz em radiation as Josephson radiation generated by moving soliton sequences. EEG would also correspond to Josephson radiation: it could be generated either by moving or standing soliton sequences (latter are naturally assignable to neuronal cell bodies for which $\hbar$ should be correspondingly larger): synchrony is predicted also now.

3. At microscopic level nerve pulse could correspond to a phase transition changing the value of Planck constant h_{eff} at the either side or both sides of the cell membrane at the flux tube associated with the transmembrane protein. This would induce transition to a new ionic equilibrium since cyclotron energies for ions change. This transition would give rise to the change of the membrane potential. Cyclotron energy difference would however dominate in the generalized Josephson energy. This phase transition should be adiabatic and should not require heat or generate it.

4. The previous view about microtubules in nerve pulse conduction can be sharpened. Microtubular electric field (always in the same direction) could explain why kHz and EEG waves and nerve pulse propagate always in same direction and might also feed energy to system so that soliton velocity could be interpreted as drift velocity. This also inspires a generalization of the model of DNA as TQC sine also microtubule-cell membrane systems are good candidates for performers of TQC. Cell replication during which DNA is out of game seems to require this and microtubule-cell membrane TQC would represent higher level TQC distinguishing between multi-cellulars and mono-cellulars.

5. New physics would enter in several way. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [L4]. [L4] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. Clearly, the temperature at dark magnetic flux tubes could be lower than the physiological temperature. The model for the role of DC currents and potentials in healing discussed in [K10] suggests that metabolic energy quanta of order 1 meV are involved in bio-control so that the temperature at magnetic flux tubes containing ions could be by a factor of order 10^{-2} lower than the physiological temperature. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^\pm$ bosons is a natural ways to achieve this if new nuclear physics is indeed present.

12.1.2 The Function Of Neural Transmitters

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. Electromagnetic membrane oscillations induced by Z^0 MEs provide a realization of the memetic code as a fundamental cognitive code. The binding of various information molecules to the corresponding receptors gives rise to neuronal qualia analogous to tastes and odors but providing information about external world whereas ordinary receptors give information about nearby environment. At our level of hierarchy these qualia probably correspond to emotions in consistency with the finding that neurotransmitters can be identified as information molecules. Neurotransmitters might be also seen as conscious links in quantum web. The view that inhibition actually requires active energy feed and that excitation occurs automatically in the absence of the energy feed and induces entanglement with environment, is defended. This view conforms with Huxley's vision about brain as a filter inhibiting conscious experiences.

12.1.3 What Happens At The Micro-Tubular Level During Nerve Pulse?

What happens at the micro-tubular level during the nerve pulse? How gel phase differs from sol phase? What occurs in sol-gel transition? These questions represent some of the principal challenges faced by quantum theories of consciousness.

There are two candidates for Bose-Einstein (BE) condensates associated with the ordered phases (say gel) of water. This derives from the fact that the zero point kinetic energy of hydrogen atom at space-time sheet k is in a good approximation same as the zero point kinetic energy of an electronic Cooper pair at space-time sheet $k + 10$ (see the article "Time, Space-time, and Consciousness" in [L2]). Thus both the BE condensates of hydrogen atoms at tubular $k = 139$ space-time sheets forming bundles behaving like liquid crystals and BE condensates of electronic Cooper pairs at $k = 149$ space-time sheets forming linear structures could accompany gel phase and ordered water phases. Positive and negative energy IR photons at energy of $\sim .125$ eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this BE condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler [I38] has demonstrated that photons with energy $E \sim .1$ eV have a maximal effect on cells.

The seesaw mechanism discussed in the article "Quantum model of sensory receptor" of [L2] minimizes dissipative losses and allows to understand how micro-tubular surfaces could provide dynamical records for the cellular sol-gel transitions, and thus define a fundamental micro-tubular representation of declarative long term memories.

As far as nerve pulse is considered, one ends up with the proposal that the soliton propagating along axon might be a shadow of a more fundamental soliton propagating along microtubular surface and inducing gel-sol-gel transition meaning disassembly and reassembly of tubulins which induces a braiding of magnetic flux tubes coding the details of the sensory signal below millisecond time scale to the braiding pattern.

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` [L11].

12.2 Background For The Model Of Nerve Pulse

The following sections give some background for the model of nerve pulse.

12.2.1 General Vision About Living Matter As A Macroscopic Quantum System

The following assumptions summarize the general vision achieved before the dark matter revolution. The picture is consistent with the findings of Libet about strange time delays of consciousness [?, ?] discussed in the article "Time, Space-time and Consciousness" in [L2] and chapter [?].

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of bosonic ions or of Cooper pairs of fermionic ions in excited cyclotron states.

2. Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic and cognitive representations, writes the sensory music to notes. The mental images defined by these representations can be shared by personal magnetic body or magnetic bodies associated with the sensory organs in a similar manner. Also classical communications to the personal magnetic body are possible. A tree like structure with the root represented by sensory mental images and branches and leaves represented by various symbolic and cognitive mental images results.

   The selective entanglement by negative energy MEs allows to understand the active aspects of sensory experience involving direction of attention and selection between percepts at various levels. In the case of motor actions, the negative energy MEs received from magnetic body communicate the desires of the magnetic bodies about motor actions to be performed and the response by positive energy MEs would realize these desires as nerve pulse patterns.

3. Positive energy interior MEs lie along interior of magnetic flux tubes of the personal magnetic body. These MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. Sensory perception and memory differ only is that the time scale involved is different. Declarative memory

corresponds to negative energy MEs sent from a point of the personal magnetic body at the distance $L = cT$ to the material body and reflected back as positive energy MEs. Thus the material body serves as the mirror unlike in the original variant of the mirror mechanism of memory. The distance $L = cT$ along magnetic flux proportional to the transverse area S of the flux tube $L \propto S$ tubes codes for the temporal distance to the geometric past by transforming it to cyclotron frequency scale.

12.2.2 A General View About Quantum Control, Coordination And Communication Inspired By Dark Matter Hierarchy

The following general overview about quantum communication and control emerges from the model for EEG hierarchy as correlate for dark matter hierarchy discussed in detail in [K35].

1. Cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control.

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. A good guess is that in this case magnetic flux quanta are hollow cylindrical structures serving as templates for axons and possibly other similar structures and define the communication lines connecting cell membranes to the magnetic body.

3. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

4. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a non-local charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy.

5. Massless extremals (MEs, topological light rays) serve as correlates for coherent states and Bose-Einstein condensates of dark bosons. Besides neutral massless extremals (MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The second non-local quantum control mechanism is based on em charge entanglement involving a superposition of ordinary ions/atoms and exotic ions connected by a W massless extremal joining magnetic body and biological body. In quantum jump this state would be reduced to exotic charge state with some probability increasing with the strength of the classical W field. Charged massless extremals could be seen as correlates for non-local quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K39].

6. It has become clear that the most plausible model for nerve pulse generation is as a phase transition changing the value of h_{eff} at the flux tube portion at either or both sides of the cell membrane. In the modification of the thermodynamical model of cell membrane based on "square root" of thermodynamics forced by ZEO, this would induce a change of ionic equilibrium distributions and generation of nerve pulse.

7. These non-local quantal mechanisms can induce or change electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control of nervous system by magnetic body. The generation of nerve pulse could rely on the spontaneous state function reduction occurring for charge entangled state reducing the resting potential below

the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

12.2.3 The Role Of Electronic Super-Conductivity

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. This isolation might of course be present and make possible ionic super-conductivity. 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 Coulomb interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

A crucial element is quantum criticality predicting that new kind of superconductivity, "boundary superconductivity", appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei besides large $\hbar$ variant of ordinary superconductivity in the interior. The Cooper pairs of interior and boundary supra currents are different with interior Cooper pairs being BCS type. 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 c flux tubes and sheets are especially interesting candidates for dark supra current carriers and might define Josephson junctions. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy 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 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 possibly proton Cooper pairs are possible at room temperature. The effects of ELF em fields on vertebrates suggest that Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged [L4], [L4] are there but the model of high T_c super-conductivity does not favor them. It is of course possible that the temperature at dark magnetic space-time sheets is lower than at the visible space-time sheets.

Bose-Einstein condensates at magnetic flux quanta in astrophysical length scales

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the values of $\hbar r \hbar_0$ of Planck constant.

1. 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 scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) 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 [K35]. 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.

2. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at lowest levels of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying dark dynamics with large value of Planck constant.

3. Cyclotron energies scale as as $r = 2^{k_d}$ so that for a sufficiently high value of k_d thermal stability of cyclotron states at room temperature is achieved. Spin interaction energy $\mu \cdot B \propto S \cdot B$ scales as $1/\hbar$ since four-momentum and angular momentum are by Poincare symmetry invariant under the scaling of $\hbar$ (the highly non-trivial implications of the invariance of angular momentum are discussed in [K118]). Hence spin interaction energy has the ordinary value. Unless thermal isolation is assumed, spin degrees of freedom are thermalized, and only cyclotron degrees of freedom can be quantum coherent. This is a testable prediction distinguishing between the new and old model.

4. If the flux quanta of $B = .2$ Gauss correspond to $k_d = 44$ level of dark matter hierarchy, cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $2^{k_d} \simeq 2^{44}$ from their ordinary values and are above thermal energy at room temperature for $A \leq 233Z$, where Z is the charge of the ion. Even for $Z = 1$ this includes all stable nuclei. Bose-Einstein condensates of bosonic ions are thus possible at room temperatures at Earth's surface.

Experimental evidence for bio-superconductivity

From the beginning it has been obvious that super-conductivity serves some important function in nerve pulse conduction. For instance, Josephson currents are optimal for quantal alarm clocks [K83]. Already before the ideas inspired by the dark matter hierarchy the contact by Hafedh Abdelmelek and his group [?] led to a crucial step of progress in the understanding of this function. It became clear that genuine or effective electronic super-conductivity (in the sense that Cooper pairs are dropped temporarily to larger space-time sheets implying dissipation) is most probably involved with the propagation of the nerve signal through the myelin sheathed portions of the axon [K78].

The resulting simple model explained the experimental findings at quantitative level correctly and makes several predictions. In particular, one can understand why physiological temperature can have only a rather restricted range. The breaking of the electronic super-conductivity is an essential aspect of the ordinary nerve pulse conduction in this model. Also the distinction between poikilotherms (such as frog) and endotherms (such as rabbit) can be understood. As it often happens, the most recent model is not consistent with this model but is preferred by its simplicity.

Strange findings about cell membrane

There are very strange findings challenging the notions of ionic pumps and channels [I39, I42, I59, I30], and suggesting a mechanism dramatically reducing the metabolic costs involved with the ionic pumping. Second finding is that ionic currents seem to be quantal and are same for polymer membrane than for cell membrane! A further strange finding [?] is that the propagation of nerve pulse does not cause heating of the cell membrane implied by the model of nerve pulse based on chemistry. This suggests that dissipation is absent also during nerve pulse propagation and that the process might not be chemical as assumed hitherto.

One can imagine two explanations.

1. The first explanation would be that ionic currents are actually dark supra currents flowing along larger space-time sheet connecting cell interior and exterior. The model of high T_c super conductivity favors only electronic and protonic super conductivity at room temperature [K17] whereas the model for EEG favors the presence of Bose-Einstein condensates of ions. Bosonic ions are required: the new nuclear physics predicted by TGD [L4], [L4] allows to assign to fermionic ions their bosonic chemical equivalents. Even permanent connections with the cell exterior (by magnetic flux tubes, say) are possible since Josephson currents oscillate. One can of course consider the possibility that dissipation rate is small due to the large value of Planck constant even in the absence of super conductivity. Also the temperature could be lower at the magnetic flux tubes containing dark ions but this assumption will not be made.

2. Second model that one can imagine relies on the exotic nuclear physics predicted by nuclear string model [L4] , [L4] and the predicted hierarchy of fractally scaled up variants of weak interaction physics. If weak interactions can be present in cell length scales, the exchange of virtual or real $W^{\pm}$ bosons between nuclei could induce purely quantal and non-dissipative charge transfer between cell interior and exterior. Also charge entanglement becomes possible. The emission of $W^{\pm}$ would modify the nucleus to an exotic charged state in which one of the neutral color bonds connecting nucleons is charged. Since W exchange does not depend on cell membrane at all, the prediction would indeed be that ionic currents do not depend at all on the membrane in question. The model of nerve pulse however suggests that W exchange can have only a role of a control signal.

One can argue that pumps in case of basic ions are needed only when the cell interior and exterior are connected by join along boundaries bonds/flux tubes and that this connection is built only for diagnostic purposes in order to measure the concentrations of ions by measuring the ionic currents by their dissipation. The remote metabolism made possible by many-sheeted lasers reduces further the energy costs when pumping actually occurs. The transfer as Josephson current might apply only to the biologically important ions and pumps might be needed to achieve more efficient transfer also in this case. Pumps (active transport) and channels (passive transport) for more complex polar molecules realized as genetically coded proteins are certainly needed.

12.2.4   The Role Of MEs And Magnetic Flux Tube Circuitry

The developments in the understanding of the role of MEs and magnetic flux tube circuitry have repeatedly forced to rethink the model of nerve pulse and EEG.

Universe as a conscious hologram

1. The notion of conscious hologram means that Universe is an extremely complex fractal Feynman diagram with lines replaced by 4-dimensional space-time sheets and MEs are particular kinds of lines analogous to photon lines. These lines are like laser beams, which interfere in the vertices of the Feynman diagram: vertices correspond to material space-time sheets, atoms, molecules, ..., cells, ... Super-conducting magnetic flux tubes are also important and act effectively as wave guides along which MEs propagate.

2. Topological field quantization allows to assign to any material system a field (magnetic) body. The view that "me" corresponds to the personal magnetic body of an astrophysical size receiving information from the material body by both classical communications and by sharing of the mental images realized in terms of bound state entanglement having negative energy MEs as a space-time correlate, has become a key hypothesis in the attempts to understand the functions of nerve pulse and EEG. The idea about brain as the sole seat of consciousness is deeply rooted in scientific thinking, and it took some time before I was able to take really seriously the idea about magnetic body as an intentional agent controlling the material body serving as its sensory and motor organ. In this respect the latest developments occurred while writing this article.

3. MEs, in particular, the topological field quanta of ELF fields are in a crucial role as far as the understanding of EEG (and the predicted ZEG and WEG) is involved. After dark matter revolution it became clear that MEs are the natural correlates for coherent states and Bose-Einstein condensates of dark matter bosons. It is still an open question whether ordinary laser light might be regarded as a special case of dark photons. Certainly the transformation of dark bosons to ordinary ones would occur through a de-coherence phase transition just like the transformation of laser light to ordinary photons.

Various kinds of MEs

One can imagine many kinds of MEs.

1. Interior MEs correspond to what might be called ELF MEs but they form only a small portion of the spectrum of MEs characterized by the fundamental frequencies defined by their lengths $f = c/L$ extended to ULF frequencies which correspond to length scales of order light lifetime. Also MEs in time scales at least down to 10^{14} Hz corresponding to visible photons are predicted be important.

2. Also boundary MEs identified as MEs attached to the boundaries of matter carrying space-time sheet and drifting along it quantum jump by quantum jump by a velocity $v < c$ can be considered and MEs of this kind were in a key role in the previous model for nerve pulse generation. In the case of boundary MEs, which are assumed to be positive energy MEs, the effective phase velocity satisfies $v << c$, and from $f = v/L$ the sizes of the structures associated with a given frequency are smaller by a factor v/c.

3. Negative energy MEs, which correspond to phase conjugate laser light, make possible intentional action at the micro-tubular level, they are crucial for the understanding of the macro-temporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. The newest discovery along this line is what might be called see-saw mechanism of energy metabolism (see the article "Time, Space-time and Consciousness" in [L2]). Phase conjugate laser beams [D12, D6] seem to be the standard physics counterpart of negative energy em MEs and negative energy photons accompanying them.

4. Fractality implies that MEs contain MEs within MEs: this conforms with the general ideas about dark matter hierarchy and p-adic length scale hierarchy. MEs within MEs is the topological correlate for de-coherence of Fourier components of classical field. In the simplest situation MEs appear as pairs of high frequency and low frequency MEs. The scaling law of homeopathy [I14] states that low frequencies are accompanied by high frequencies such that the frequency ratio has preferred predictable values identifiable as characteristic velocities in the system (such as EEG phase velocity): $f_{low}/f_{high} = v/c$. The most general assumption about the spectrum of high frequency MEs inside low energy MEs is that it is scale invariant in the sense that the intensity satisfies $I(f_{high}, f_{low}) = I(f_{high}/f_{low})$.

   Low frequency negative energy MEs could serve as correlates for remote quantum entanglement in cyclotron degrees of freedom. W MEs would make possible charged entanglement. High frequency MEs travel effectively like massless particles along the bridges defined by the low frequency MEs and can transform to boundary MEs serving as bridges between different space-time sheets at the receiving end, in which case their effective phase velocity is reduced to $v << c$. These MEs could induce a leakage of ions between different space-time sheets, breaking of super-conductivity and dissipative self-organization. This process which is analogous to the formation of hologram, is responsible for homeostasis and metabolism and gives rise to many-sheeted ionic flow equilibrium. Also many-sheeted lasers acting in a very wide range of frequencies become possible. The frequencies correspond to differences for the energies of ions at the space-time sheets involved. MEs parallel to axons can also act as Josephson junctions connecting space-time sheets which can correspond to different p-adic primes.

The strange effects of ELF em fields on vertebrates as a key to the model for hierarchy of EEGs

The experimental findings of the pioneers of bio-electromagnetism [**?**] demonstrate that electromagnetic radiation at the harmonics of cyclotron frequencies of various ions in magnetic field $B = .2$ Gauss, in particular Ca^{+2} ion, are somehow involved with the bio-control. The dropping of ions from smaller space-time sheets to the super-conducting magnetic flux tubes of B indeed generates cyclotron radiation. The generalization of this [I21] [L1] explains the findings of Gariaev [I26] about radio waves induced by laser irradiation of DNA. The detailed model explaining various aspects of these findings on basis of TGD inspired model of high T_c superconductivity led to a detailed model for the hierarchy of EEGs (or EWEGS, with EW for electro-weak) generated by Josephson junctions as Josephson and by cyclotron transitions of Bose-Einstein condensates of bosonic ions.

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.

12.3 TGD Based Model For The Generation Of Nerve Pulse

The general vision about living system as a conscious hologram and the view about how "topological light rays" (massless extremals, MEs) serve as remote entanglers and induce self-organization via the leakage of ionic currents between various space-time sheets implies that several space-time sheet pairs are involved with the bio-control. Perhaps the most radical deviation from the standard neuroscience thinking came with the realization that in TGD Universe every physical system has also magnetic/field body of size much larger than the material body and that material bodies can be seen as motor and sensor organs of the personal magnetic body. This counter intuitive conclusion is unavoidable if one accepts many-sheeted macroscopic quantum coherence, Uncertainty Principle and topological field quantization. p-Adic physics as physics of intention and cognition provides an additional support for this view: the smaller the space-time sheet is p-adically, the larger it is in the real sense so that cognition and intentionality are predicted to be astrophysical phenomena and evolve from long to short length and time scales just as it indeed occurs when motor activity is learned.

The TGD based view about dark matter hierarchy involving a hierarchy of values of Planck constant provides a justification for this picture. Dark matter hierarchy corresponds to the hierarchy of moments of consciousness with increasingly long duration with respect to geometric time and defines a hierarchy of conscious entities and reflective levels of consciousness.

Dark matter hierarchy provides a mechanism for the formation of macroscopic and macro-temporal quantum phases in all length scales. The earlier assumption about thermal isolation of space-time sheets corresponding to different p-adic length scales can be given up and thermal stability condition becomes an additional strong constraint allowing to eliminate various options very effectively. Since cyclotron energies scale like $\hbar$, thermal stability is possible to achieve for them.

The quantum model of nerve pulse requires answer to several questions. Some of them are following.

1. Are various charged currents quantal or ohmic currents? For electrons and even protons an attractive answer is that they are quantal currents. The effects of ELF em fields on vertebrate brain suggest that also ionic currents are quantal and that Cooper pairs of ions might be involved. Hodkin-Huxley model assumes ohmic currents but the observations about cell membrane do not support this view.

2. If the ionic currents are quantal, are they oscillating Josephson currents or direct currents? For the direct quantal currents a model was constructed in previous section. If the thickness of Josephson junction is not much larger than Compton length then all Josephson currents in

cell membrane length require non-standard value of Planck constant. For electron it would be about 2^{11} and for proton about 2^{22} using the standard value of $\hbar$ as unit. For ions even large Planck constant would be required (its value scales like mass). The hierarchy of preferred values of Planck constant given by powers $m_p/me \simeq 2^{11}$ is suggestive. DNa as TQC suggests that also quarks are involved in this case the low masses would suggest Josephson currents.

3. Already the visible cell membrane is a highly structured object and many-sheetedness of space-time could play a key role. This could mean the presence of magnetic flux tubes with many values of Planck constant. Magnetic flux tubes would be natural models for the ionic channels and pumps. Note that DNA as TQC model involves flux tubes connecting DNA nucleotides and lipids. One can quite well consider the presence of both Josephson currents and direct quantal currents except perhaps for electron Cooper pairs and possibly they protonic counter parts.

4. In the case of fermionic Cooper pairs one can consider Cooper pairs as building bricks of Bose-Einstein condensate. Also exotic nuclei which are bosons but chemically equivalent with fermionic ions can be considered. The argument of previous section favors Cooper pair option and direct ionic currents.

5. One can consider two kinds of basic extremals. Near vacuum extremals for which classical Z^0 fields are important and far from vacuum extremals for which they are small. The latter extremals would correspond naturally magnetic flux tubes carrying monopole Kähler magnetic flux. Both of them might be involved with the ionic channels and pumps. As extreme situations one can consider two models of cell membrane assuming only near to or far from vacuum extremals.

6. What is the mechanism generating the nerve pulse? This mechanism should change the stationary situation in which only oscillatory Josephson currents are present and generation of quantal direct current is suggestive. Does this current consist of electron Cooper pairs or possibly ions of their Cooper pairs? Is there a primary wave - say Ca^{++} wave - involved. Why de-polarization instabilizes the situation? As found in previous section, the model for ionic direct currents suggest a possible explanation for this.

In this section TGD based model of nerve pulse and EEG inspired by the soliton model of Danish researchers and the model of Pollack is discussed. Also a model for the action of anesthetics is proposed.

12.3.1 Soliton Model Of Nerve Pulse

Let us first briefly summarize soliton model of nerve pulse proposed by Danish researchers [**?**, **?**, **?**, **?**].

1. The temperature of the axon is slightly above the critical temperature T_c for the phase transition leading from crystal like state of the lipid layers to a liquid crystal state. Near criticality the elastic constants and heat capacity of the membrane vary strongly and have maxima at criticality so that also sound velocity varies strongly near criticality. Also the relaxation times are long. There is also dispersion present meaning that the frequency of sound wave depends nonlinearly on wave vector. Non-linearity and dispersion are prerequisites for the presence of solitons which by definition do not dissipate energy.

2. Variations of temperature, volume, area, and thickness and also other mechanical effects are known to accompany nerve pulse propagation. It is also known that the heat density and temperature of the cell membrane increases slightly first and is then reduced. This suggests adiabaticity in average sense. These findings motivate the assumption that nerve pulse actually corresponds to acoustic soliton [**?**, **?**].

3. Soliton model reproduces correctly the velocity of nerve pulse inside myelin sheaths but it is not clear to me how well the much lower conduction velocity in non-myelin sheathed regions is reproduced. It is not clear how the lower values of the conduction velocity and its

proportionality to the axonal radius in non-myelinated regions can be understood. Intuitively it however seems clear that the lower velocity is due to the feedback from the interaction of ions with the region exterior to cell membrane. In the case of myelin sheaths the conduction of nerve pulse is usually believed to take place via saltation [**?**]: the de-polarization induced at Ranvier node is believed to be enough to take the membrane potential below critical value in the next node so that nerve pulse hops between the nodes. Insulation would improve the insulation and make this process possible. The reversible heat transfer process is however known to be present also in the myelinated portions of axon so that there must be a pulse propagating also in these regions [**?**]. It is not clear how the myelin sheet can increase the velocity in the soliton model but the reduction of the feedback inducing friction suggests itself.

4. Soliton property predicts adiabaticity. Ordinary ionic currents however dissipate so that adiabaticity assumption is questionable in standard physics context. The model does not predict the growth of entropy followed by its reduction. This behavior is consistent with adiabaticity in a time resolution of order millisecond.

5. The estimate for the capacitor energy density during the nerve pulse is considerably smaller than the energy density is many times magnitude smaller than that of the acoustic wave. This might allow to demonstrate that Hodgkin-Huxley model is not a complete description of the situation.

6. Authors notice [**?**, **?**] that the shapes curves representing solitonic energy density and the capacitor energy density as a function of time are essentially identical. Same applies to the experimentally deduced heat change release curve and capacitor energy density for garfish axon. Also heat release and the deviation of the membrane potential from its resting value are in exact phase. These similarities could reflect a control signal responsible for the nerve pulse originating somewhere else, perhaps at micro-tubules. This could explain why secondary nerve pulse is not generated immediately after the first one although the temperature is slightly lower after the pulse than before it. This could of course be also due to the exhaustion of the metabolic resources.

12.3.2 TGD Based Model Of Nerve Pulse Assuming Far From Vacuum Extremals

The model of nerve pulse described below can be motivated by the observed adiabaticity of the nerve pulse and by the strange findings about ionic currents associated with the cell membrane and by the model of Danish researchers for the nerve pulse [**?**, **?**, **?**, **?**]. The model involves also a fusion of various ideas of earlier models. In particular, Josephson currents and solitons are in a key role in the model but with the necessary flexibility brought in by the hierarchy of Planck constants. The model of nerve pulse by Pollack [I39] discussed at the end of previous section allows to understand the behavior of ionic currents quantitatively. In this subsection a model of nerve pulse based on the assumption that cell membrane represents far from vacuum extremals so that classical Z^0 field is very small will be discussed. In subsequent subsections the model for which cell membrane is almost vacuum extremal will be developed with main motivation coming from the observation that the model predicts correctly the frequencies of peak sensitivity for the four photoreceptors.

Consistency with the absence of dissipative currents through the axonal membrane

The basic inputs of the TGD based model are following.

1. The presence of acoustic soliton or density pulse proposed by Danish researchers [**?**] looks plausible but a a more fundamental quantum control mechanism inducing the acoustic soliton cannot be excluded. Among other things this should explain why acoustic solitons propagate always in the same direction. In particular, one can consider a soliton like excitation (say breather for Sine-Gordon equation) associated with the electronic or ionic Josephson currents running along magnetic flux tubes. The strange effects associated with the ionic currents

through the cell membrane suggest quite generally that at least weak ionic currents through normal cell membrane are non-dissipative quantal currents. The adiabaticity of the nerve pulse suggests that also strong ionic currents are quantal. This suggests identification as either Josephson currents or direct quantal currents discussed in previous section. In stationary situation direct currents would vanish by boundary conditions whereas Josephson currents would be oscillating. Direct currents as generator of nerve pulse would allow to understand why de-polarization induces nerve pulse.

2. Strong ionic currents generating nerve pulse through axonal membrane are absent in the resting state. The naïve explanation is simple: the life time of the magnetic flux tubes connecting the axonal interior to the exterior is short or the flux tubes are altogether absent. The observation that Josephson currents in constant voltage are automatically periodic suggests a less naïve explanation allowing the flux tubes to be present all the time. The presence of ionic Josephson currents predicts a small amplitude oscillation of membrane potential for which 1 kHz synchronous oscillation is a natural identification. Josephson oscillation correspond naturally to propagating soliton sequences for Sine-Gordon equation. The dynamics of the simplest modes is equivalent to the rotational motion of gravitational pendulum: the oscillation of membrane potential corresponds to the variation of $d\Phi/dt \propto V$. Note that if axon is above the melting temperature, the lipid layer is in gel phase and fluid motion is impossible. The surface density of lipids is dramatically reduced at criticality so that lipid layers behave like fluids [?]. This means that TQC is not possible by the braiding of lipids.

3. Nerve pulse is generated when the magnitude of the negative membrane potential is reduced below the critical value. Generation of the nerve pulse is like a kick to a rotating gravitational pendulum changing the sign of $\Omega = d\Phi/dt$ so that rotational motion is transformed to oscillatory motion lasting for about the period of rotation. An opposite but slightly stronger kick must reduce the situation to the original one but with a slightly higher value of Ω. These kicks could correspond to voltage pulse between micro-tubules and inner lipid layer of cell membrane induced by the addition of small positive (negative) charge on lipid layer. This pulse would induce electronic DC Josephson current inducing the kick and thus reducing V. For instance, the exchange of scaled variants of W bosons (assignable to W MEs) could mediate the transfer of charge through the cell membrane and reduce the membrane potential below the critical value but one can consider also other mechanisms. Another possibility is generation of direct ionic currents of Ca^{++} and Cooper pairs of Na^+ ions. This in turn could be induced by a perturbation of electronic (and perhaps protonic) Josephson current. The analog for the stationary situation is a sequence rotating penduli with constant phase difference along axonal membrane. Nerve pulse corresponds to a propagation along the axon of a wave in which some penduli oscillate rather than rotate.

4. The conservative option would be that ordinary ionic currents take care of the rest and Hogkin-Huxley model applies. This was assumed in the earliest model in which soliton sequence for Josephson current was assumed to induce nerve pulse sequence: in the recent model this assumption does not make sense. The findings of Danish researchers do not however support the conservative option [?] . Nerve pulse could be due to dark ionic (possibly supra -) currents with large $\hbar$ with a low dissipation rate. Their flow would be made possible by the presence of magnetic flux tubes connecting cell interior and exterior.

The relationship with the model of Pollack

In the model of Pollack [I39] for the action potential gel-sol-gel phase transition for the peripheral cytoskeleton accompanies the generation of the action potential. The model allows to understand reasonably well the behavior and the physical role of the ionic currents and explains various anomalies. Using pendulum analogy, the kick to the rotating pendulum representing Josephson junction would force it to an oscillatory motion inducing a gel-sol-gel phase transition propagating along the peripheral cytoskeleton.

The challenge is to understand how quantum criticality making possible the phase transition is induced.

1. The primary Josephson currents from the micro-tubuli to the axonal membrane would reduce the magnitude of the cell potential below the critical value (slowing down of the pendulum rotation). This should somehow take the peripheral cytoskeleton near to quantum criticality and induce the increase of Planck constant for the flux tubes connecting peripheral cytoskeleton to the axonal membrane and increasing their length so that they would extend to axonal exterior. This would make possible the flow of Cooper pairs of monovalent dark ions (say Na^+) from the axonal exterior replacing Ca^{+2} acting as cross links between negatively charged proteins and in this manner induce gel-sol phase transition. The reverse phase transition would reduce Planck constant. If ionic currents are non-dissipative they flow back automatically much like oscillating Josephson currents.

2. Gel-sol phase transition can be compared to melting since in the gel phase the hydrogen bonds induce effective freezing of various globular proteins to their folded configuration and naturally unfolded proteins to their unfolded configurations. This melting quite generally induces protein aggregation. Melting requires energy to destroy the hydrogen bonds and during action potential the system receives this energy somehow. One could even imagine that action potential generates both positive energy Josephson radiation inducing melting and phase conjugate Josephson radiation inducing freezing again and that these two steps correspond to an increase of Planck constant and its reduction back to the original value. Josephson radiation could quite generally control biological functions by inducing protein aggregation.

3. There are two forms of quantum criticality corresponding to critical sub-manifolds $M^2 \times CP_2$ and $M^4 \times S^2$, where $M^2 \subset M^4$ has interpretation as plane of non-physical polarizations and $S^2 \subset CP_2$ is a homologically trivial geodesic sphere of CP_2 with vanishing induced Kähler form (see the Appendix of [K2]). The latter kind of quantum criticality corresponds to very weak induced Kähler fields and thus to almost vacuum extremals. Given electromagnetic field can be imbedded as a 4-surface in many ways: as a vacuum extremal, as a surface maximizing Kähler electric energy, or something between them.

4. Quantum criticality suggests that em fields in the cell interior correspond to non-vanishing but not too large induced Kähler fields in the resting state. The magnitude of the cell potential in the absence of the membrane is about -50 mV and slightly below the magnitude of the critical potential of -55 mV [I39]. Hence the reduction of the magnitude of the em (-or more precisely- Kähler-) voltage between the inner boundary of the peripheral cytoskeleton and cell exterior to a small enough value could induce almost vacuum extremal property and quantum criticality making $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axonal membrane possible. This framework would also allow to understand the paradoxical fact that a reduction of the magnitude of the cell potential induces the action potential rather than its increase as the naïve idea about dielectric breakdown would suggest.

5. Action potential should induce gel-to-sol phase transition somehow and Josephson radiation generated during the action potential could be responsible for this. During action potential the energy of Josephson covers a wide range so that it could couple to metabolic energy quanta. If the frequency of Josephson radiation is considerably higher than the rate of variation of the action potential the situation is adiabatic in the sense that the energy of Josephson radiation is effectively constant. The situation is optimal during the maximum +40 mV of the action potential. Josephson radiation could couple resonantly to the gel defined by the peripheral cytoskeleton and induce fast transfer of protons from large to small space-time sheets and generate metabolic energy quanta helping to destroying the hydrogen bonds. This should somehow induce the increase of Planck constant for the magnetic flux tubes responsible for the gel-to-sol phase transition. This admittedly speculative and somewhat misty idea has been discussed already earlier and will reconsidered in the section where the relationship of the model with microtubular level is discussed.

6. The value of the membrane potential is -55 meV at criticality for the generation of the action potential and +40 meV at the maximum [J3]. All the values between them could correspond to energies of Josephson radiation, which for certain values of membrane potential correspond

to metabolic energy quanta. The range of variation for membrane voltage allows all Josephson energies down to cutoff energy for which the frequency of Josephson radiation is of same order than the rate of relative variation of the membrane potential. Explicitly this condition reads as

$$\frac{\frac{dV}{dt}}{V} \ll \frac{f_0}{r} \frac{V}{V_0} \quad , \quad r = \frac{\hbar}{\hbar_0} \quad .$$

Here f_0 is the the Josephson frequency for $r = 1$ and for the resting potential V_0 and is of order 10^{14} Hz for almost vacuum extremals and 10^{13} Hz for far from vacuum extremals. Josephson frequency must be considerably above kHz frequency defined by the duration of the action potential. Therefore Josephson radiations below *resp.* above kHz frequency must relate to resting state *resp.* action potential and must correspond to different biological functions. For $r = 2^{k_d}$ the kHz frequency correspond roughly to $k_d = 36$ for almost vacuum extremals and to $k_d = 33$ for far from vacua. Note that the p-adic length scale determined by the wave length of Josephson radiation for $k_d = 36$ is 16 cm - the size scale scale of brain.

7. There are two options depending on whether the cell membrane is assumed to correspond to almost vacuum extremal or not.

   (a) For far from vacuum extremal option the energies of Josephson photons in the case of proton are 55 meV and 40 meV for the mentioned values of membrane potential and corresponds to IR radiation. The Josephson energies in case of proton and electron are by an order of magnitude smaller than the nominal energy.5 eV for standard metabolic energy quantum. The metabolic energy quantum liberated in the dropping of proton Cooper pair from $k = 139$ atomic space-time sheet or of electron Cooper pair from $k = 151$ cell membrane space-time sheet to a much larger space-time sheet is $\simeq .62$ eV for the nominal value of.5 eV for the dropping of proton from $k = 137$ space-time sheet to much larger space-time sheet. Note however that $E = E_0(1 - 2^{-k})$ spectrum for metabolic energy quanta gives energy $E = 47$ meV for $k = 2$. One can criticize this option because one must assume non-standard metabolic energy quanta and there must be a separate control mechanism inducing their generation.

   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.

   (b) The cutoff frequency is certainly considerably higher than kHz. For almost vacuum extremal the Josephson energy is

   $$E = Q_{eff}(p)e \times V \quad , \quad Q_{eff}(p) = 3 - \frac{1}{2p} \quad , \quad p = sin^2(\theta_W) = .029 \quad .$$

   One has $E = .7$ eV for V=-55 mV and $E = .56$ eV for V=+40 meV. The latter value is not too far from the nominal value.5 eV for the basic metabolic energy quantum. Note that during nerve pulse Josephson radiation in a wide range of energies is emitted. Besides this there is energy spectrum associated with ions. The energies for $(Na^+.Cl^-, K^+, Ca^{+2})$ are (2.2, 2.74, 3.07, 2.31) eV for -55 mV and (1.60, 2.00, 2.23, 1.68) eV for +40 mV (Table 3). Note that at maximum of V 2.00 eV metabolic energy quantum is associated with Cl^-.

$$
\begin{array}{llll}
Ion & f_c/Hz & Pseudo-ion & f_c/Hz \\
{}^{23}Na^+ & 13.1 & {}^{19}Ne_+ & 15.7 \\
{}^{23}Na^+ & 13.1 & {}^{24}Mg_-^{++} & 12.5 \\
{}^{39}K^+ & 7.7 & {}^{40}A_+ & 7.5 \\
{}^{39}K^+ & 7.7 & {}^{40}Ca_-^{++} & 7.5 \\
{}^{35}Cl^- & 8.6 & {}^{40}A_- & 7.5
\end{array}
\tag{12.3.1}
$$

Table 12.1: The modification of cyclotron frequencies of most important ions are modified by simplest replacements with exotic ions

What the replacement of Ohmic ionic currents with quantal currents means?

Before the replacement of Hodgkin-Huxley model with a genuinely quantal model can be taken seriously, one must answer many difficult questions which also Hodgkin and Huxley must have faced as they developed their own model. It is best to proceed by making questions and answers.

Q: In the resting state membrane potential is negative and cell has a negative net charge. What stabilizes the cell against the leakage of the negative charge if pumps and channels are not responsible for this?

A: The findings about the strange behavior of cell membrane inspire TGD based answer. Cell membrane space-time sheet is its own quantum world and the flow of ions occurs only in the presence of magnetic flux tubes connecting it to the external world. These currents a however oscillatory Josephson currents if dissipation is absent. Hence there is no need to cut completely the connections to the external world.

Q: How the resting state can result spontaneously if pumps are absent?

A: If ionic currents are Josephson currents, they are automatically oscillating and the return to the original state is guaranteed. The flux tubes carrying the ionic currents will be assumed to connect axonal micro-tubules to the space-time sheet of the cell interior. Consider first the most obvious objections.

1. Dark ions cannot transform to ordinary ones in the exterior of the cell membrane. This might indeed kill the model.

2. The second objection is that all biologically important ions are not bosons and the model for high T_c super-conductor in its recent form allows only electronic and protonic Cooper pairs at room temperature [K17]. TGD based nuclear physics however predicts the possibility of exotic nuclei for which one or more color bonds connecting nucleons to the nuclear string are charged. These exotic nuclei with electronic states identical to those of genuine ions could save the situation.

Table 12.1 describes how cyclotron frequencies for $B = .2$ Gauss of the most important ions are modified in the simplest replacements with exotic ions. For instance, the notation Mg_-^{+2} tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.
$f_c(K+)$ and $f_c(Cl^-)$ are replaced with the frequency 7.5 Hz and one can do only using the cyclotron frequencies $f(Ca^{+2})/2 = 7.5$ Hz, $f_c(Mg^{+2}) = 12.5$ Hz, and $f(Ca^{+2}) = 15$ Hz. The nominal values of the lowest Schumann frequencies are 7.8 Hz and 14.3 Hz. All ions with relevance for nerve pulse and EEG could be bosonic ions or bosonic pseudo-ions. I do not know how well the needed ionization mechanisms are understood in the standard framework.

For small oscillations the maximal charge transfer ΔQ generated by an oscillating ionic Josephson current during the cycle is proportional to $\hbar/f_J \propto \hbar^2$ and $\hbar/\Omega \propto \hbar$ for solitonic situation. ΔQ is very small for the ordinary value of $\hbar$: also the oscillation period is very small. For large values of $\hbar$ situation changes and large maximal ion transfers are possible. An $\hbar$ increasing phase transition could be involved with the generation of the nerve pulse. Quantum criticality during nerve pulse generation indeed suggest the presence of flux tubes with varying values of $\hbar$. The

lifetimes of the connected flux tubes could be proportional to $\hbar$ at criticality. A fractal hierarchy of pulses and EEG like oscillations of the membrane potential corresponding to various values of $\hbar$ is suggestive.

Q: Can one make this more quantitative?

A: One can construct a model based on Sine-Gordon wave equation for the phase difference Φ between the superconductors connected by Josephson junction sequences defined by magnetic flux tubes and idealizable as a continuous Josephson junction.

1. For a Josephson junction idealizable as a hollow cylinder with radius R and thickness d the expression of the Josephson current reads as

$$J = J_0 sin(Ze \int V\,dt/\hbar) \ .$$

J_0 is in case of cell membrane given by

$$J_0 = \frac{Ze2\pi dR}{\Lambda^2}\frac{\hbar}{m} \ ,$$

where R and d would be now the radius and thickness of the axon, Λ is the magnetic peneration length, and m is the mass of the charge carrier. Although this expression does not hold true as such when Josephson junctions are replaced by magnetic flux tubes connecting micro-tubules and axon, one can can safely make some qualitative conclusions. The amplitude of the Josephson current increases with $\hbar$. For electron the value of the amplitude is by a factor $x \simeq Am_p/m_e \simeq 2^{11}A$ larger than for ion with a mass number A. This gives for electron Cooper pairs a unique role as an initiator of the nerve pulse. Note that the amplitudes of the Josephson currents of electron and ions are quite near to each other if one has $\hbar(ion) = 2^{11}A\hbar e$.

2. Electronic Josephson current dominates and makes it ideal for the generation of nerve pulse (kick to gravitational pendulum). This is possible if the net amount of electronic charge is so small that it flows out during the generation of flux tubes. For ions this need not occur even if ion densities are of same order of magnitude. Constant voltage V creates an oscillating current and no catastrophic leakage takes place and the resting state results automatically. The ionic Josephson currents assignable to the magnetic flux tubes connecting micro-tubules through the cell membrane to the external world could be responsible for the nerve pulse.

3. The mechanical analog for Sine-Gordon system [B3] assignable to Josephson junction is rotating pendulum but one must be cautious in applying this analogy. There are two options concerning the modelling of the situation.

   (a) Membrane potential represents an external voltage $V(t)$ and one has $\Phi_i = Z_i e \int V\,dt/\hbar$, where Φ is the phase difference between Bose-Einstein condensates.

   (b) System is autonomous and membrane potential $V(t) = \hbar(d\Phi_i/dt)/Z_i e$ is completely determined by the dynamics of any phase Φ_i. This option is highly predictive and discussed in the sequel.

4. The analogy with gravitational pendulum allows to identify the phase angle Φ as the counterpart of angle Θ characterizing angular position of mathematical pendulum (note that this analogy can be misleading since it implicitly brings in 3-D thinking).

   (a) In this picture rotating pendulum corresponds to a soliton sequence containing infinite number of solitons: both stationary and moving soliton sequences are obtained. The sign of $\Omega = d\Phi/dt$ is fixed and approximately constant for large values of Ω. Resting potential could correspond to this kind of situation and $\Omega \simeq 2\pi$ kHz is suggested by kHz synchrony. A mechanism of this synchrony will be discussed below. For large

values of $\hbar$ even values of Ω in EEG range could correspond to membrane potential. For large values of Ω one as $V \simeq \hbar\Omega_i/Z_ie$. If also EEG rhythms correspond to Ω they must correspond to different values of $\hbar$ and $f \propto 1/\hbar$ would hold true. Changes in the dominating EEG rhythm (40 Hz, 10 Hz, 5 Hz, ..) could correspond to phase transitions changing $\hbar$ to given value for a large number of axons. The maximal charge transfer during single period is proportional to $\Delta Q \propto 1/\Omega$.

(b) Hyper-polarization/depolarization would mean fastening/slowing down of the pendulum rotation and slowing down would make the system unstable. Near criticality against the generation of nerve pulse would mean that pendulum is rotating rather slowly ($\Omega \ll f_J$) so that a small kick can transform rotation to oscillation. The sign of $V \propto d\Phi/dt$ would change and large amplitude oscillatory motion would result for single period only after which a kick in opposite direction would lead back to the resting state. Membrane potential varies between the resting potential $V_0 = -75$ mV and $V_1 = +40$ mV during nerve pulse: $V_1 > |V_0|$ would have killed the model. Note that $V_1 = 40$ mV is rather near to the critical potential about $V_1 = 50$ mV: ideally these potentials should be identical.

(c) The so called breathers -both stationary and moving- correspond to soliton-antisoliton bound state (see the visualization in [B3]). Breathers could be identified as large amplitude oscillations around $\Phi = 0$ ground state. Physical intuition suggests that breathers are possible also for a ground state corresponding to a rotating pendulum (representing moving or stationary waves). They would correspond to kicking of one pendulum in a sequence of penduli along z-axis rotating in phase at the initial moment. The kick could correspond to a genuine external perturbation generated by a pair electronic supra current pulses of opposite sign giving constant velocity increments $\Delta\Omega$ initiating and halting the nerve pulse just like they would do in the case of TQC but in opposite time order. If the background corresponds to a propagating EEG wave, also nerve pulse is expected to propagate with same velocity. The propagation direction of EEG wave would also explain why nerve pulses propagate only in single direction.

5. For the ordinary value of $\hbar$, the frequency Ω of the Josephson current corresponds to that assignable to energy .07 eV being around $f = 1.6 \times 10^{13}$ Hz and quite high. One can look at the situation in light of $r \equiv \hbar/\hbar_0 = 2^{11k}$ hypothesis, which has however turned out to be quite too restrictive. For $r \equiv \hbar/\hbar_0 = 2^{44}$ the frequency would be near to cyclotron frequency of about 1 Hz assignable to DNA strands. For $x = 3 \times 2^{3\times13}$ f would be near to the fundamental 10 Hz frequency which is secondary p-adic time scale associated with electron and correspond to the temporal duration of negative energy space-time sheet assignable to electron. For $r = 3 \times 2^{3\times11}$ one would obtain a 640 Hz frequency which corresponds to the time scale of nerve pulse. It seems clear that the original hypothesis that only powers of 2^{11} define the spectrum of Planck constant is too restrictive and Mersenne hypothesis introduced in the introduction seems more plausible hypothesis although even this hypothesis is too too restrictive [K35]. The requirement that cyclotron frequencies and Josephson frequencies are proportional to each other for small oscillations would guarantee resonant behavior for common strength of the magnetic field would give $\hbar \propto A$. This would require that each ion species lives at its own flux tubes.

6. The realization that cell membrane could correspond to almost vacuum extremal [K35] changed the situation completely. For vacuum extremals Z^0 and em fields are proportional and if one assumes that almost vacuum extremals define a phase in which the Z^0 charges of quarks are fed to almost vacuum extremal unlike electrons, one must replace ionic charges with effective charges proportional to the nuclear charge. This raises the energy scale defined by the resting potential to visible and UV range. Note that also neutral atoms are Z^0 ions in this phase. Otherwise the model for cell membrane as Josephson junction remains the same. This hypothesis can be defended by its success: it predicts correctly the values of frequencies of maximum sensitivity for photoreceptors in terms of Josephson energies of various ions and almost vacuum extremal property conforms also with the quantum criticality of living matter. This model will be be discussed in detail in the sequel.

Q: What instabilizes the axon? Why the reduction rather than increase of the magnitude of the membrane potential induces the instability? Why the reduction of the resting potential below the critical value induces nerve pulse?

A: Large enough voltage pulse between micro-tubules and membrane could generate electronic DC supra current. The introduction of a small amount of positive charge to the inner lipid layer and staying there for some time would generate the voltage pulse between micro-tubules and lipid layer so that DC electronic supra current would be induced, and induce the reduction $\Delta V \simeq .02$ eV of the magnitude of the membrane potential. A similar introduction of negative charge would induce hyper-polarization and the direction of the current would be opposite if it is generated at all. The proposed model for direct current explains why de-polarization induces instability. Ionic direct quantum currents could thus be the generators of nerve pulse as in Hodkin-Huxley model and Ca^{++} ions and Na^{+} Cooper pairs are in preferred position. The mechanism generating the small positive charge to the inner lipid layer could be based on the exchange of exotic W bosons between pairs of exotic nuclei at opposite sides of the cell membrane so that the negative charge of the inner lipid layer would be reduced.

Q: Can one understand the observed radial force, the increase of the radius of axons and the reduction of its thickness, and heating followed by cooling?

A: The observed outward force acting on a test system might be due to quantum currents. Josephson currents are oscillatory and are not expected to cause any force. Ionic direct currents could induce the force. The pressure caused by the ionic direct current pulse might relate to the increase of the radius of the axonal membrane and with the reduction of its thickness as well as the slight increase of its temperature as being due to the ions which heat the lipid layer as they collide with it and are transferred to smaller space-time sheets if they energy is large enough.

1. This hypothesis combined with the model for direct quantal currents allows to express the momentum flux as product of ionic particle current $n_I v = n_I p/m$ and momentum of charged current carrier equal to $p = \sqrt{2mE_n}$ at the plate of the analog of capacitor. This gives the estimate for the contribution of given bosonic ion or Cooper pair of fermionic ions to the force f per unit area as

$$
\begin{aligned}
f_I &= n_I \times 2E_n \ , \ , \\
E_n &= sin(2\delta)(\frac{nqE\hbar}{r\sqrt{m}})^{2/3} \ , \ \ r == \frac{2}{3} \ , \\
\Psi &= Rcos(U+\delta)exp(-iE_n t) \ .
\end{aligned}
\tag{12.3.2}
$$

The representation of Ψ was introduced in previous section. Here δ parametrizes the current, which vanishes for $\delta = 0, \pi/2$. This gives

$$
f_I(t) = n_I \times (\frac{nqE\hbar}{r\sqrt{m_I}})^{2/3} \ , \ \ r = \frac{2}{3} \ .
\tag{12.3.3}
$$

The force is proportional to $E^{2/3}$ rather than $E = V/d$ (electric field). There is proportionality to $m^{-1/3}$ so that lightest charges give the dominating contribution if their densities are small for some reason.

2. The force caused by ionic Josephson currents on a small piston of area S parallel to the membrane is given by

$$
F = \sum_I n_I \times (\frac{nqE\hbar}{r\sqrt{m_I}})^{2/3} S \ .
\tag{12.3.4}
$$

The comparison with the observed force gives estimate for the densities n_I of ions at the flux tubes.

3. According to [**?**] in one particular experiment the force on piston of area $S = .01$ cm^2 at the maximum of voltage is $F = 2$ nN. This gives for proton mass the rough estimate $n_I \sim 2/L_e(151)^3$, where $L_e(151) = 10$ nm is the p-adic length scale defining cell membrane thickness. For heavier ions large densities of super-conducting ions or their pairs would be required. Perhaps the simplest option is that the direct current pulse of dark proton Cooper pairs induces the force whereas the Josephson currents of electrons give rise to negligibly weak force.

Q: Where the primary wave propagates: along axon or along micro-tubules?

A: This question need not make sense if micro-tubules and axon are connected by magnetic flux tubes to form single quantum coherent system. That axonal micro-tubules have constant electric field which is always in same direction could explain why the background soliton sequences and nerve pulses propagate always in the same direction and suggests that the primary wave propagates along micro-tubules. On the other hand, if W exchange between cell exterior and exterior reduces the negative charge of the inner lipid layer then axon could be seen as initiator. This could induce conformational or gel-sol phase transition propagating along micro-tubule and inducing the pair of voltage pulses in turn inducing the fusion of flux tubes at cell membrane which in turn would induce criticality of the axonal membrane. For this option axonal soliton would be a shadow of the micro-tubular soliton rather than completely independent dynamical process.

Q: How nerve pulse velocities are determined?

A: At first glance it seems nerve pulse velocity v could be determined by boundary conditions guaranteeing synchronization of neuronal activity rather than by dissipation as in Hodgkin-Huxley model. As a matter fact, dissipation turns out to affect also v just because it is determined by boundary conditions!

1. Hodgkin-Huxley model would suggest that nerve pulse velocity is dictated by frictional effects as an analog of a drift velocity. The rough order of magnitude estimates for the velocities of conformational waves along micro-tubuli are consistent with the velocities of nerve pulses. The proportionality $v \propto d$ of nerve pulse velocity to nerve axonal radius might be understood as resulting on the dependence on the length of flux tubes connecting axon and micro-tubules and mediating a frictional feedback interaction from axon. Feedback would be naturally reduced as d increases. Feedback interaction could explain also the sensitivity of the thermal parameters of the axonal membrane to the proteins in its vicinity. If the frictional feedback is due to the environmental noise at the axon amplified at quantum criticality this is what one expects. Quite generally, quantum criticality would explain the high sensitivity of the thermal parameters on noise. Saltation cannot be responsible for the higher conduction velocity in myelin sheathed portions of axon. The insulation would reduce the environmental noise at the level of axons and thus reduce the frictional feedback from axon to the micro-tubules.

2. The introduction of friction is however problematic in the recent situation. In absence of boundary conditions Sine-Gordon equation predicts for the propagating soliton sequences a continuous velocity spectrum and friction should affect Ω and V rather than phase velocity v but it is not clear whether it can affect v.

   (a) In this framework the boundary boundary conditions at the ends of the axon or some subunit of axon would dictate the values of v: $\gamma \Omega L/v = n 2\pi$ corresponds to periodic boundary conditions (note that $\gamma = \sqrt{1 - (v/c)^2} \simeq 1$ holds true). $v = \Omega L/n2\pi$ implies that friction indeed affects also v.

   (b) The relationship states that the time taken by the nerve pulse propagate through the axon is always $T = L/v = n2\pi/\Omega$: this would synchronize neurons and $\Omega \simeq 2\pi$ kHz is suggested by the well-known 1 kHz synchrony difficult to understand in the standard framework where v would be determined by chemistry rather than geometry. Myelin shielding could in this picture guarantee that coherent wave propagation is possible over the entire axon so that boundary conditions can be applied.

(c) This would give $v \simeq \Omega L/n2\pi < \Omega L/2\pi$. $\Omega = 2\pi$ kHz and $n = 1$ would give for $L \in$ [1 cm -10 cm] $v \in$ 10 m/s-100 m/s corresponding roughly to the observed range of values. For short axons velocity would be lower: for $L = 10$ μm one would have $v = .01$ m/s. For longer axons the value of n could be higher or the axon would decompose into structural units for which periodic boundary conditions are satisfied. The sections between Ranvier nodes have length measured in millimeters as are also the lengths of axonal micro-tubules and 1 mm would correspond to a velocity of 1 m/s. The actual velocity for the myelinated sections varies between 18-100 m/s so that basic structural units should be longer. The proportionality of v to the radius of axon would follow from the proportionality of the length of the axon or its basic sub-unit (not longer than ~ 10 cm) to its radius: the simplest geometric explanation for this would be in terms of scaling invariance of the axonal geometry consistent with fractality of TGD Universe. In the standard framework this proportionality would be explained by the minimization of dissipative losses in the case of long axons: one cannot exclude some variant of this explanation also now since friction indeed reduces v.

(d) There is an electric field associated with micro-tubules (always in same direction). Could this electric field play the role of external force feeding energy and momentum to the moving soliton sequence to compensate dissipation so that v would have interpretation as a drift velocity?

Q: Can one understand EEG in this framework?

A: Just like kHz waves also EEG generating waves could correspond to propagating soliton sequences. Since V is not affected, the value of $\hbar$ must be much larger and one must have $\hbar \propto f$, where f defines the EEG rhythm. It is known that EEG amplitudes associated with EEG rhythms behave roughly like $1/f$. This can be understood. By Maxwell's equation the divergence of electromagnetic field tensor is proportional to 4-current implying the amplitude of EEG identified as Josephson radiation is proportional J_0/Ω and therefore to $\hbar$. The propagation velocity $v = \Omega L/2\pi n$ of EEG generating waves is rather slow as compared to kHz waves: for $f = 10$ Hz one would have 10 cm long axon $v = 1$m /s. Synchronization results automatically from periodic boundary conditions at the ends of the axons.

Nerve pulses during EEG rhythms would have much slower velocity of propagation and the duration of nerve pulse would be much longer. The maximal charge transfer would be proportional to $1/\hbar$. It would thus seem that EEG and nerve pulse activity should exclude each other for a given axon. Ω is however smaller so that the generation of nerve pulse is easier unless also ion densities are lower so that J_0 (analogous to gravitational acceleration g in pendulum analogy) is reduced. Perhaps this takes place. The consistency with the propagation velocity of micro-tubular conformational (or even gel-sol-gel) waves might pose additional constraints on v and thus on frequencies Ω for which nerve pulses are possible. That ordinary EEG is not associated with ordinary cells might be due to the fact that $\hbar$ is much smaller: the fractal analog of EEG generating waves could be present but these EEG waves would correspond to faster oscillations in accordance with the view about evolution as an increase of $\hbar$.

Could Hodgkin-Huxley model provide a phenomenological description?

It is now clear that the physics behind Hodgkin-Huxley model is not consistent with the physics behind the TGD based model of nerve pulse. The cell as gel hypothesis excludes Hodkin-Huxley model even without any TGD based physics. If ionic currents were ordinary Ohmic currents as in the case of soliton model and Pollack's model, Hodgkin-Huxley model might be interpreted as a phenomenological description. In TGD framework the dark currents do not dissipate and the model can serve only a recipe to mimic the time evolution of the ionic currents by a judicious tailoring of the time dependence of ionic conductances.

The current associated with a given ion would be proportional to the sum of the electric forces experienced by the particle:

$$I_X = g_X \left[Q_X e(V_{em} - V_X) \right] \quad .$$

In the catastrophe theoretic variant of the Hodgkin-Huxley model [A12], which assumes a wave (Ca^{+2} now) triggering the nerve pulse, the values of the ionic conductivities g_{Na}, g_{Cl} and g_K at resting state are $g_{Na} = 0$, $g_{Cl} = .15$ $mmho/cm^2$ and $g_K = .24$ $mmho/cm^2$ The values of V_X are $V_K = -77$, $v_{Na} = +50$, $v_{Cl} = -46$, when millivolt is used as unit. The value of the resting potential is $v_R = -65$ mV. The vanishing of g_{Na} at the resting value and down to the point, when nerve pulse is triggered, is assumed in Hodgkin-Huxley model and in the catastrophe theoretic model of the nerve pulse [A12]. The vanishing of g_{Na} codes for the absence of magnetic flux tubes in TGD framework.

12.3.3 Model Of Nerve Pulse Assuming Almost Vacuum Extremal

Both near to and far from vacuum extremals might be important in living matter. Near to vacuum extremals are favored by quantum criticality reflecting as a large degeneracy of ground states assignable to small deformations of vacuum extremals. Also the vision about living matter as 4-D spin glass phase favors almost vacuum extremals. Magnetic flux tubes would in turn be more naturally far from vacua. Also the hierarchy of Planck constants can be associated with the deformations of vacuum extremals so that one would expect them to be important.

At this stage one can make only guesses and it is interesting to consider also the possibility that near to vacuum extremals are more appropriate for the modelling of cell membrane and perhaps even nerve pulse. It is also possible that both kinds of extremals are involved. One must also remember that cells are at different evolutionary levels and the effects of ELF em fields have been observed for vertebrate brain so that ionic Bose-Einstein condensates might appear only in vertebrate neurons. Also vacuum extremals might become increasingly vacuum like as the evolutionary level becomes higher.

Cell as almost vacuum extremal

Although the possible fundamental role of vacuum extremals for quantum criticality and life has been obvious from the beginning, it took a long time to realize how one could model living cell as this kind of system.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [I43] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.

2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that wormholes are in some sense "square root" of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields.This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts.

Cell membrane is the basic example about electret and one of the basic mysteries of cell biology is the resting potential of the living cell. Living cell membranes carry huge electric fields: something like 10^7 Volts per meter. For neuron resting potential corresponds to about.07 eV energy gained when unit charge travels through the membrane potential. In TGD framework it is not at all clear whether the presence of strong electromagnetic field necessitates the presence of strong Kähler field. The extremely strong electric field associated with the cell membrane is not easily understood in Maxwell's theory and almost vacuum extremal property could change the situation completely in TGD framework.

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general visiona about living matter as a quantum critical system. For vacuum extremals classical em and Z^0 fields would be proportional to each other. The second half of Maxwell's equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of Z^0 charges creating the classical Z^0 fields is implied. Neutrinos are the most candidates for the carrier of Z^0 charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.

2. There are also space-time surfaces for CP_2 projection belongs to homologically non-trivial geodesic sphere. In this case classical Z^0 field can vanish [L3], [L3] and the vision has been that it is sensible to speak about two basic configurations.

   (a) Almost vacuum extremals (homologically trivial geodesic sphere).

   (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge Z^0 component (homologically non-trivial geodesic sphere).

   The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.

   (a) The action of color rotations in the holonomy algebra of CP_2 is non-trivial and corresponds to the action in $U(2)$ sub-group of $SU(3)$ mapped to $SU(2)_L \times U(1)$. Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local $U(1)$ sub-group local with respect to CP_2 point.

   (b) Kähler form remains certainly invariant under color group and the right handed part of Z^0 field reducing to $U(1)_R$ sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local $U(1)_L$ gauge rotation acting on the neutral left handed part of Z^0 in the same manner as it acts on the right handed part. This is true if the $U(1)_L$ sub-group does not depend on point of CP_2 and corresponds to Z^0 charge. If only Z^0 part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If Z^0 part vanishes and non-vacuum extremal is in question, then color rotation rotation of W components mixing them but acts as a pure $U(1)$ gauge transformation on the left handed component.

   (c) It might not be without significance that for any partonic 2-surface induced electroweak gauge fields have always U(1) holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.

4. The unavoidable presence of long range Z^0 fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different

ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to $T_p = 1/2$, the mass scale would be multiplied by a factor $\sqrt{M_{89}}$ and Compton lengths of weak bosons would be around 10^{-4} meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.

5. From the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field [L3] , [L3]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{12.3.5}$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of p would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged Z^0 fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter - say quarks with Compton lengths of order cell size and Planck constant of order $10^7 \hbar_0$ - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implies $\hbar \sim 10^{13} \hbar_0$ and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a large neuron. The quarks involved with with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical Z^0 fields and not acting as its source- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical Z^0 field. The flow of Na^+ ions during nerve pulse could take along same dark flux tube as the flow of dark quarks and leptons. This near vacuum extremal property might be fundamental property of living matter at dark space-time sheets at least.

Are photoreceptors nearly vacuum extremals?

The surprising outcome of following considerations is that one could understand the preferred frequencies for photo-receptors [?] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large $\hbar$.

In Hodgkin-Huxley model ionic currents are Ohmic currents. If one accepts the idea that the cell membrane acts as a Josephson junction, there are also non-dissipative oscillatory Josephson currents of ions present, which run also during flow equilibrium for the ionic parts of the currents. A more radical possibility is that the dominating parts of the ionic currents are oscillatory Josephson currents so that no metabolic energy would be needed to take care that density gradients for ions are preserved. Also in this case both nearly vacuum extremals and extremals with nearly vanishing Z^0 field can be considered. Since sensory receptors must be highly critical the natural question is whether they could correspond to nearly vacuum extremals. The quantitative success of the following model for photoreceptors supports this idea.

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wave

length range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [J10, **?**]. The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes $dI/d\lambda + 2I/\lambda = 0$, which means a shift to a larger value of λ, which is largest for smallest λ. Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From **Table 12.3** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and Z^0 fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1. Na^+ and Ca^{+2} currents are known to present during the activation of the photoreceptors. Na^+ current defines the so called dark current [**?**] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also K^+ current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors. Interestingly, currents of Ca^{+2} ions and Na^+ Cooper pairs are also in special role that they would give rise to initiation of nerve pulse with values of Planck constant which can be same for both options (near vacuum extremal or far from vacuum extremal). This is seen by studying the expression of the parameter $x = r^2/A(A - Z)$, $r = \hbar/\hbar_0$, appearing in the amplitude of the direct current: the ratio of these parameters is 1.4 in good approximation for same value of Planck constant (see previous section about quantum model for Becker's direct currents). Does this mean that Josephson currents of Ca^{+2} ions and Na^+ Cooper pairs appear in photoreceptors and for ordinary neurons the currents are direct currents? This would require that photoreceptors have higher value of Planck constant so that the Compton length of ion is of order cell membrane thickness.

2. One ends up with the model in the following manner. For Ca^{+2} the Josephson frequency does not depend on p and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to $V = .055$ V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of $p = .0295$.

The predictions of the model come as follows summarized also by the Table 3 below.

1. The resting potential for photoreceptors is $V = -40$ mV [**?**]. In this case all Josephson energies are below the range of visible frequencies for $p = .23$. Also for maximal hyper-polarization Na^+ Josephson energy is below the visible range for this value of Weinberg angle.

2. For $V = -40$ mV and $p = .0295$ required by the model the energies of Cl^- and K^+ Josephson photons correspond to red light. 2 eV for Cl^- corresponds to a basic metabolic quantum. For Na^+ and Ca^{+2} the wave length is below the visible range. Na^+ Josephson energy is below visible range. This conforms with the interpretation of Na^+ current as a counterpart for the sensation of darkness.

3. For $V = -55$ mV - the threshold for the nerve pulse generation- and for $p = .0295$ the Josephson energies of Na^+, Ca^{+2}, and K^+ a correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also Cl^- is in the blue region. Ca^{+2} Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to $V = -59$ mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ($V \simeq -55$ mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of $\hbar$ the frequency scales is that of EEG).

Ion	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	B	W
E_{max}	2.19	2.32	3.06	2.49
energy-interval/eV	1.77-2.48	1.97-2.76	2.48-3.10	

Table 12.2: Table gives the prediction of the model of photoreceptor for the Josephson energies for typical values of the membrane potential. For comparison purposes the energies E_{max} corresponding to peak sensitivities of rods and cones, and absorption ranges for rods are also given. R, G, B, W refers to red, green, blue, white. The values of Weinberg angle parameter $p = sin^2(\theta_W)$ are assumed to be .23 and .0295. The latter value is forced by the fit of Josephson energies to the known peak energies.

4. In a very bright illumination the hyper-polarization is $V = -65$ mV [**?**], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of Ca^{+2}. This would suggests that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.

The model reproduces basic facts about vision assuming that one accepts the small value of Weinberg angle, which is indeed a natural assumption since vacuum extremals are analogous to the unstable extrema of Higgs potential and should correspond to small Weinberg angle. It deserves to be noticed that neutrino Josephson energy is 2 eV for $V = -50$ mV, which correspond to color red. 2 eV energy defines an important metabolic quantum.

It interesting to try to interpret the resting potentials of various cells in this framework in terms of the Josephson frequencies of various ions.

1. The maximum value of the action potential is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.

2. For neurons the value of the resting potential is -70 mV. Na^+ and Ca^{+2} Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that Ca^{+2} Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.

3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case Ca^{+2} Josephson frequency corresponds to 4 eV metabolic energy quantum as the **Table 12.3** shows.

4. For smooth muscle cells the value of resting potential is -50 mV. In this case Na^+ Josephson frequency corresponds to 2 eV metabolic energy quantum.

5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for Cl^- corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.

6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

Could nuclei and neutrinos couple to light variants of weak gauge fields in the critical phase?

One of the hard-to-kill ideas of quantum TGD inspired model of quantum biology is that neutrinos might have something do with hearing and cognition. This proposal looks however unrealistic in the recent vision. I would be more than happy to get rid of bio-neutrinos but the following intriguing finding does not allow me to have this luxury.

1. Assume that the endogenous magnetic field $B_{end} = .2$ Gauss is associated with s nearly vacuum extremal and therefore accompanied by $B_Z = 2B_{end}/p$. Assume for definiteness $m_\nu = .3$ eV and $p = sin^2(\theta_W) = .23$. The neutrino cyclotron frequency is given by the following expression

$$f_\nu = \frac{m_e}{m_\nu} \frac{1}{2sin^2(\theta_W)} f_e \ .$$

From $f_e \simeq .57 \times$ MHz and $p = sin^2(\theta_W) = .23$ one obtains $E_\nu = 1.7 \times 10^{-2}$ eV which is roughly one third to the Josephson frequency of electron assignable to cell membrane. Could Josephson frequency of cell membrane excite neutrino cyclotron transitions?

2. The model for photoreceptors to be discussed below forces to conlude that the value of Weinberg angle in the phase near vacuum extremal must be $p = .0295$ if one wants to reproduces the peak energies of photoreceptors as Josephson frequencies of basic biological ions. This would predict $E_\nu = .41$ eV, which is rather near to the metabolic energy quantum. The non-relativistic formula however fails in this case and one must use the relativistic formula giving

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \ eV$$

giving the metabolic energy quantum. Does this mean that Z^0 cyclotron frequency for neutrino is related to the transfer of metabolic energy using MEs in the phase near vacuum extremals.

3. Josephson frequency is proportional to $1/\hbar$, whereas neutrino cyclotron frequency does not depend on $\hbar$ at non-relativistic energies. For larger values of $\hbar$ the neutrino becomes relativistic so that the mass in the formula for cyclotron frequency must be replaced with energy. This gives
$$E = \sqrt{n} r^{1/2} \sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2} \times .48 \ eV \ , \ r = \sqrt{\hbar/\hbar_0} \ .$$

Here n refers to the cyclotron harmonic.

These observations raise the question whether the three frequencies with maximum response assignable to the three different types of receptors of visible light in retina could correspond to the three cyclotron frequencies assignable to the three neutrinos with different mass scales? The first objection is that the dependence on mass disappears completely at the relativistic limit. The second objection is that the required value value of Planck constant is rather small and far from being enough to have electroweak boson Compton length of order cell size. One can of course ask whether the electroweak gauge bosons are actually massless inside almost vacuum extremals. If fermions -including neutrino- receive their masses from p-adic thermodynamics then massless electroweak gauge bosons would be consistent with massive fermions. Vacuum extremals are indeed analogous to the unstable extrema of Higgs potential at which the Higgs vacuum expecation vanishes so that this interpretation might make sense.

It is easy to test whether Hodgkin-Huxley model tolerates the inclusion of Z^0 field and the assumption that nuclei and neutrinos or antineutrinos serve as its sources. In the cell scale

neutrinos would indeed serve as a natural source of classical Z^0 fields. The simplest assumption is that neutrino current guarantees that the almomst acuum extremal property prevails during the nerve pulse.

Goldman equation in Hodgkin-Huxley model

Consider first Hodgkin-Huxley model in order to understand how to generalize it to take into account the couplings of nuclei and neutrinos to the classical Z^0 field. In Hodkin-Huxley model the basic equations state flow equilibrium. The basic equation is so called Goldman equation [**?**].

1. Ion current j_A is a sum of two terms:

$$j_A = D_A(\frac{dn_A}{dz} - b_A n_A) \ , \ \ b_A = \frac{q_A e E}{k_B T} \ , \ \ E = \frac{V}{d} \ . \tag{12.3.6}$$

   The first term is a diffusion term proportional to concentration gradient of ion and second term a drift term proportional to ion concentration n_A and the electric field E assignable to cell membrane and defined as membrane potential V divivided by the thickness of cell membrane d. Stokes-Einstein equation implies that the coefficient of electric force in drift velocity is expressible in terms of the diffusion constant D_A defining ionic permeability as $P_A = D_A/d$.

2. The equations for the ion currents can be integrated with respect to the coordinate z orthogonal to the cell membrane and give the currents in terms of differences of concentrations outside and inside membrane. The outcome is

$$j_A = D_A b_A \frac{n_A(in)exp(b_A d) + n_A(out)}{1 - exp(b_A d)} \ . \tag{12.3.7}$$

   The change of the sign of the charge changes the sign of b and implies only the replacement in↔out and changes of the sign in the above formula. The explicit expression reads as

$$j_A = \mu q_A P_A \frac{n_A)(out) - n_A(in)exp(q_A\mu)}{1 - exp(q_A\mu)} \ , \ \ \mu = \frac{eV}{kT} \ . \tag{12.3.8}$$

   Note that the multiplication by q_A compensates the change of sign in j_A.

3. The condition that total electric current vanishes reads as

$$j_{tot} = \sum q_A j_A = 0 \tag{12.3.9}$$

   It gives Goldman equation [**?**]. If the charges have same magnitude ($q_A = \pm 1$) the equation can be solved as

$$
\begin{aligned}
\mu &= log(\frac{w}{v}) \ , \\
w &= \sum_C P_C n_C(out) + \sum_A P_A n_A(int) \ , \\
v &= \sum_C P_C n_C(in) + \sum_A P_A n_A(out) \ .
\end{aligned}
\tag{12.3.10}
$$

Here C refers to positively charged ions (cations) and A to negatively charged ones (anions). In the physical situation only K_+, Na_+, and Cl_- are the interesting ions and only K_+ conductivity differs considerably from zero due to the continual pumping of K_+ ions against the concentration gradient. This gives a more explicit formula

$$eV = k_B T \times log(\frac{P_{K^+} n_{K^+}(out) + P_{Na^+} n_{Na^+}(out) + P_{Cl^-} n_{Cl^-}(in)}{P_{K^+} n_{K^+}(in) + P_{Na^+} n_{Na^+}(in) + P_{Cl^-} n_{Cl^-}(out)}) \ .$$

(12.3.11)

relating the resting potential to the ratios of ionic concentrations outside and inside membrane and ionic conductivities which are parameters, which cell is able to modify and does it during the generation of nerve pulse. During nerve pulse in practice only the flows of K_+ and Na_+ ions matter. In the beginning of nerve pulse Na_+ conductance increases and K_+ conductance is reduced. This changes the sign of potential and after that the situation returns to the original one.

Hodgkin-Huxley model for the resting potential for nearly vacuum extremals

One can formulate Hodgkin-Huxley model for the resting potential for exact vacuum extremals by replacing the membrane potential with its Z^0 counterpart since the couplings to em charge vanish assuming that Weinberg angle vanishes for vacuum extremals

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural. Also neutrino conductance could be added as a parameter to the model.

2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical Z^0 field whereas the coupling to classical em field vanishes. Both K_+, Na_+, and Cl_- $A - Z = Z + 1$ so that by p-n pairing inside nucleus they have the weak isospin of neutron (opposite to that of neutrino) whereas Ca_{++} nucleus has a vanishing weak isospin. This might relate to the very special role of Ca_{++} ions in biology. For instance, Ca_{++} defines an action potential lasting a time of order.1 seconds whereas Na_+ defines a pulse lasting for about 1 millisecond [J3]. These time scales might relate to the time scales of CDs associated with quarks and electron.

3. The basic question is whether only nuclei couple to the classical Z^0 field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from Z^0 coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical Z^0 field, one ends up with difficulties with atomic physics. If only quarks couple to the Z^0 field and one has $Z^0 = -2\gamma/p$ for vacuum extremals, and one uses average vectorial coupling $\langle I_L^3 \rangle = \pm 1/4$ with + for proton and - for neutron, the resulting vecotor coupling is following

$$(\frac{Z - N}{4} - pZ)Z^0 + q_{em}\gamma = Q_{eff}\gamma \ ,$$
$$Q_{eff} = -\frac{Z - N}{2p} + 2Z + q_{em} \ .$$

(12.3.12)

Here γ denotes em gauge potential. For K^+, Cl^-, Na^+, Ca^{+2} one has $Z = (19, 17, 11, 20)$, $Z - N = (-1, -1, -1, 0)$, and $q_{em} = (1, -1, 1, 2)$. **Table 12.3** gives the values of Josephson energies for some values of resting potential for $p = .23$. Rather remarkably, they are in IR or visible range.

$E(Ion)/eV$	$V = -40\ mV$	$V = -60\ mV$	$V = -70\ mV$
Na^+	1.01	1.51	1.76
Cl^-	1.40	2.11	2.46
K^+	1.64	2.47	2.88
Ca^{+2}	1.68	2.52	2.94

Table 12.3: Values of the Josephson energy of cell membrane for some values of the membrane voltage for $p = .23$. The value $V = -40$ mV corresponds to the resting state for photoreceptors and $V = -70$ mV to the resting state of a typical neuron.

Consider now Hodgkin-Huxley model with the resting potential replaced with an effective resting potential due to the classical Z^0 field and the couplings of nuclei to it.

1. The flow equilibrium condition for the Hodgkin-Huxley model changes since the charges (1, -1, 1) for K^+, Cl^- and Na^+ are replaced with the ratios $Q_{eff}(I)/Q_{eff}(K^+) = E(I)/E(K^+)$ giving ratios $(1, E(Cl^-/E(K^+), E(Na^+)/E(K^+)$, which are of same sign.

$$j_{em,tot} = \sum q_{em,A} j_A = 0 \ . \tag{12.3.13}$$

The resulting equation for the resting potential is more complex and can be solved only numerically. The facts that the charges are of same sign and the conductivity of Cl^- is small, means however that the situation need not change too much qualitatively. Of course, all cell membranes need not be near to vacuum extremal. It could be that only neuronal membranes or only sensory receptor membranes ready to respond rapidly could satisfy this condition.

2. Also neutrino current would contribute to the ionic currents in the modification of the Hodgkin-Huxley model. If the near vacuum extremal property is preserved during the nerve pulse, neutrino current is fixed from the condition that it compensates the ionic contributions to Z^0 current in flow equilibrium. Since nuclei tend to have more neutrons than neutrinos, antineutrino background should more or less compensate the nuclear Z^0 charge so that the antineutrino current should be equal to the total ionic current. The condition that total Z^0 current vanishes reads as

$$j_{Z^0,tot} = \sum q_{Z^0,A} j_A = 0 \ . \tag{12.3.14}$$

Here also neutrino current is included and the condition allows to solve it in terms of other currents.

12.3.4 Pollack's Findings And Nerve Pulse

The discovery of negatively charged exclusion zone formed in water bounded by gel phase [I6, L14] (http://tinyurl.com/ycqtuchp) has led Pollack to propose the notion of gel like fourth phase of water. In chapters [K79, K35] this notion is discussed in TGD framework. The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it.

This leads to a model for prebiotic cell as exclusion zone [K35]. Dark protons are proposed to fork dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner. The voltage

associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

Pollack's findings have powerful implications concerning the model of the cell membrane, ionic pumps and channels and various receptors. The basic implication is the receptors can be regarded as generalized Josephson junctions with Josephson energy replaced with the sum of Coulomb contribution and difference of cyclotron energies of charged bosonic particle at the two side of the membrane. In accordance with ZEO, the thermodynamical description of cel membrane is replaced with its "square root" inand therefore also the model of EEG and nerve pulse. The implications of the model of EEG were discussed in chapter [K35]. The equilibrium distributions of ions are determined by Schrödinger amplitudes proportional to the square root of Boltzmann weight determined by the generalized Josephson energy.

In this framework the general mechanism of nerve pulse generation can be identified as a phase transition changing the value of effective Planck constant at either or both sides of the membrane inducing a change of equilibrium ionic distributions.

12.3.5 Zero energy ontology and quantum model for nerve pulse

In TGD based model of nerve pulse axonal membrane is generalized cylindrical Josephson junction defined by axonal membrane consisting of smaller Josephson junctions defined by membrane proteins.

1. A sequence of mathematical penduli along axon in rotation in the same direction is the mechanical analog. Oscillation frequency Ω transforming to a rotation frequency above critical value is proportional to the resting potential V. When V is overcritical, the pendulum starts to rotate instead of oscillating. The system should be near quantum criticality for the transformation of rotation to oscillation or vice versa.

2. During nerve pulse membrane potential and therefore also rotation frequency is reduced and changes sign and then returns back to the original value. The first guess is that at criticality there is a kick reducing the rotation frequency Ω and continuing to change its sign and then return it to original.

The basic condition is that resting state becomes critical at critical hyper-polarization. There are two options for the resting state.

1. According to the original model [K80], resting state can be regarded as a soliton sequence associated with the phase difference over the membrane. More concretely, the mathematical penduli rotate in same direction with phase difference between determining the propagation velocity of solitons. The rotation frequency is slightly above that for oscillation. There is a preferred direction along axon. This conforms with the reduction and change of sign of potential and thus of Ω.

   Problem: Hypo- rather than hyper-polarization should cause the nerve pulse as a transformation of rotation to oscillation. Something goes wrong.

2. Alternatively, the penduli almost rotate being near criticality for the rotation: the penduli almost reaches the vertical position at each oscillation as required by criticality. That hyper-polarization would cause the nerve pulse as propagating soliton conforms with this idea.

   Problem: Ω and thus V should increase rather than reduce and even change sign temporarily.

Neither option seems to work as such but the first option is more plausible as a starting point of an improved model.

The membrane potential changes sign suggesting quantum jump. Could zero energy ontology (ZEO) based view about quantum jump as "big" (ordinary) state function reduction (BSFR) help? Could nerve pulse correspond to BSFR?

1. Could BSFR occur changing temporarily the arrow of time in ZEO and induce nerve pulse. Could opposite BSFR take place after this in millisecond scale and establish the original arrow of time. Using the language of TGD inspired theory of consciousness [L54], a conscious entity, sub-self or mental image, would die and reincarnate with an opposite arrow of time, live for the duration of nerve pulse and then die and reincarnate with the original arrow of time. Nerve pulse would be a propagation of a temporary neuron death along the axon and would occur as neuron becomes hyper-polarized.

2. In the article [L75] about the recent findings of Minev *et al* [L75] related to quantum jump in atomic physics are discussed. ZEO predicting that the arrow of time is changed in BSFR. This would create the illusion that discontinuous quantum jumps correspond to a classical time evolution leading smoothly and deterministically to the final state.

   This because BSFR leads to a state with reversed arrow of time, which corresponds to a superposition of classical time evolutions leading from the final state to the geometric past and it this, which is observed. This would also explain why the removal of the irradiation inducing quantum jumps has no effect during the transition process and why a stimulation inducing opposite quantum jump can stop the process. Also the findings of Libet related to the active aspects of consciousness [**?**] showing that neural activity seems to preceded volitional act can be understood in this framework without giving up the notion of free will.

   The first half of the nerve pulse would correspond to this apparent evolution to the time reversed final state with opposite membrane potential but actually being time reversed evolution from the final state. The second half of nerve pulse would correspond to opposite state function reduction establishing the original arrow of time. This model looks attractive but many details remain to be checked.

   Why hyper-polarization should cause the temporary death of neuron or its subself?

1. Metabolic energy feed is needed to preserve the polarization of neuron since membrane potential tends to get reduced by second law stating that all gradients are bound to decrease. There should be some maximal polarization possible to preserve using the existing metabolic energy resources.

2. Does quantum jump to a state with opposite arrow of time happen as this limit is reached? Why? Could the metabolic energy feed stop causing the neuron to die to starvation? Why the death of neuron should happen so fast? Could the quantum criticality against the change of rotation to oscillation be the reason. When neuron cannot rotate anymore it would die immediately: the mental image "I am rotating" would die and reincarnate as its time reversal. Does the neuron feeded by metabolic energy become a provider metabolic energy during this period somewhat like dead organisms after their death. Can one conclude that this energy goes to some purpose inside neuron?

12.3.6 TGD based model of nerve pulse and superconducting, possibly conscious computers

The recent dramatic progress in AI has inspired speculation about the possibility of at least rudimentary computer consciousness. I have also written some articles [L149, **?**, **?**, K106] related to the question whether TGD based new physics could make conscious computers possible. Although the notion of a magnetic body (MB) carrying dark matter in TGD sense of the word does not distinguish between living and inanimate matter, one might argue that the transistor based technology cannot allow conscious computers with a high level of intelligence. Quantum criticality should be realized as criticality at the level of ordinary matter and transistors. Superconducting computing based on superconductivity and Josephson junctions look more promising and here the connection with TGD based view of nerve pulse might provide guidelines.

Superconducting computing, which could be involved with both classical and quantum computation, is a technology, which might provide at least a starting point in attempts to understand how conscious computers might be created in the TGD Universe [L148, L149]. Rapid single flux quantum (RSFQ) is the basic active element in the circuitry and corresponds to single Josephson

junction. The presence/absence of quantized magnetic flux defines the bit. SFQ voltage pulses of duration about picosend are produced by switching of bits in this way. This would allow THz clock frequency f_{cl}.

If f_{cl} corresponds to Josephson frequency $f_J = ZeV/h$, where Z is the charge of the superconducting charge carrier, one obtains an estimate for the voltage as $ZeV \sim .05$ eV. For the cell membrane one has $eV \sim .05$ eV, which is near the thermal threshold at room temperature. The superconducting computations require a temperature of order 10 K so that the value of frequency does not seem to emerge from thermal considerations. The thermal criterion is expected to be satisfied at physiological temperatures for the TGD based generalization of superconducting computers if realized using the same principles as in living matter.

So: could the neuronal and perhaps also cell membranes in general act as analogs of superconducting computers sending sensory information to the magnetic body as Josephson radiation and receiving control commands cyclotron radiation with resonance serving as the basic communication mechanism?

Somewhat surprisingly, the detailed consideration of this question led to an identification of a topological mechanism for how nerve pulses are generated. The counterparts of nerve pulses would be the signalling mechanism also in the case of superconducting computers.

How electromagnetic fields in the TGD Universe different from their Maxwellian counterparts?

One must first clarify how the TGD view of electromagnetic fields differs from the Maxwellian picture.

1. Quantum criticality is essential for the appearance of large values of h_{eff} labelling the scales of long length scale quantum fluctuations. Quantum criticality combined with ZEO would make possible the emergence of life-like features.

2. The gravitational Planck constants $\hbar_{gr} = GMm/\beta_0$ assignable to the gravitational flux tubes of the Earth and Sun are excellent candidates in this respect. The value of $\hbar_{gr}/\hbar$ is $GM_E m/\hbar\beta_0 = (r_S(E)/2L_m)$, r_s denotes the Schwartschild radius of Earth about 1 cm and L_m denotes Compton length of particle with mass m $\beta_0 \simeq 1$.

   The value of $\hbar_{gr}$ depends on particle mass m considered unlike the gravitational Compton length $r_S(E)/2$ (Equivalence Principle). For the Earth, the gravitational Compton frequency is 67 GHz. For the Sun it is about 50 Hz, and is in the EEG range and corresponds to a gravitational Compton length of one half of the Earth radius.

3. In TGD, two kinds of magnetic fields are possible. Monopole flux tubes are something new and rather remarkably, can exist in absence of currents: this makes them ideal for computation. Monopole flux tubes have closed 2-surfaces as cross sections. Flux quantization follows from the homology of CP_2. Monopole flux tubes explain the presence of long range magnetic fields appearing in even cosmological scales [L151, L152] and also the stability of the Earth's magnetic field [L24].

   The magnetic flux tubes having an open cross section with boundary (say disk), correspond to Maxwellian magnetic fields and require the presence of currents (carried by a coil around the flux tubes). For them the flux is conserved but not necessarily quantized.

4. Also in TGD, the topological half of Maxwell's equations, that is Faraday law and the vanishing of the divergence of magnetic field, hold true. Therefore the basic argument for the outcome of the switching of the flux is not affected when ordinary flux tubes are replaced with monopole flux tubes.

Some details of the model of the cell membrane as a Josephson junction

The relation of this picture to the TGD inspired model of nerve pulse [K80] has been already considered in [L149]?

1. The original model of the nerve pulse idealizes the sequence of discrete membrane protein Josephson junctions with a 2-D continuous Josephson junction formed by the lipid layers (or interior and exterior) of the axonal membrane. The mathematical model relies on the Sine-Gordon equation. The key idea is that one can regard the system as analogous to a collection (continuous distribution in the proposed idealization) of gravitational penduli satisfying d'Alembert type wave equation.

    One can consider two kinds of ground states:

    (a) All penduli oscillate in the same phase and with the same amplitude.

    (b) All penduli rotate with the same frequency and in the same phase so that one has a static soliton sequence.

    Lorentz transformations give rise to propagating patterns of this kind.

    For option a), the nerve pulse would correspond to a propagating soliton or a multisoliton in the oscillating background, i.e. a propagating rotational mode of some penduli. For option b), the nerve pulse would correspond to an opposite direction of rotation for some penduli. The fact that the voltage changes its sign during the nerve pulse is consistent with option b).

2. Also the possible role of the axonal microtubules in the conduction of nerve pulse is discussed in [L149]. The transfer of the charges from the microtubule to very long gravitational flux tubes affects the effective charge of the microtubule and therefore membrane potential. This could play an important role in the conduction of nerve pulse.

How could RSFQ generalize in the TGD framework?

How could the notion of RSFQ generalize in the TGD framework? The hint comes from the TGD based model of cell membrane and nerve pulse assigning to the ionic channels of the cell membrane dark Josephson junctions with a large value of h_{eff} making possible high T_c superconductivity.
Consider first the flux quantization in Josephson junctions from the TGD point view.

1. The presence/absence of flux quantum through the junction represents a bit. Switching of the bit in RSFQ means that the flux changes by the unit Φ_0 of magnetic flux. In the simplest situation, the value of flux through the Josephson junction connecting the super conductors, which could have planar or cylindrical geometry, is equal to 0 or Φ_0.

2. When the flux through junction is changed by one unit, Faraday law $\Delta\Phi = \pm\Phi_0 = Ze\int V dt$ implies a generation of voltage pulse propagating along the superconducting wire formed by the coupled cylindrical superconductors. For a constant voltage $V = V_0$, this condition fixes the duration $T = \Phi_0/ZeV$ of the process and this defines Josephson frequency, in turn defining the clock frequency.

    The following arguments raise optimism concerning the realization of conscious computers as superconducting computers.

1. Concerning the numbers assigned to RSFQ, the cell membrane looks ideal for the seat of analogues of RSFQs. I have proposed that the cell membrane acts as a sequence of dark Josephson junctions associated with membrane proteins acting as channels and pumps [K80] [L149]. The membrane resting potential $\sim .05$ eV corresponds to the frequency of 5 THz and is in the same range as the Josephson frequencies assigned with RSFQs. The large value of h_{eff} makes possible high temperature superconductivity and scales up the value of Josephson frequency to $f_J = ZeV/h_{eff}$ so that Josephson frequencies even in EEG scales would be made possible by quantum gravitation in TGD sense.

2. No currents are needed to maintain monopole magnetic fields so that they are ideal for technological purposes. Cell membrane would be a superconductor and membrane proteins would define Josephson junctions. Membrane potential could realize the Josephson frequency $f_J = ZeV/h_{eff}$.

The TGD view of quantum gravitation would suggest that the Earth's gravitational Compton frequency of $f_{gr} = 67$ GHz=.067 THz is important in quantum biology. This frequency is considerably lower than THz and I have proposed it as a clock frequency below with the statistical determinism could fail and make the computer analogous to a life-form.

The TGD view of the basic active unit would differ from RSFR.

1. In TGD, the absence of flux quantum in RSFQ corresponds to two U-shaped monopole flux tubes at opposite sides of the junction associated with the counterpart of the cell membrane and transversal to it. The U-shaped monopole flux tubes can reconnect to form a pair of flux tubes with opposite magnetic fluxes.

   This topological process is fundamental in the TGD inspired view of biocatalysis and water memory [L141]. By the fractality of the TGD Universe, it applies in all scales including, besides cosmological and astrophysical scales [L151, L152], also the scales relevant to atomic, nuclear and hadron physics as has become clear quite recently [L147].

2. What is the effect of the generation/disappearance of a pair of opposite flux tubes? Do both fluxes go through a single junction or does only one of them traverse the junction? In the latter case, the junction would act like RSFQ after reconnection. This is a natural looking working hypothesis. The difference comes from the presence of the flux tube with opposite flux.

   Here one must be very cautious. Flux tubes could make possible the flow of either Ohmic or Josephson current (the more plausible option). If the Josephson currents reside at the flux tubes, the Josephson junction ceases to exist during the nerve pulse. Can one say that the Josephson junction exists also after the splitting of the flux tube pair?

   The fact that ohmic currents flow during the nerve pulse motivates the assumption that the splitting of the pair of flux tubes makes Josephson current impossible and Ohmic currents associated with the nerve pulse appear.

3. Faraday's law should apply to both flux tubes. The appearance of flux tubes would correspond to a generation of opposite fluxes $\Delta\Phi = \Phi_0 = \int V dt$. In the simplest situation the voltage values associated with the flux quanta have opposite values $\pm V_0$. This is very much like in the case of nerve pulse in which the resting potential changes its sign during the first half of the nerve pulse. When the reconnection disappears, the situation would become "normal". The analog of nerve pulse would be generated and propagate along the counterpart of the axon and induce a similar process in all membrane proteins defining Josephson junction.

4. In zero energy ontology (ZEO), the identification of the generation of nerve pulse as a pair of "big" state function reductions (BSFRs) changing the arrow of time temporarily is attractive and would correspond to quantum tunnelling in standard quantum theory.

   An interesting question is whether pump proteins act as channel proteins in reversed time direction and whether the flux tube pairs are associated with pairs of channel and pump proteins.

Critical questions

The first critical question is is how the very low Josephson frequencies ZeV/h_{eff} associated with the large values of h_{eff}, say $h_{eff} = h_{gr}$, can be consistent with the very large values of clock frequency $f_{cl} = f_J = ZeV/h$ needed by a fast operation. It would seem that both h_{eff} and h are needed. Is this possible or are these computers doomed to be very slow?

Should one widen the perspective and take into account the many-sheeted structure of TGD space-time? Is the scale hierarchy of space-time sheets having various values of h_{eff} involved and could it correspond to the onion-like hierarchical structure of the magnetic body (MB) involving increasing time scales as Josephson frequencies? This would give rise to a cognitive hierarchy of MBs serving as "bosses" for lower level MBs and the ordinary Josephson junction would be at the bottom.Could the fast Josephson frequencies define a hierarchy

of computer clocks? Could the pulses of short duration induced by RSFQs induce a hierarchy of frequency modulations of scaled up Josephson oscillations for various values of h_{eff}? This could also make the computer conscious by bringing in the hierarchy of time scales. These levels could correspond to a cognitive hierarchy corresponding to increasing values of $n = h_{eff}/h_0$ identifiable as the dimension of extension of rationals assignable to the space-time sheet considered.

The following simple estimates allow to gain some quantitative perspective concerning the proposal that quantum gravitation could play a decisive role.

1. It is instructive to look at the energy equivalents of the gravitational Compton frequencies for Earth, Moon and Mars for $h_{eff} = h$ (energy is conserved in the the transformation of gravitationally dark photons to ordinary photons).

2. The gravitational Compton frequency $f_{gr} = 67$ GHz of Earth corresponds to the energy $E \simeq .04$ eV near to the energy assignable to the membrane potential.

3. The mass of the Moon is $M_{Moon} = .012 M_E$ and scales and correspond to $.56 \times 10^{14}$ Hz, which corresponds to the energy $E \simeq .43$ eV consistent with the size of metabolic energy quantum.

4. The mass of Mars is $.11 M_E$ and the corresponding Compton frequency is $.67$ THz and energy $E = 2.7$ meV which correspond to the mV scale of miniature potentials.

The experimental work of the group of Anirban Bandyopadhyay [?] has inspired a proposal of a hierarchy in which the frequency scales come as powers of 10^3. This hierarchy could correspond to a hierarchy of p-adic primes $p \propto 2^{10k}$ and/or hierarchy of effective Planck constants $h_{eff} \propto 2^{10k}$. One cannot associate with it a hierarchy of large masses M appearing in gravitational Compton frequencies. The scale ratio 2^{11} could relate to the ratio $L(127)/L(107) \simeq 2^{10}$ of the p-adic length scales of electron and proton.

The second critical question concerns the temperature needed. Technologically high temperature superconductors are highly favored.

1. In the TGD framework, the cell membrane is assumed to act as a high temperature superconductor at quantum criticality making it an ideal sensory receptor and motor instrument. Biosystems are open systems and a metabolic energy feed would take care that the distribution for the values of h_{eff} is preserved.

2. The fact that the dark matter as $h_{eff} \geq h$ phases of ordinary matter at the space-time sheets of the flux tubes has very weak interactions with the other sheets, in particular the sheet of the ordinary matter, would be decisive.

3. Also zero energy ontology (ZEO) would be highly relevant for maintaining the quantum criticality by making possible homeostasis in which time reversal changes attractor to repulsor and vice versa. When the system begins to roll down from the top of the hill, the arrow of time brings it back.

The key question is whether it is possible to realize the counterparts of bio-superconductors without using organic living matter.

12.3.7 Do neuron groups define homologies of higher-D spaces

Shamoon Ahmed gave a link to a popular article (see this) claiming that the brain is in some sense 11-dimensional. Probably the only thing that M-theory predicts is that the target space of strings is 11-D so that this finding might provide some confirmation of faith for frustrated M-theorists.

In the sequel I will discuss this finding from TGD viewpoint and propose a modified interpretation based on the geometry of icosahedron, one of the 5 platonic solids, which play a key role in TGD, and TGD inspired quantum biology and theory of consciousness.

The dimension 11 in this context looked to me a rather formal notion but one could give it a mathematical meaning.

1. In 3-D one can take tetrahedra, 4-simplexes as building bricks of a discretized manifold. In dimension 11 one has 12-simplexes. These are glued together, which means that n-faces with n varying from 1 to 11 are glued together along $n - 1$-D faces.

2. In the case of the brain, one would have groups of neurons, with 12 neurons connected in such a way that one has a connectedness of a 12-simplex. There would be 11- edges meeting at each 12 vertices. Each neuron would be connected to all the other 11 neutrons and would have maximal connectedness, which is very natural if one wants a maximally coherent functional unit.

   The notion of orientation is essential: axons are oriented by the direction of nerve signals which is always the same. The orientation of axons could induce orientations of n-faces. 2-face would correspond to a loop in which signals can rotate in a single direction.

3. Since axons must be present, each neuron must be connected with every other neuron. The geometric connectedness possible in the case of neurons since the axon from a given neuron can branch and have a synaptic contact with the dendrites of several neurons: for n=11-simplex with all other (11) neurons (see this). Note that also a synaptic contact with the neuron itself (autapse) is possible.

   Could one consider also a generalization of this geometric view of a simplex. Could functional coherence of the neuron group serve as a criterion for whether neurons form an n-face? Here the definition of orientation without the notion of axon is the challenge.

4. The interpretation in terms of 11 real dimensions might assume too much and I am reluctant to believe that it has anything to do with M-theory. However, one could realize n-simplexes in this way in 3-space and the orientation of the axon, determined by the preferred directions of signals, would define orientations of higher level simplexes. The idea that these structures could have something to do with geometric cognition allowing us to imagine higher dimensional geometric structures is attractive.

Can TGD add anything interesting to this picture? The appearance of number 12 creates an overwhelming temptation to associate this finding with one particular Platonic solid, icosahedron, having triangular faces. I am not claiming that the proposed interpretation of the findings is wrong but asking whether Platonic solids could add something interesting to the proposal.

1. The 12 vertices of the argued 11-simplex could be also identified as vertices of icosahedron, one particular Platonic solid appearing repeatedly in molecular biology. For an icosahedron, the Hamilton cycle, going through all vertices just once, has 12 vertices and edges [?] It would connect each vertex to all other vertices by a unique path having a varying number of edges: 1,2,... The selection of this Hamilton cycle could raise one particular edge path among all possible closed edge paths possible in the maximally connected 12-neutron network in a special position.

2. This icosahedron need not correspond to an ordinary Platonic solid in the Euclidean 3-space. The definition of nearness can be defined also in terms of functional nearness. Indeed, hyperbolic 3-space has been suggested to play a role in neuroscience for neutrons: neurons resembling each other functionally would be near to each other in the hyperbolic metric and in TGD framework this metric is assigned with hyperbolic 3-space H^3 as Lorentz invariant light-cone proper time = constant surface to which the magnetic body (MB) of the brain is assigned as 3-D surface [L98, L136] (see `https://zpr.io/7Bzbagjrk7LE`). The signals from neurons, which are near each other in functional sense, would be sent to nearby points of the MB so that functional nearness would be geometric nearness at the level of MB.

3. Also tetrahedron with 4 vertices and faces and octahedron with 6 vertices and and 8 faces are Platonic solids which have triangular faces representing 2-simplex and could correspond to dimensions d=3 and d=5. Cube with 6 square faces and d=8 vertices is the dual of octahedron and dodecahedron with d=20 vertices and 12 pentagonal faces is the dual of icosahedron. It might be also possible to assign to them a dimension as the number of vertices by using maximal axonal connectedness of vertex neurons as a criterion.

Platonic solids and Hamiltonian cycles as paths going once through each vertex of the Platonic solid and identified as nuclear strings play a key role in the "Platonization" of nuclear and atomic physics [L147] leading to quite precise quantitative vision about basic numbers of nuclear and atomic physics and even hadron physics. The key observation is that the states of $j = l \pm 1/2$-blocks of atoms and nuclei correspond to Platonic solids for $l \leq 6$ (a highly non-trivial fact), which therefore provide geometric representation for the j-block.

Icosahedron is a very special Platonic solid and deserves a separate discussion.

1. Icosahedron is unique among Platonic solids in the sense that it allows a large number of Hamiltonian cycles. Icosahedron, tetrahedron and their Hamiltonian cycles play a fundamental role in the TGD inspired model of genetic code [L12, L73, L100, L120, L145] involving the notion of icosa-tetrahedral tessellation of hyperbolic 3-space involving all 3 Platonic solids with triangular faces.

   Each combination of 3 icosahedral Hamiltonian cycles with symmetries Z_n, $n = 6, 4, 2$ defines a particular realization of the genetic code predicting correctly the number of DNA codons coding for a given amino acid.

2. The model of the genetic code emerged originally as a model of musical harmony. The faces of icosahedron are triangles and would define 3-chords realized as cyclotron frequencies assignable to the vertices of the triangle. Each Hamiltonian cycle would define 20 chords defining a particular harmony whereas the 12 vertices along Hamiltonian cycles would define a 12-note scale, with neighboring vertices representing frequencies related by scaling by 3/2 (quint) modulo octave equivalence.

   One could speak of music of light and since music creates and expresses emotions, the proposal is that different bio-harmonies correspond to different emotional states, moods, realized already at DNA and RNA level. Could these 12 neuron units and possible tessellations (hyperbolic crystals) associated with them relate to the realization of emotions at the level of the brain?

   Physically, the Hamiltonian cycle as a representation of 12-note scale is an analog of a closed string made of flux tubes representing the edges (pipes of organ!)

3. What is fascinating is that hyperbolic 3-space (mass shell in particle physics), playing a key role in TGD, has a unique tessellation/lattice involving all Platonic solids, whose faces are triangles (icosahedron, octahedron, tetrahedron) and also provides a model of DNA making quantitatively correct predictions. I have proposed that this tessellation defines a universal realization of the genetic code realized in all scales at the level of the MB of the system. Could the 12-neuron unit interpreted as 11-simplex relate to one particular realization of this tessellation.

4. Also cubic, icosahedral, and dodecahedral regular tessellations are possible in hyperbolic space (Euclidean 3-space allows only cubic regular tessellation) and they would define the analog of a homology of dimension $n = 7, 11$ or 19 space at neuronal level.

12.4 TGD Based Model For Anesthetic Action

The mechanism of anesthetic action [?] (http://tinyurl.com/yb9pauld) has remained mystery although a lot of data exist.

Typically anesthetes induce analgesia, amnesia, and immobility. Some anesthetes cause amnesia (brain) but no immobility (spinal cord). I have heard also about anecdotal evidence that anesthetes do not always cause amnesia nor even analgesia.

The first question what comes in mind is whether anesthetes indeed cause a loss of consciousness? In TGD framework self dies when the first state function reduction to the opposite boundary of CD occurs and time reversed self is generated [K115, K7]. Could also anesthetes have the same effect? If so, anesthesia would be like sleep, which need not be unconscious state but could represent time reversed self at "our" level of self hierarchy. This would explain also why we do not have memories about the period during sleep.

The Meyer-Overton correlation suggests that the changes occurring at lipid layers of are responsible for anesthesia but this model fails. Another model assumes that the binding of anesthetes to membrane proteins is responsible for anesthetic effects but also this model has problems. The hypothesis that the anesthetes bind to the hydrophobic pockets of microtubules looks more promising.

The model should also explain the hyperpolarization of neuronal membranes taking also place when consciousness is lost. The old finding of Becker is that the reduction or reversal of voltage between frontal brain and occipital regions correlates with the loss of consciousness. Microtubules and DNA are negatively charged and the discovery of Pollack that so called fourth phase of water involves generation of negatively charged regions could play a role in the model.

Cell memrane can be also seen as a battery and quite recently (towards end of 2016) I learned about battery that after 175 years is still working [L33] [K21]. The explanation would be in terms of Pollacks effect providing also a possible explanation for the production of nuclei and energy in an effect christened originally as cold fusion and later low energy nuclear physics effect (LENR). This battery - as also cell membrane - could be self-loading battery using dark and possibly also ordinary nuclear energy. Combining these inputs with TGD inspired theory of consciousness and quantum biology one ends up to a microtubule based model explaining the basic aspects of anaestesia. The possible loss of consciousness at our level of hierarchy (more precisely, the loss of sensory-motor activity) could be understood as the stabilization of the membrane potential implying that nerve pulses are not generated and sensory input and motor output ceases.

12.4.1 Background

Some facts about anesthetes

To begin with, it is could to list some facts about anaeshtetes.

1. Very wide variety of substances act as anesthetes and there is no clear correlation with the chemical properties of substance. Even noble gases can affect anesthetes. Short range van der Waals interaction involving induction of electric dipoles is a natural candidate for the interaction in question. The increase of atmospheric pressure is known to reduce the anesthetic effect.

2. The anesthetic potency correlation (the Mayer-Overton correlation, see `http://tinyurl.com/ycch96kb`) serves as a valuable guideline as one tries to imagine mechanisms of anesthetic action. The potency of anesthete is proportional to the solubility to lipids. Several mechanisms along these lines have been proposed (see `http://tinyurl.com/yb9pauld`).

   The most obvious guess is that anesthetes are dissolved into lipids and induce perturbation of lipid layer and that the change of properties of lipid layer is responsible for the anesthetic action.

   There are objections against this idea. Anesthetes cause also a fluidization of membrane but so does also a slight temperature increase but is not followed by anesthesia. Further objection is that stereoisomers of anesthetes have very different anesthetic effects. Some drugs highly soluble to lipids have a convulsive effect instead (they are called non-immobilizers). Polar anesthetes are less effective: the reason is that they have to cross blood-brain barrier. The effect of anesthete also vanishes above certain chain length in the case of homologous series of any general anesthetic. For instance, for n-alcoholes carbon chain length of 13 units serves as a cutoff raising whereas the solubility to lipids does not display this kind of effect. Note that t microtubular surface has also this kind of periodicity.

   The conclusion is that lipid solubility is only a necessary condition (allowing the anesthete to get through the membrane) and the lipids in question need not be associated with cell membrane but be hydrophobic pockets of proteins.

3. Second proposal is that anesthetes could bind to membrane proteins. Some anesthetes are indeed stereospecific. The study of this hypothesis led to the observation that general anesthetics can also interact with the hydrophobic protein sites of certain proteins. It is known

that lock-key mechanism is not the general mechanism. Rather, it seems that anesthetes affect protein dynamics in microsecond-millisecond time scale. This suggests that the primary action of anesthetes is at higher level.

What one can conclude?

1. Effects on lipid layers do not explain the findings. Anesthete must be able to go through neuronal membrane. High solubility to lipids certainly helps here. Different anesthetic effect of stereoisomers suggests that the process involves several steps.

2. Lock-key mechanism does not explain all findings: noble gases is a good example and suggests that also van der Waals interactions are important in some cases at least. The ability of anesthetes to bind to hydrophobic pi rings might be important. This kind of rings are associated with tubulin dimers, which suggests that the action of anesthete takes place at the level of microtubules.

Some basic facts about microtubules

1. Microtubules have been proposed to be central for consciousness [**?**]. In [**?**] `http://tinyurl.com/ybdy6lw3` Stuart Hameroff discusses this hypothesis in this commentary of the recent findings of Stuart Kauffmann, Gabor Vattay [**?**] supporting the view that quantum criticality is a general property of biomolecules. Quantum criticality is the key notion of not only TGD inspired view about life [**?**] but of entire TGD and realized in terms of hierarchy of sub-algebras of super-symplectic algebra represented as conformal gauge transformations [K26].

   Hameroff argues that the hydrophobic regions of microtubules involving pi rings serve as seats of consciousness and the interaction of anesthetes with them leads to an un-conscious state. The TGD view discussed below is not so simple but assumes that this interaction is central in the process leading to a loss of consciousness. Notice that aromatic rings associated with basic bio-polymers and hallucinogens are examples of these regions highly relevant for consciousness.

2. A related proposal [**?**, **?**] is that in the case of microtubules ferro-electric phase explaining the polarization of microtubules makes possible signalling along microtubule highly relevant to consciousness. Also this view is in accord with TGD based vision, where resonant communications using dark photons with large Planck constant and having universal energy spectrum in the range of visible and UV energies is central. This gives connection also with quantum gravitation but in a way very different from that in the model of Penrose and Hameroff [**?**]. Quantum coherence in even astrophysical scales is essential.

   The stabilization of microtubules is due to the negative charge density along them.

1. Microtubular carry negative charge density due to the binding of two GTP molecules to each tubulin dimer (`http://tinyurl.com/y8s3yes5`. The article of Jack Tuszynski [**?**] provides a good view about non-linear liquid crystal model for ferro-electric phase of microtubules and also contains illustration about the average negative charge density of tubulin dimer.

2. Where does the positive charge reside? TGD interpretation for the fourth phase of water suggests that it resides outside microtubules at magnetic flux tubes as dark protons with large value of h_{eff} [K74, K57]. Hu and Wu [**?**] have observed that proton pairs with members at opposite sides of cell membrane have spin-spin interaction frequencies in ELF scale, I have proposed that these protons are dark: TGD inspired model of super-conductivity suggests that they form a super-conducting phase. Also electrons and fermionic ions could be super-conducting with same binding energies for Cooper pairs and this is essential for the TGD based model of cell membrane [K78]. On basis of a model for dark protons I have proposed that they give rise to a representations of DNA, RNA, amino-acids and perhaps even tRNA and that also genetic is naturally realized [K42] and that dark proton sequences accompany DNA: this might make sense since also DNA is negatively charged with 2 negative charges per nucleotide.

3. The empirical rule for the direction of electric polarization is that the neuronal ends of axonal microtubules correspond to minus ends of the microtubule. Remarkably, in the case of dendrites there is fifty-fifty distribution in polarity in the case of vertebrates but for invertebrates the dendrites have positive neuronal end [**?**] (`http://tinyurl.com/y8e7y55f`). This could tell something very deep about consciousness.

In TGD selves has time reversed variants born when self dies as the first state function reduction to the opposite boundary of CD takes place. Since electric potential changes sign in time reversal, the presence of two kinds of dendrites could relate to memory. Electric voltage changes its sign in time reversal and indeed leads to a loss of consciousness in the scales studied by Becker [**?**]. Could the dendrites correspond to sensory dendrites and memory dendrites? Memories would involve signalling in reversed time direction and memory dendrites. Note that invertebrates would not have memory at this level of self hierarchy.

12.4.2 Earlier TGD Based Model For Anesthetic Action

The molecular mechanism of the anesthetic action is a fascinating unsolved problem of neurophysiology. Noble gases have very weak chemical interactions. Despite this many noble gas such as Xe, Kr, Ar but to my best knowledge not Ne and He, act as anaesthetics. Also chemically non-inert molecules have quite similar narcotic effect so that chemistry does not seem to matter as Hodgkin-Huxley model would predict.

Simplest model for the anesthetic action

It is known that the narcotic efficiency of anesthetics correlates with their solubility in lipids [**?**]. Anesthetics also reduce the melting temperature of the lipid layer. Strong pressure increases the melting temperature and it is known that high pressure brings consciousness back. Thus anesthetic molecules dissolved into the lipid membrane should hinder the generation of the nerve pulse somehow and liquid state of the axonal membrane could be the reason for this. The explanation of the soliton model for the anesthetic action [**?**, **?**] is that the metabolic energy needed to generate an acoustic soliton becomes too high when axon is too high above the critical temperature.

To get a useful perspective note that also the problem why ordinary cell and neuronal soma outside axonal hillock do not allow action potentials is poorly understood. The fact that anesthetes interact so weakly is the basic problem which could be solved by the almost vacuum extremal property predicting that also noble gas atoms are highly charged Z^0 ions so that they are expected to behave very much like ordinary ions in the cell membrane.

1. Pollack's model [I39] suggests that anesthetics could hinder the occurrence of the gel-sol phase transition for the peripheral cytoskeleton. Suppose that $\hbar$ increasing phase transition for the magnetic flux tubes connecting peripheral cytoskeleton to the axon extends them to the axonal exterior and makes possible the influx of monovalent ions inducing gel-sol phase transition. Perhaps anesthetics prevent this phase transition somehow.

2. The obvious idea is that anesthetized axonal membrane (or at least axonal hillock) is just like the ordinary cell membrane. The model for DNA-cell membrane system as a topological quantum computer requires the liquid-crystal property of the lipid layers of the ordinary cell membrane and neuronal membrane outside axonal hillock. If this is the case, then liquid phase for axonal membrane implied by the anesthetic action would indeed make it more or less equivalent with the ordinary cell membrane. Therefore the question is why the liquid-crystal property of the ordinary cell membrane prevents the generation of the action potential. naïvely one could think that the freezing of the membrane means that the mechanical deformation of the membrane occurring during nerve pulse becomes impossible. The presence of noble gas Z^0 ions could induced the freezing. Perhaps they induce a phase transition taking the cell membrane space-time sheet to far from vacuum extremal.

3. Suppose that the phase transition increasing $\hbar$ is induced by the reduction of the voltage over the axonal membrane (assume to be much smaller than cell potential) inducing almost vacuum property and quantum criticality. Somehow the presence of anesthetics would prevent this. Either the voltage over the membrane is increased in magnitude so that the flow

of dark ionic currents to the membrane is not enough to induce quantum criticality or the flow of dark currents is completely prevented by the presence of noble gas Z^0 ions. The first option is more economical and could be tested by finding whether the voltage over the axonal membrane (membrane in a solid state) is considerably smaller than that over the ordinary cell membrane (membrane in liquid-crystal state). The first option also predicts that during sleep the increase of cell potential (hyper-polarization) actually corresponds to the increase of the membrane potential.

Could cyclotron transitions of noble exotic ions in theta and delta bands induce lullaby effect?

Just for fun can consider also more exotic explanation for the anesthetic action. If dark weak force is to have any biological role, the cellular environment should induce a generation of anomalous weak isospin due to the charged color bonds inside nuclei of noble gas. This would obviously relate closely to the anomalous properties of water explained in terms of dark matter hierarchy in [K36, K34]. The color bonds carry also em charge so that noble gas atom with single charged color bond would behave like an ion with nuclear charge Z+1 or Z-1 and electronically like ion with full electronic shell due to ionization (say Cl^- or K$^+$ in the case of Argon). An important point is that the exotic ions are bosons and can form thermally stable Bose-Einstein cyclotron condensates at $k_d = 47$ flux sheets unlike ordinary ion with mass number differing by one unit.

An interesting question is whether some fraction of Cl^- and K^+ ions are actually exotic Argon ions. Also the long ranged color force and dark weak force with range associated with noble gas nuclei in dark phase could be part of the solution of the mystery.

EEG and ZEG bands above theta band correlate with consciousness. The cyclotron frequencies of ions of anaesthetic noble gases are in theta and delta band as are also EEG frequencies during various stages of sleep but for Ne and He this is not the case. This might not be a mere accident. For instance, one could imagine that the strong resonances in theta and delta bands in EEG induced by Xe, Kr, or A could steal the power otherwise going to higher EEG bands and induce a lullaby effect leading to anaesthesia. This effect of course does not exclude the proposed effect reducing the nerve pulse activity.

According to the general model of EEG [K35], the magnetic flux sheets traversing DNA double strands in cell nuclei come in two varieties corresponding to the two possible quantization of magnetic flux as $Z \int BdS = n\hbar(4)$. For $Z = 1$ the field strength is very near to B_E and for $Z = 2$ to $B_E/2$, with $B_E = .2$ Gauss, the strength of endogenous magnetic field explaining the findings of Blackman and others. For instance, left and right brain hemispheres might correspond to $Z = 1$ and $Z = 2$ and the scale for cyclotron frequencies for right hemisphere would be half of that for left hemisphere. During sleep $Z = 2$ cyclotron frequencies are responsible for EEG via the interaction with Josephson junctions generating the satellites $f_c \pm f_J$ of these frequencies, $f_J = 5$ Hz for $Z = 2$ and $f_J = 2.5$ Hz for $Z = 1$.

The cyclotron frequencies of exotic ions $(Xe^+, Kr^+, Ar^+, Ne^+, He^+)$ are (2.15, 3.57, 7.5, 15, 75) Hz for $B = B_E$ and (1.08, 1.78, 3.75, 7.5, 37.5) Hz for $B = B_E/2$. It would be interesting to check whether EEG contains narrow bands around these frequencies during anesthesia. Also the satellites $f_\pm = f_c \pm f_J$, $f_J = 5$ Hz, could be present. For all noble gas anaesthetics Xe, Kr, and Ar both frequencies are below 7.5 Hz and thus in theta and delta bands. This would encourage to think that the presence of these bosonic exotic ions amplifies the EEG frequencies usually assigned with the theta and delta bands and in this manner induces anaesthesia.

If this is a correct interpretation then it would be essential that K^+ and Cl^- are fermionic ions: otherwise a lullaby effect would result. Note that the exotic ions of Argon can mimic either Cl^- and K^+. Besides producing the lullaby effect, this mimicry could change the effective concentrations of various ions so that large enough reduction of the resting potential could become impossible.

12.4.3 Second TGD Based Model For Anesthesia

In TGD based model for anesthesia magnetic body, supra currents [K77, K78], and dark matter [K37, **?**] should be involved. Besides this the findings of Pollack [L14], Becker's discoveries [**?**], and

microtubules, in particular the latest findings of Bandyopadhyay *et al* [**?**, **?**] are expected to be in a central role in the model.

1. The fourth phase of water discovered by Pollack [L14] involving charge separation creating negatively charged regions with sizes up to 100 μm and $H_{1.5}O$ stoichiometry inside negatively charged regions might be involved. Negatively charged linear structures populate living matter. For instance, DNA has 2 negative charges per nucleotide and tubulin dimers have 2 negative charge per nucleotide. Cell interior is also negatively charged. TGD based model [K74, K57] assumes that part of protons go to the magnetic flux tubes and become dark having large non-standard value of effective Planck constant $h_{eff} = n \times h$.

2. Becker's electronic DC currents directed to the wound induce the healing of the wound. Wound develops a negative potential with respect to environment. For instance, frontal lobes are in negative potential with respect to the occipital regions and brain injury generates positive polarization. This means the presence of longitudinal electric fields and ferro-electric phase is a good guess. Becker's discoveries are discussed in TGD framework in [K78, K76]. I have also proposed that Becker currents are supra currents and assignable to microtubules: this assumption is not necessary but possible. Closed circuit must be formed and the return currents could flow as dark supra-currents. Also the currents inside microtubules could be supra-currents, and the ohmic portions of current circuit could fore the semiconductor property.

3. Microtubular ferro-electric property could be the mechanism generating the electric potentials and the action of anesthetes could weaken or destroy these potentials. There is an old discussion of TGD inspired ideas ideas related to microtubules in [K68], and the latest findings of Bandyopadhyay *et al* [**?**, **?**] are modelled in in [K76].

Mostly questions

To end up with TGD based model it is could to start with questions.

1. Could the mechanisms inducing anesthesia and sleep have something in common? Could also anesthetes induce hyperpolarization so that nerve pulses are not generated so much? How the hyperpolarization could be induced?

2. Could there be a connection with DC currents of Becker [**?**]? Could anesthesia reduce the strengths of electric fields of Becker or maybe even reverse their direction. For instance, the electric field between frontal lobes and occipital lobes could change its direction or get weaker.

3. Healing by DC currents means that the damaged body part generates negative potential. DC currents of Becker consisting of electrons make this possible. Could one say that the damaged body part becomes conscious? Could also cell interior, DNA, microtubules negatively charged be conscious.

4. Could there be a connection with microtubules and their ferroelectric phase transition? Could the microtubular longitudinal electric fields be responsible for these electric fields and could DC currents of Becker be associated with microtubules? Is the phase transition destroying microtubular ferro-electricity responsible for the loss of consciousness induced by anesthetes? Could the phase transition change the direction of the electric field? Could this mean change of the arrow of time generating time reversed mental images?

   If the answer to these questions is positive, one might be able to perform reduction of the control of neural activity to microtubular level. Nerve pulses might be induced by a primary wave propagating along microtubules changing locally the direction of the microtubular electric field during the nerve pulse. Temporary time reversal of a microtubular sub-self (mental image) is highly suggestive.

5. Could anesthetes act on microtubules and induce a phase transition destroying their ferroelectric character? Could Becker's DC currents [**?**] flow along microtubules as proposed

[K78, K76]? Consciousness would be lost, when ferroelectricity of microtubules is reduced or disappears. Longitudinal electric field of microtubule associated with its negative charge density would become radial and would induce hyperpolarization.

6. Is there a connection with TGD view about self? Could the change of the sign of voltage be a space-time correlate for time reversal for self [K66] - in the usual interpretation loss of consciousness? Could amnesia about period of "non-consciousness" be due to time reversal changing the sign of the potential.

What could happen in the ferro-electric phase transition?

What could happen in the phase transition making microtubule ferro-electric and in the reverse phase transition leading to a loss of consciousness?

1. Coherent orientation of the microtubular dipoles in longitudinal direction can generate a longitudinal electric field which for long enough microtubules is proportional to the electric charge at the second end. If the orientations of tubulin dipoles are random, the net electric field is also random. The effect of anesthete would be to randomize the directions of dipoles so that the potential between the ends of microtubule would be random. One can wonder whether this field is really strong enough to explain the experimental findings [**?**].

2. Microtubule carries non-vanishing constant negative charge density due to the presence of two GTPs differing from ATPs only in that A is replaced with G attached to the tubulin dimer and stabilizing it.

   The non-topological half of Maxwell's equations also in TGD framework at the level of space-time surfaces. One can however assume it at QFT limit. Consider first the solutions to the Maxwell equation $\nabla^2 \Phi = -\rho_q$ for constant charge density ρ_q concentrated on long linear structure, say microtubule. The standard ansatz is that outside of a very long microtubule the potential depends on the radial coordinate ρ only. Φ satisfies Laplace equation $\partial_\rho^2 \Phi + \partial_\rho \Phi / \rho = 0$ giving a potential of form $\Phi = k log(\rho/\rho_0)$ creating a slowly varying radial electric field. For this option microtubule would be analogous to a conductor for which the tangential electric field at microtubular surface vanishes. The value of k is proportional to the surface charge density.

3. In the article of Tuzcinsky *et al* [**?**] it is assumed that inside microtubular surface the potential restricted to the microtubular surface satisfies the equation $\partial_z^2 \Phi = \rho_q$). A more general ansatz reads as $\Phi = az + bz^2 + c\rho^2$ with $2b + 3c = \rho_q$. The electric field increases along the microtubule and voltage between the ends can be higher than the voltage solely due to a coherent polarization. One can indeed pose this kind of condition as a boundary condition in Maxwell's theory although it makes solution numerically complex.

   The physical picture would be that the electric decomposes to two parts. The first part flows along the microtubule and second part flows in good approximation in the radial direction. The electric field generated by microtubule would be at large distances that of a point like charge but nearby radial field would be weaker than for the solution carrying maximal radial flux and there would be longitudinal electric field carrying part of flux.

   If a phase transition to a situation in which the electric field is radial occurs, the value of the radial flux becomes maximal and could lead to a hyperpolarization of the cell membrane and reduce neural activity. Also the longitudinal electric field would be reduced and would accompany the loss of consciousness in accordance with the findings of Becker. Becker's findings and a basic fact from neuroscience would be understood as aspects of one and same phenomenon.

4. Can one imagine a phase transition changing the sign of the longitudinal electric field of the microtubule. Could this occur for the dendritic microtubules of vertebrates for which both directions of electric field are present? The direction of electric field correlates with the structure of the microtubule so that the reversal very probably cannot occur for an existing microtubule.

5. How the anesthete bound to hydrophobic pi resonance rings generates the phase transition from ferro-electret to non-ferro-electric phase or to a phase with weaker longitudinal electric field? anesthete should induce a phase transition in which the electric field transforms from longitudinal to radial. The interaction with the pi rings defining hydrophobic pockets should somehow redirect the electric flux to radial direction. The simplest possibility is that the anesthete increases the resistance in the longitudinal direction and reduces the current and therefor also the voltage. Also super-conductivity might be destroyed locally.

6. Situation would be also quantum critical. Quantum criticality of TGD Universe is basically due to the huge vacuum degeneracy of Kähler action inducing 4-dimensional spin glass degeneracy, which predicts that a given induced Kähler field allows all symplectic transforms of the space-time surface as its representations. Only classical gravitational fields differ for these representations. Hierarchy Planck constants is one manifestation of the hierarchy of quantum criticalities.

   Also classical gravitation would be relevant and assuming the condition $\hbar_{eff} = \hbar_{gr} = GMm/V_0$, where v_0 is some characteristic velocity in 2-body system involving large mass M and mass m of electron, proton, or heavier particle. TGD predicts macroscopic quantum gravitational coherence [**?**] and universal energy spectrum for cyclotron photons (no dependence on the mass m of charged particle mass) highly relevant for the model of bio-photons as decay products of dark photons serving as key tool of quantum control also at the microtubular level. By universality also bio-super-conductivity is universal- that is possible for all charged fermions involved being characterized by same binding energies of Cooper pairs associated with pairs of flux tubes. Also bosonic analogs of supra-currents acting also as spin currents and associated with single flux tube are predicted [K78].

   One can relate this model to the TGD based model for the findings of the group led by Anirban Bandyonophyay [**?**, **?**].

1. Microtubules allow two kinds of conformations. For type B microtubules helical symmetry is broken and their is kind of a gap along microtubule. In this phase classical signalling is expected to be possible but macroscopic quantum coherence is restricted to single portion of microtubule helix consisting of 13 tubulins. Also super-conductivity is expected to fail and the conductivity of microtubule is expected to be low. Type A microtubules have helical symmetry since gap is absent. They might be ideal for quantum computation and consciousness since quantum coherence scale would increase from a length of single helical twist to the length scale of entire tubule.

2. There is however a problem: microtubules of type A appear in neither vivo or vitro! This problem can be solved in TGD inspired model [K76].

   The group of Anirban Bandyonophyay [**?**, **?**] have found highly interesting effects of AC electric fields on microtubules at frequency ranges about kHz, MHz, and GHz. The TGD inspired proposal is that the external AC signal can induce a phase transition transforming microtubules of type B to microtubules of type A, and in this manner can make possible quantum computation and consciousness. Dark photons at these frequencies but with energies above thermal threshold - perhaps in the energy range of bio-photons in visible and UV range - would serve as a control tool inducing this phase transition increasing the value of h_{eff}. The generation of the gap would also break the long superconducting wire to pieces and super-conductivity inside microtubule would become super-conductivity in much shorter scale and therefore reduces microtubular conductivity. This implies the reduction of longitudinal electric field and explains the other signatures for the loss of consciousness (reduction of Becker's DC voltage and hyperpolarization).

3. This transition has analog also in TGD based description of both bio-super-conductivity and ordinary high T_c super-conductivity [K78]. There are 2 critical temperatures. At higher critical temperature Cooper pairs are formed at flux tubes carrying antiparallel magnetic field but supra-currents flow in rather short length scale (the analog of B phase for microtubules). At lower critical temperature the flux tube pairs reconnect to from much longer flux tube pairs (microtubules of type A) and give rise to macroscopic super-conductivity. The process

is percolation type process. In the recent case the external AC frequency has the same effect as lowering of temperature.

The model could generalize to other important biopolymers.

1. The presence of negative charge density due to GTP and ATP could provide biopolymers with negative charged density generating the stabilizing electric fields. The negative charge could be due to the generation of fourth phase of water discovered by Pollack [L14] transforming part of protons to dark protons and providing the ionizing electron for GTP or ATP. This suggests a very close connection with metabolism.

2. Also the denaturation of basic biopolymers such as DNA and proteins could rely on a phase transition reducing the longitudinal electric fields made possible by GTP or ATP generated in Pollack's phase transition. In TGD framework one could say that biopolymer loses consciousness.

3. The two strands of DNA could represent sub-selves with opposite time directions. Also brain hemispheres could have opposite arrow of time at some level of self-hierarchy. The other hemisphere would remember and the other hemisphere would pre-cognize (remember in reverse time direction).

Aromatic rings as the lowest level in the molecular self hierarchy?

Of special interest from TGD point of view were the talks of Hameroff and Bandyopadphyay, who talked about aromatic rings (ARs, `http://tinyurl.com/yb492da6`) (`p://tinyurl.com/nrntzs5`).

I have also wondered whether ARs might play key role with motivations coming from several observations.

1. In photosynthesis ARs are a central element in the energy harvesting system , and it is now known that quantum effects in longer length and time scales than expected are involved. This suggests that the ARs involved fuse to form a larger quantum system connected by flux tubes, and that electron pair currents follow along the flux tubes as supra currents.

   DNA codons involve ARs with delocalized pi electrons (`http://tinyurl.com/jqj56wz`), neurotransmitters and psychoactive drugs involve them, 4 amino-acids Phe, trp, tyr and his involve them and they are all hydrophobic and tend to be associated with hydrophobic pockets. Phe and trp appear in hydrophobic pockets of microtubules.

2. The notion of self hierarchy suggests that at molecular level ARs represent the basic selves. ARs would integrate to larger conscious entities by a reconnection of the flux tubes of their magnetic bodies (directing attention to each other!). One would obtain also linear structures such as DNA sequence in this manner. In proteins the four aromatic amino-acids would represent subselves possibly connected by flux tubes. In this manner one would obtain a concrete molecular realization of self hierarchy allowing precise identification of the basic conscious entities as aromatic rings lurking in hydrophobic pockets.

3. Given AR would be accompanied by a magnetic flux tube and the current around it would generate magnetic field. The direction of the current would represent a bit (or perhaps even qbit). In the case of microtubules the phe-trp dichotomy and direction of current would give rise to 4 states identifiable as a representation for four genetic letters A,T,C,G. The current pathways proposed by Hameroff *et al* consisting of sequences of current rings (`http://tinyurl.com/j9pgm6q`) could define the counterparts of DNA sequences at microtubule level.

   For B type microtubules 13 tubulins, which correspond to single 2π rotation, would represent basic unit followed by a gap. This unit could represent a pair of helical strands formed by flux tubes and ARs along them completely analogous to DNA double strand. This longitudinal strand would be formed by a reconnection of magnetic flux tubes of the magnetic fields of ARs and reconnection occurring in two different ways at each step could give rise to braiding.

4. The magnetic flux tubes associated with the magnetic fields of nearby aromatic rings could suffer reconnection and in this manner a longitudinal flux tubes pair carrying supra current could be generated by the mechanism of bio-superconductivity discussed in [K78] and working also for the ordinary high T_c super conductivity. The interaction of microtubule with frequencies in the scales kHz, GHz, and THz scales would induce longitudinal superconductivity as a transition to phase A from phase B meaning generation of long super-conducting wires.

   This view suggests that also DNA is superconductor in longitudinal direction and that oscillating AC voltage induces the superconductivity also now. Bandyopadphyay indeed observed the 8 AC resonance frequencies first for DNA with frequency scales of GHz, THz, PHz, which suggests that dark photon signals or AC voltages at these frequencies induce DNA superconductivity. According to the model of DNA as topological quantum computer DNA is superconductor also in the transversal degrees of freedom meaning that there are flux tubes connecting DNA to a lipid layer of the nuclear or cell membrane [K2, K114].

5. Interestingly, the model of Hameroff *et al* for the helical pathway (`http://tinyurl.com/j9pgm6q`) assumes that there are three aromatic rings per $d = 1$ nm length along microtubule. This number is same as the number of DNA codons per unit length. It is however mentioned that the distance between aromatic rings trp and phe in MT is about $d = 2$ nm. Does this refer to average distance or is $d = 1$ nm just an assumption. In TGD framework the distance would scale as h_{eff} so that also scaling of DNA pathway by a factor 6 could be considered. In this case single tubulin could correspond to genetic codon.

   If $d = 1$ nm is correct, these helical pathways might give rise to a representation of memetic codons representable as sequences of 21 genetic codons meaning that there are 2^{126} different memetic codons [K41]. DNA would represent the lowest level of hierarchy of consciousness and microtubules the next level. Note that each analog of DNA sequences corresponds to different current pathway.

6. What is especially interesting, that codon and its conjugate have always altogether 3 aromatic cycles. Also phe and trp appearing in MTs have this property as also tyr and his. Could these 3 cycles give rise to 3-braid? The braid group B_3 which is covering of permutation group of 3 objects (`http://tinyurl.com/ycnar9sa`). Since B_2 is Abelian group of integers, 3-braid is the smallest braid, which can give rise to interesting topological quantum computation.

   B_3 is also the knot group of trefoil knot (`http://tinyurl.com/of6t3sw`), and the universal central extension of the modular group PSL(2,Z) (a discrete subgroup of Lorentz group playing a key role in TGD since it defines part of the discrete moduli space for the CDs with other boundary fixed [K63]). Quite generally, $B(n)$ is the mapping class group of a disk with n punctures fundamental both in string model: in TGD where disk is replaced with partonic 2-surface.

Why some anesthetes do not prevent motor activity?

Some anesthetes (non-immobilizers (`http://tinyurl.com/jqlncvn`)) do not prevent motor activity and thus break the Meyer-Overton rule. This piece of data could provide a test for the model.

   The two kinds of dendrites giving rise to sub-selves with possibly different arrows of time are expected to be similar. Suppose sensory-motor duality realized as dendrites-axon dichotomy. Suppose that the two kinds of dendrites correspond to sensory experience (and pre-cognition as having an idea about what will probably happen) and memories and have opposite arrows of time. If so, there would be no memories about sensory experiences - including pain. The interaction of anesthetes with axonal microtubules would prevent motor activity. If it can happen that an anesthete can bind only to dendrites or to microtubules inside them, one could understand the finding.

   What could distinguish between dendrites and motor axons? Size scale is different and could prevent the interaction of some anesthetes with the microtubules of motor axons. Also the microtubules inside dendrites and axons could differ.

12.4.4   Could Pollack effect make cell membrane a self-loading battery?

The so called Clarendon dry pile is 175 years old battery still working. The current is very weak (nano Ampere) but the working of the battery is claimed to be not well-understood. The TGD inspired model for cold fusion leads to the proposal that Pollack effect is part of electrolysis. This inspires the idea that Pollack effect and possibly also the associated cold fusion could make Clarendon dry pile a self-loading battery. Cell membrane can be regarded as the analog of self-loading battery, and in TGD framework also as a generalised Josephson junction. Hence one can ask whether also cell membrane could be seen as a self-loading battery utilizing Pollack's mechanism. This would also allow to understand why hyperpolarization stabilizes the membrane potential and why depolarization generates nerve pulse.

Clarendon pile: 175 years old battery still working

Elemer Rosinger had a Facebook link to an article telling about Clarendon dry pile, a very long-lived battery providing energy for an electric clock (see `http://tinyurl.com/zeut69y`, `http://tinyurl.com/jhrww2a`, and `http://tinyurl.com/gvbrhra`). This clock known also as Oxford bell has been ringing for 175 years now and the article suggests that the longevity of the battery is not really understood. The bell is not actually ringing so loud that human ear could hear it but one can see the motion of the small metal sphere between the oppositely charged electrodes of the battery in the video.

   The function principle of the clock is simple. The gravitational field of earth is also present. When the sphere touches the negative electrode, it receives a bunch of electrons and gives the bunch away as it touches positive electrode so that a current consisting of these bunches is running between electrons. The average current during the oscillation period of 2 seconds is nanoampere so that nanocoulomb of charge is transferred during each period (Coulomb corresponds to a 6.242×10^{18} elementary charges (electrons)).

   The dry pile was discovered by priest and physicist Giuseppe Zamboni at 1812 (see `http://tinyurl.com/jkvtj6f`). The pile consists of 2,000 pairs of pairs of discs of tin foil glued to paper impregnated with Zinc sulphate and coated on the other side with manganese dioxide: 2,000 thin batteries in series. The operation of battery gradually leads to the oxidation of Zinc and the loss of magnase dioxide but the process takes place very slowly. One might actually wonder whether it takes place too slowly so that some other source of energy than the electrostatic energy of the battery would be keep the clock running. Karpen pile is analogous battery discover by Vasily Karpen (see `http://tinyurl.com/jpzcs32`). It has now worked for 50 years.

   Cold fusion is associated with electrolysis. Could the functioning of this mystery clock involve cold fusion taken seriously even by American Physical Society thanks to the work of the group of prof. Holmlid. Electrolytes have of course been "understood" for aeons. Ionization leads to charge separation and current flows in the resulting voltage. With a feeling of deep shame I must confess that I cannot understand how the ionization is possible in standard physics. This of course might be just my immense stupidity - every second year physics student would immediately tell that this is "trivial" - so trivial that he would not even bother to explain why. The electric field between the electrodes is immensely weak in the scale of molecules. How can it induce the ionisation? Could ordinary electrolytes involve new physics involving cold fusion liberating energy? These are the questions which pop up in my stupid mind. Stubborn as I am in my delusions, I have proposed what this new physics might be with inspiration coming from strange experimental findings of Gerald Pollack, cold fusion, and my own view about dark matter has phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant. Continuing with my weird delusions I dare ask: Could cold fusion provide the energy for the "miracle" battery?

What batteries are?

To understand what might be involved one must first learn some basic concepts. I am trying to do the same.

1. Battery (see `http://tinyurl.com/8xqsnab`) consistes of two distinct electrochemical cells (see `http://tinyurl.com/jq8ljmo`). Cell consists of electrode and electrolyte. The elec-

trodes are called anode and catode. By definition electron current along external wire flows to catode and leaves anode.

2. There are also ionic currents flowing inside the battery. In absence of the ionic currents the electrodes of the battery lose their charge. In the loading the electrodes get their charges. In the ideal situation the ionic current is same as electron current and the battery does not lose its charging. Chemical reactions are however taking place near and at the electrodes and in their reversals take place during charging. Chemical changes are not completely reversible so that the lifetime of the battery is finite.

   The ionic current can be rather complex: the carriers of the positive charge from anode can even change during the charge transfer: what matters that negative charge from catode is transferred to anode in some manner and this charge logistics can involve several steps. Near the catode the currents of positive ions (cations) and electrons from the anode combine to form neutral molecules. The negative current carriers from catode to the anode are called anions.

3. The charge of the clectrochemical cell is in the electrolyte near the surface of the electrode rather than inside it as one might first think and the chemical processes involve neutralization of ion and the transfer of neutral outcome to or from the electrode.

4. Catode - or better, the electrochemical cell containing the catode - can have both signs of charge. For positive charge one has a battery liberating energy as the electron current connecting the negative and positive poles goes through the load, such as LED. For negative charge current flows only if there is external energy feed: this is loading of the battery. External voltage source and thus energy is needed to drive the negative charges and positive charges to the electrodes. The chemical reactions involved can be rather complex and proceed in reverse direction during the loading process. Travel phone battery is a familiar example.

   During charging the roles of the anode and catode are changed: understanding this helps considerably.

Could dark cold fusion make possible self-loading batteries?

Could cold fusion help to understand why the Clarendon dry pile is so long lived?

1. The battery is series of very many simpler batteries. The mechanism should reduce to the level of single building brick. This is assumed in the following.

2. The charge of the battery tends to be reduced unless the ionic and electronic currents are identical. Also chemical changes occur. The mechanism involved should oppose the reduction of the charging by creating positive charge to the catode and negative charge to the anode or induce additional voltage between the electrodes of the battery inducing its loading. The energy feed involved might also change the direction of the basic chemical reactions as in the ordinary loading by raising the temperature at catode or anode.

3. Could be formation of Pollack's exclusion zones (EZs) in the elecrolytic cell containing the anode help to achieve this? EZs carry a high electronic charge. According to TGD based model protons are transformed to dark protons at magnetic flux tubes. If the positive dark charge at the flux tubes is transferred to the electrolytic cell containing catode and transformed to ordinary charge, it would increase the positive charge of the catode. The effect would be analogous to the loading of battery. The energy liberated in the process would compensate for the loss of charge energy due to electronic and ionic currents.

4. In the ordinary loading of the battery the voltage between batteries induces the reversal of the chemical processes occurring in the battery. This is due to the external energy feed. Could the energy feed from dark cold fusion induce similar effects now? For instance, could the energy liberated at the catode as positively charged dark nuclei transform to ordinary ones raise the temperature and in this manner feed the energy needed to change the direction of the chemical reactions.

Cell membrane as self-loading battery and how nerve pulse is generated?

This model might have an interesting application to the physics of cell membrane.

1. Cell membrane consisting of two lipid layers defines the analog of a battery. Cell interior plus inner lipid layer (anode) and cell exterior plus outer lipid layer (catode) are analogs of electrolyte cells.

   What has been troubling me for two decades is how this battery manages to load itself. Metabolic energy is certainly needed and ADP-ATP mechanism is essential element. I do not however understand how the membrane manages to keep its voltage.

   Second mystery is why it is hyperpolarization rather than polarization, which tends to stabilize the membrane potential in the sense that the probability for the spontaneous generation of nerve pulse is reduced. Neither do I understand why depolarization (reduction of the membrane voltage) leads to a generation of nerve pulse involving rapid change of the sign of the membrane voltage and the flow of various ionic currents between the interior and exterior of the cell.

2. In the TGD inspired model for nerve pulse cell interior and cell exterior or at least their regions near to lipid layers are regarded as super-conductors forming a generalized Josephson junction. For the ordinary Josephson junction the Coulombic energy due to the membrane voltage defines Josephson energy. Now Josephson energy is replaced by the ordinary Josephson energy plus the difference of cyclotron energies of the ion at the two sides of the membrane. Also ordinary Josephson radiation can be generated. The Josephson currents are assumed to run along magnetic flux tubes connecting cell interior and exterior. This assumption receives support from the strange finding that the small quantal currents associated with the membrane remain essentially the same when the membrane is replaced with polymer membrane.

3. The model for Clarendon dry pile suggests an explanation for the self-loading ability. The electrolytic cell containing the anode corresponds to the negatively charged cell interior, where Pollack's EZs would be generated spontaneously and the feed of protonic charge to the outside of the membrane would be along flux tubes as dark protons to minimize dissipation. Also ions would flow along them. The dark protons driven to the outside of the membrane transform to ordinary ones or remain dark and flow spontaneously back and provide the energy needed to add phosphate to ADP to get ATP.

4. The system could be quantum critical in the sense that a small reduction of the membrane potential induces nerve pulse. Why the ability to generate Pollack's EZs in the interior would be lost for a few milliseconds during nerve pulse? The hint comes from the fact that Pollack's EZs can be generated by feeding infrared radiation to a water bounded by gel. Also the ordinary Josephson radiation generated by cell membrane Josephson junction has energy in infrared range!

   Could the ordinary Josephson radiation generate EZs by inducing the ionization of almost ionized hydrogen bonded pairs of water molecules. The hydrogen bonded pairs must be very near to the ionization energy so that ordinary Josephson energy of about .06 eV assignable to the membrane voltage is enough to induce the ionization followed by the formation of $H_{3/2}O$. The resulting EZ would consist of layers with the effective stoichiometry $H_{3/2}O$.

   As the membrane voltage is reduced, Josephson energy would not be anymore enough to induce the ionization of hydrogen bonded pair of water molecules, EZs are not generated, and the battery voltage is rapidly reduced: nerve pulse is created. In the case of hyperpolarization the energy excees the energy needed for ionization and the situation becomes more stable.

5. This model could also allow to understand the effect of anesthetes [K76] [L26]. Anesthetes could basically induce hyperpolarization so that Josephson photons would continually generate Pollack's EZ:s and creating of dark particles at the magnetic flux tubes. This need not mean that consciousness is lost at the cell level. Only sensory and motor actions are prevented because nerve pulses are not possible. This prevents formation of sensory and motor mental images at our level of hierarchy.

Meyer-Overton correlation states that the effectiveness of the anesthete correlates with its solubility to the lipid membrane. This is the case if the presence of anesthete in the membrane induces hyperpolarization so that the energies of the photons of Josephson radiation would be higher than needed for the generation of EZs accompanied by magnetic flux tubes along which ionic Josephson currents would flow between cell interior and exterior. For these quantal currents evidence exists [K80]. In the case of battery these dark ions would flow from the cell containing anode to that containing catode. For depolarization the energy of Josephson photons would be too low to allow the kicking off protons from hydrogen bonded pairs of water molecules so that EZs would not be created and self-loading would stop and nerve pulse would be generated.

It is interesting to compare this Hameroff's vision with TGD view about the roles of microtubules and cell membrane already discussed in [L26]. The new elements are cell membrane as self-loading battery based on the TGD based model for the exclusion zones (EZ) of Pollack [L14] in terms of $h_{eff}/h = n$ phases.

12.4.5 Anesthetes again

The writing of the summary about SSE-2016 conference forced to think again the model for anesthetes in light of the vision about cell membrane as sel-loading battery relying on TGD based model for Pollack's exclusion zones (EZ) [L14] in terms of $h_{eff}/h = n$ phases.

First however a philosophical remark.

1. According to the behavioristic definition of consciousness, the ability to respond to sensory input and perform motor actions are essential aspects of consciousness. To my opinion these abilities correspond to only particular type of consciousness and consciousness might be possible even without neural activities (OBEs and NDEs). In any case, the inability to generate nerve pulse patterns would be an essential aspect for what we call loss of consciousness. This happens if there is hyperpolarization of neuronal membrane.

2. Hyperpolarization means reduced rate of spontaneous nerve pulse generation. This would be achieved if microtubules gain additional negatively charge so that the radial component of microtubule electric field increases. Hence the interaction of anesthetes with the microtubuli should generate this negative charge. One possibility is that Pollack effect [L14] generates in the presence of anesthete negatively charged exclusion zone (EZs) [L14]. The TGD based model assumes that the protons are transferred to the magnetic flux tubes as dark protons and perhaps end up to the exterior of cell membrane and transform to ordinary protons. This would induce hyperpolarization. The neutral anesthete atoms or molecules in turn could be transferred to the microtubules along flux tubes.

Consider next a model for the cell membrane.

1. In TGD Universe cell membranes could be generalized Josephson junctions. The energy of generalized Josephson photons (dark with energies in bio-photon range) would be the difference of cyclotron energies for flux tubes at the two sides of the membrane plus the ordinary Josephson energy. Generalized Josephson photons would take care of communications of sensory data to MB.

   Unless the cyclotron energies at the two sides of the membrane are same, the new contribution would dominate in the communications to MB for large values of h_{eff} since cyclotron energy is proportional to h_{eff}, and neuronal contribution would represent frequency modulation allowing to code nerve pulse patterns to kind of "whale's song". For smaller value of h_{eff} ordinary Josephson energy would dominate.

   There is a temptation to assume that the value of h_{eff} serves as a kind of intelligence quotient of cell. Frequency scale and energy scale for the analog of EEG would serve for the same purpose. For instance, pyramidal neurons responsible for EEG would represent the intellectual elite of brain and ordinary cells could have much smaller value of h_{eff} being say by factor 2^{-10} smaller than for pyramidal cells so that generalized Josephson energy would be of the same order of magnitude as ordinary Josephsone energy and in IR range.

2. Generalized Josephson photons with biophoton energies would also generate Pollack's EZs [L14] by ionizing one proton from hydrogen bonded pair of water molecules. The reduction of the membrane potential below the threshold for nerve pulse generation could reduce the energy of Josephson photons below threshold for generating Pollack's EZs and neuronal membrane would cease to be self-loading battery: this would replace ionic Josephson currents with ohmic currents through cell membrane and generate nerve pulse.

   The objection is that for low values of h_{eff} generalized Josephson energy reduces to ordinary one in IR range and for high values to cyclotron energy in visible-UV range. It is known that IR photons generate EZs in the experiments of Pollack. The process could occur in two steps involving cyclotron radiation - perhaps from MB - kicking of hydrogen bonded water molecules to a state, where proton is almost ionized so that the IR radiation would take care of the ionization. The mechanism generating EZs cannot be different for ordinary cells and neurons. Either the notion of generalized Josephson junction must be given up or in the case of neurons glial cells accompanying also axons generate the IR radiation giving rise to EZs inside axons.

3. It is also attractive to see at least ordinary cell membrane as a self-loading battery [L33]. The generation of Pollack's EZs with negative charge and dark proton charge at magnetic flux tubes of the associated MB could make cell a self-loading battery [L33].

   Generalized Josephson photons from cell membrane or cyclotron photons could generate EZs by kicking protons to dark protons at flux tubes of MB of the cell. The energy must be in some critical range in order that this can happen. For too small energies the process stops. Besides ionic charge distributions EZs and the delocalized dark proton charges and the flux tubes extending beyond cell interior would be responsible for the resting potential.

   EZs are not expected to be completely stable. The $h_{eff} \to h$ phase transition would bring dark protons back as ordinary protons and destroy EZs and reduce the magnitude of membrane potential. There could be a competition between the generation and destruction of EZs by $h_{eff} \to h$ phase transition.

4. This picture is enough to explain the effect of anesthetes. Anesthetes at microtubules would generate a negative charge assignable to additional EZs thus increasing the magnitude of the membrane potential. This would imply stable hyperpolarization preventing the generation of nerve pulses.

What about generation of nerve pulses in this framework? I have suggested a TGD based model for nerve pulse [K80] relying on the idea about cell membrane as array of Josephson junctions consisting of membrane proteins (channel and pump proteins) but the model leaves open what exactly generates the nerve pulse. The expectation has however been that microtubules play a key role in the generation of nerve pulse. A charge wave with positive charge propagating along microtubule could induce the reduction of the membrane potential and lead to a generation of nerve pulse as a secondary wave.

1. The propagation of $h_{eff} \to h$ phase transition followed by its reversal along axon interior could serve as a weak control signal inducing the nerve pulse propagation at quantum criticality. This phase transition could be assignable to microtubules. Battery would temporarily discharge during the nerve pulse. If glial cells generate the EZs making axons glial-cell loaded batteries then the return back to the normal state after nerve pulse would be possible by the presence glial cells.

2. During nerve pulse either the generation of EZs ceases and/or the existing EZs suffer an h_{eff} reducing phase transition so that flux tubes are shortened and the positive dark charge returns to EZs and cell membrane potential is reduced. The generation of nerve pulse is usually modelled using ohmic ionic currents, which suggests that quantum coherence is lost by a reduction of h_{eff}, which is predicted to be proportional to ion mass so that cyclotron energy spectrum is universal and in visible-UV range for bio-photons.

3. Nerve pulse could be a "secondary wave" induced by a wave of positive charge propagating along microtubule. This wave of positive charge would rather naturally result from the

reduction $h_{eff} \to h$ and return back to h_{eff}. A pair of phase transitions dark-ordinary-dark would propagate along the microtubule. The unidirectionality of the propagation direction would be forced by the fact that it can begin only from axonal hillock. Axonal hillock contains a large number of voltage gated ion channels, which would serve as generalized Josephson junctions in TGD framework.

4. What one can one conclude about the development of total charge during the time development of membrane potential $V(t)$? Nerve pulse corresponds to certain segment of axon and lasts for few milliseconds. The cell membrane voltage goes from resting potential $V(t = 0) = V_{rest}$ to approximately $V(t = T) = -V_{rest}$ and returns back. The total charge in cell interior defines the value of electric field E at the interior side of cell membrane and approximation interior as conductor, the value of E in good approximation one has $V = Ed = Q_{cell}d/4\pi R^2$ in spherical geometry and $V = Ed = dQ_{tot}/dld/2\pi R$ in cylindrical geometry of axon. Here Q_{tot} is the charge of the piece of axons at which nerve pulse is located. Total charge is sum of microtubular charge Q_{mt} serving as a control parameter and the total ionic charge Q_I changing due to the presence of ohmic ionic currents during the pulse (ionic currents are Josephson currents except during nerve pulse).

To get some quantitative grasp, let us idealize the situation by assuming that during nerve pulse the negative microtubular charge $Q_{mt}(0) < 0$ goes to $Q_{mt}(T) = 0$ for $V(T) = -V_{rest}$ (EZs disappear totally) and returns back to its original value as the phase transition returning the value of h_{eff} occurs.

One has $Q_{tot}(0) = Q_{mt}(0) + Q_I(0)$ before the nerve pulse. At $V = -V_{rest}$ one has $Q_{tot}(T) = -Q_{tot}(0)$, which gives $-Q_{tot}(0) = Q_I(T)$. This gives $Q_{mt}(0) = Q_I(T) - Q_I(0)$.

What can one say about the magnitude of Q_{mt}? If this charge serves control purpose and if the system is kicked off from quantum criticality, the change of Q_{mt} need not be large so that no large modifications of the ordinary model of nerve pulses are needed. The negative microtubular charge is partially due to the GTPs along microtubular to which EZs are associated. The value of resting potential of order .06 eV at threshold for nerve pulse generation and estimates for linear ionic charge densities $dQ_I(0)/dl$ and $dQ_I(T)/dl$ and $Q_{mt}(0)/dt$ would allow to test the model. The $h_{eff} \to h$ phase transition outside quantum criticality would take place in millisecond time scale.

The distinctions between neurons and ordinary cells allow to invent objections against the proposed scenario.

1. Ordinary cell membrane should act as a self-loading battery with Josephson radiation generating Pollack's EZs. Axonal microtubules are missing but the cytoskeleton consisting also of microtubules is present. Inside the cell soma the microtubules meet the cell membrane transversally. There is also T-shaped antenna like structure involving microtubules whereas ordinary neurons have axonal microtubules. Also now a microtubular positive charge generated by $h_{eff} \to h$ phase transition could induce the reduction of membrane potential.

2. Why the analog of nerve pulse does not take place also now? In the case of cancer cells membrane potential is reduced and can become even vanishing, and one might think that the lack of recovery is due to the absence of glial cells taking care that EZs are generated. For too low Josephson energies the self-loading would stop and due to the spontaneously occurring $h_{eff} \to h$ phase transitions, the membrane potential would be gradually reduced.

In the case of neurons the $h_{eff} \to h$ phase transition would occur fast. The transition away from quantum criticality could cause this since long range quantum fluctuations would disappear. The value of membrane potential or the difference between neuronal and glial membrane potentials could serve as a critical parameter changing as the membrane potential is reduced. The quantum criticality of ordinary cell membrane would be analogous to self-organized quantum criticality. That of neuronal axon to quantum criticality induced by glial cells.

12.4.6 TGD interpretation of new experimental results about the mechanism of anesthesia

I received a link to a highly interesting popular article with title "*Century-Old Scientific Debate Settled: Anesthesia's Effect on Consciousness Solved*" (`https://tinyurl.com/yd4ztmph`). The article tells about a study from Scripps Research published in the Proceedings of the National Academies of Sciences (PNAS). The paper [**?**] "*Studies on the mechanism of general anesthesia*" has appeared in PNAS (`https://tinyurl.com/y8oa97eo`). In addition to Lerner and Hansen, the authors are Mahmud Arif Pavel, E. Nicholas Petersen and Hao Wang, all of Scripps Research.

I have pondered possible mechanism of anesthesia in TGD framework several times earlier [K80] [L26] and it is interesting to see whether the findings allow to make earlier insights more detailed or even develop new ones.

What was observed

According to the popular article the discovery by chemist Richard Lerner, MD, and molecular biologist Scott Hansen, PhD, settles a century-old scientific debate about whether anesthetics act directly on cell-membrane gates called ion channels, or do they somehow act on the membrane to signal cell changes in a new and unexpected way. The conclusion of the researches is that anesthetic action is a two-step process that begins in the membrane. The anesthetics perturb ordered lipid clusters within the cell membrane known as "lipid rafts" to initiate the signal. There are two kinds of clusters involved and known with names GM1 and PIP2.

What was observed was following.

- A shift in the GM1 cluster's organization, a shift from a tightly packed ball to a disrupted mess occurred first As GM1 grew disordered, it spilled its contents, among them, an enzyme called phospholipase D2 (PLD2). Melting is a good analog for what happens. Gel-to-sol transition in cytoplasm is second analogy.

- PLD2 moved like a billiard ball away from its GM1 home and over to a different, less-preferred lipid cluster called PIP2.

- This activates key molecules within PIP2 clusters, TREK1 potassium ion channels and their lipid activator, phosphatidic acid (PA) are among them. The activation of TREK1 potassium channels releases potassium hyper-polarizing the nerve and it makes it more difficult to fire. Nerve pulse generation rate becomes low and leads to a loss of consciousness - at least in clinical sense. Something analogous to this could happen when one falls in sleep.

In the sequel I try to understand in the framework provided by TGD inspired model of cell membrane and nerve pulse [K80], compare these findings to TGD inspired views about anesthesia based on hyperpolarization, and also try to build a bridge from TGD description provided by a generalization of thermodynamics forced by zero energy ontology (ZEO) predicting that in ordinary state function reduction the arrow of time changes [L86, L103].

TGD background

In the following Pollack effect and its generalization are discussed, ZEO based view about self-organization involving time reversal as key element is compared to the non-equilibrium thermodynamics (NET) based approach, and the TGD based view about nerve pulse generation and EEG is discussed.

1. Pollack effect as starting point

The generalization of Pollack effect [I40, L14, I67, I53] plays a key role in TGD inspired biology.

1. TGD based model of cell membrane relies on a generalizaton of Pollack effect so that it would allow also to other ions - at least positively charged ions inside neuronal (cell) membrane. Pollack effect occurs in presence of energy feed such as IR photons, and means charge separation in water bounded by gel so that negatively charged exclusion zone (EZ) is formed. TGD

interpretation is that part of protons goes outside EZ to magnetic flux tubes and form dark proton sequences having effective Planck constant $h_{eff} = nh_0 > h$ and forming macroscopic quantum phase. Dark particles at magnetic flux tubes of magnetic body of system (MB) would control its dynamics like master and induce coherence as forced coherence.

EZ has the strange property that it drives out impurities. The interpretation is that the arrow of time is change at MB controlling EZ and induces effective change of the arrow of time at EZ differing from the standard arrow of time of observer. DNA nucleotides involve negatively charged phosphate ion, which leads to the proposal that they are accompanied by magnetic flux tubes parallel to them carrying dark proton triplets as a representation of genetic codons [L29, L73].

Negatively charge entities appear abundant in biology.

(a) Cell interior is negatively charged, which suggests similar charge separation with positive charge assignable to dark ions at the magnetic flux tubes outside cell. Fermionic ions such as K^+, Na^+,.. could form Bose-Einstein (B-E) condensates of Cooper pairs whereas bosonic ions like such as Ca^{2+}, Mg^{2+}, Fe^{2+} could as such form B-E condensates. It is not clear whether also negatively charged ions like Cl^- form B-E condensates at flux tubes and whether they are in the interior or exterior of cell.

(b) Microtubules carry constant negative charge density per unit length realized in terms of GTP molecules suggesting that they are accompanied by parallel flux tubes carrying say dark protons. Microtubules could be partially responsible for the negative charge of cell and could be related to the control of membrane potential.

(c) ATP has charge -3. This forces to ask whether there is charge +3 of 3 protons associated with a magnetic flux tube accompanying ATP. Could the 3 protons form the analog of genetic codon so that information processing might take place already at this level?

2. Pollack effect would basically transform part of ordinary ions in cell interior to dark ions or their Cooper pairs outside cell at flux tubes. Note that also the analogs of 3-proton units can be considered for positive ions. This would require energy feed, which need not come from metabolic energy. Integral proteins acting as ion channels do not require ATP to function and are a good candidate in this respect. Their opening could make possible Pollack effect for ion. Ion pumps are also integral proteins and could transfer the ions produced in the decay of Cooper pairs to ordinary ions back to cell interior.

2. ZEO based thermodynamical description of self-organizing cell

TGD leads to a new kind of thermodynamical description of cell as an open self-organizing system. Cell is indeed an open self-organizing system requiring metabolic energy feed. The standard description would be using non-equilibrium thermodynamics (NET). ZEO allows both arrows of time and and the arrow of time changes in ordinary ("big") state function reductions (BSFRs) possible in arbitrary long scales. This forces a generalization of thermodynamics allowing a new kind of description.

Dissipation with reversed arrow of time corresponds to generation of gradients and gradients as seen by observer with standard time direction, and energy feed needed by self-organization corresponds to dissipation of energy by self-organizing system in reverse time direction. The arrow of time could be different from standard one in long time scales only at the level of MB carrying dark matter and can induce its effective change at the level of ordinary matter.

The energy of particle increases with h_{eff} so that generation of dark phases and the preservation of h_{eff} distribution requires energy feed. Hence one can see self-organization as a direct evidence for the notions of MB and ZEO.

How does TGD description relate to the standard description of cell in terms of NET differing from the ordinary thermodynamics by the presence of energy feed?

1. In standard thermodynamical description the presence of dark matter is not assumed. Therefore the description takes into account only the ordinary matter. For living cell the differences

between ion concentrations are in sharp conflict with naïve expectations for ions like K^+ (concentration is considerably higher in the cell interior). They are explained by using chemical potentials μ as parameters. Their values are determined experimentally from measured ion concentrations. Their values would be basically determined by the metabolic energy feed: here NET enters the picture.

2. The basic quantity is Gibbs energy $G = E - TS$, whose minimization corresponds to second law of thermodynamics. The energy minimization and entropy maximization compete and there is a competition between energy and entropy. Giggs energy for single particle corresponds to chemical potential $\mu = e - Ts$ at single particle level. Given process is thermodynamically favored at single particle level if μ decreases in it.

3. For instance, the measured density of K^+ ions is much higher inside cell than exterior - this corresponds to the fact that dark K^+ ions or of their Cooper pairs at flux tubes are not observed. When channel is opened the K^+ ions flow to the exterior of the membrane provided this corresponds to a decrease of μ. For given ion there is also a certain value of membrane potential for which there is no flow.

   In TGD framework Pollack effect transforming K^+ ions to their dark variants transferred to the flux tubes outside cell and possibly forming Cooper pairs would be the description. The safest assumption is that ions are at flux tubes at both sides but that at either side the value of h_{eff} is minimal. Also phase transitions changing h_{eff} for flux tubes are expected to occur and play a key role in TGD based model for bio-catalysis.

4. An open problem is whether the phenomenological description of ordinary matter in terms of NET is equivalent with the ZEO based description in which also dark matter is taken into account. For instance, Pollack effect for protons requires energy feed. It generates charge separation, which generates negative Coulomb energy. The Coulomb repulsion between charged protons at flux tube generates positive energy. The model as dark nuclei implies that there is also scaled dow nuclear binding energy involved. The value of entropy generated in this manner depends on the scale of de-localization at MB. If macroscopic quantum phase is generated, one expects that the generated entropy is actually small.

5. It would seem that ion channels, which do not require ATP, involve the transfer of ordinary matter to dark matter at magnetic flux tubes. Could ion pumps requiring ATP be responsible for the transfer of ordinary ions between cell interior and exterior against gradient of chemical potential? Could they correspond to standard arrow of time?

   3. EEG and nerve pulse generation in ZEO

   TGD leads to a model of nerve pulse and EEG [K80, K35, K83].

1. Cell membrane is a generalized Josephson junction in the sense that there are flux tubes at both sides of the membrane connected by a flux tubes through cell membrane. The energy assignable to the ion in junction is sum of two terms. The first term is the ordinary Josephson energy given by Coulomb energy. Second terms is the difference of the cyclotron energies of ion associated with the flux tubes at the two sides of the membrane. The generalized Josephson radiation generated by this system consists of dark photons travelling along magnetic flux tubes to the part of MB much larger than the system. The Compton length of EEG radiation at Schumann frequency 7.8 Hz gives an estimate of order Earth circumference for the size scale of MB.

2. The sensory part of EEG mediating sensory information to MB would be assigned with the generalized Josephson frequencies modulated by the variation of membrane potential and in this manner coding the sensory data. If the signal is received at certain resonance frequencies it corresponds to a sequence of peaks corresponding to critical values of membrane potential.

   MB containing cyclotron B-E condensates would receive this radiation resonantly and respond by control signal consisting of dark cyclotron radiation possibly mediated through genome (and possibly also microtubuli) and inducing biological effects. They would emerge by a

transition $\hbar_{eff} = h\hbar_0 = h_{gr} = GMm/v_0 \to h$ producing ordinary photons identifiable as bio-photons in visible and UV range [K12, K22]. These would induce molecular transitions.

3. h_{eff} hierarchy allows to interpret the generation of nerve pulse as a quantum jump in neuronal scale. The change of the arrow of time correspond to the change of the sign of the membrane potential temporarily. This process would liberate energy needed to preserve the thermodynamical non-equilibrium state but regeneration of standard arrow of time would require metabolic energy so that energy would be lost. For instance, generalized Josephson radiation would use part of the energy.

   Neural membrane is quantum critical against generation of nerve pulses by macroscopic quantum jump changing the arrow of time (automatically) - as a matter of fact, the Josephson energy for ion Cooper pairs is near to thermal energy. This makes cell membrane an ideal sensory receptor.

4. Quite generally motor actions correspond in TGD framework BSFRs whereas sensory perception corresponds to a sequences of "small" state function reductions (SSFRs). This would suggest that the EEG waves from the cell membrane as sensory input have standard arrow of time and control signals from MB comes as EEG waves with opposite arrow of time. One might also speak of time reflection of the positive energy signal. A detailed model for the sequence of SSFRs leads also to a model for what personal memories are [L86, L103].

   What happens to GM1 fart is essentially melting.

1. Melting phase transitions - analogous to gel-sol transitions for cytoplasm - occur in the lipid layer also during the propagation of nerve pulse and has been proposed to accompany a propagation of soliton [**?**] (`https://www.pnas.org/content/102/28/9790`). TGD based model of nerve pulse [K80] assumes that in the resting state of axon there is a sequence of solitons propagating along the axon mathematically. The chain of the proteins representing ion channels (and possibly also pumps) as Josephson junctions would be analogous to a chain of rotating mathematical penduli with constant phase difference.

2. Nerve pulse would correspond to a propagation of a perturbation for which some penduli oscillate rather than rotate. The local transformation of rotation to oscillation would correspond to a melting phase transition propagating along axon.

3. One cannot however exclude the possibility that the Josephson penduli are not kicked to oscillation but to a rotation in opposite direction. This would conform with the proposal of [**?**] that nerve pulse involves propagation of some kind of soliton.

   If this is true, the ions at two sides should be at flux tubes with different values of h_{eff} and the values of h_{eff} are effectively permuted at two sides to change the sign of membrane potential. This requires transfer of energy between interior and exterior. The change of the sign of membrane potential suggests local time reversal and if BSFR occurs, this must happen. If BSFR occurs, some self - neuronal mental image - at exterior dies and re-incarnates with opposite arrow of time in the interior. The observer with standard arrow of time would see ions to flow from the MB of the neuron to interior flux tubes for which h_{eff} is increased. The naïve expectation is that also the roles of channels and pumps are changed.

4. It would be natural to assign melting transition with the reduction of membrane potential and initiation of the time reversed period. The possible melting outside neuron would be accompanied by freezing in the interior. Gel-sol phase transitions in cytoplasm could accompany the nerve pulse propagation. Cavitational fluctuations of water and microtubule disassembly are known to be accompanied by gel-sol phase transitions and of emission of bio-photons and IR light [I11] (`https://tinyurl.com/ya33kdzt`). Photons are indeed in central role also in the generation of Pollack effect as providers of metabolic energy to realize the transition.

   Gel like states would correspond in TGD picture states of water in which the value of h_{eff} for the flux tubes is increased and thus to ordered states with higher number theoretic "IQ" having interpretation as dimension of extension of rationals [L82, L102, L97]. The increase

of h_{eff} requires energy and gel-sol phase transition would correspond to a reduction o h_{eff} and liberate stored metabolic energy. One expects gel-sol phase transitions for cellular water to accompany the propagation of nerve pulses. One can imagine that the energy liberated in gel-to-sol transition induces sol-to-gel transition. This would naturally allow interpretation also as information transfer too?

What could happen in anesthesia?

Anesthetes - often noble gases - are expected to have rather weak chemical effects. This suggests that the mechanism inducing hyperpolarization is not purely chemical.

1. It would seem that GM1 clusters and PIP2 clusters correspond to two different equilibria in which the dark K^+ concentrations at dark flux tubes are different and therefore also membrane potentials. The role of the anesthete and of the control step inducing sleep would be to replace GM1 with PIP2. The anesthete dissolving into lipid layers could induce its melting by lowering the density of lipids in lipid-crystal and in this manner induce the decay of GM1 clusters. The interpretation of lost coherence could be in terms of reduction of h_{eff}: if BSFR occurs, GM1 could be said to die. The decay of the GM1 clusters could be thus seen as analog of decay process in general liberating energy used in the next step of the process.

2. What could happen in the decay of GM1 cluster, which expands from tightly packed ball and looses is order? The twistor lift of TGD [L87, L76] predicts length scale dependent cosmological constant Λ characterizing various structures in all scales and the possibility of phase transitions reducing the value of Λ, scaling up the size of the structure in question, and liberating energy. Could also GM1 be characecrized by Λ decreasing in the transition and could the liberated energy be used as metabolic energy in the transfer of K^+ ions?

3. The PLD2 molecules (containing phosphate) are said to move like billiard balls to PIP2 clusters, which suggests that they could travel along magnetic flux tubes connecting the two systems. PLD2 molecules act as catalysts and could help to activate TREK1 K^+ channels and their lipid activator, phosphatidic acid (PA) containing phosphate with charge -2.

   All these molecules involve negatively charged phosphate ions and this could relate to the generation of charge separation by Pollack effect. PIP2 involves 3 negatively charged phosphates and it binds to the TREK1. The negative charge from phosphates bound to TRKE1 could make it part of an analog of EZ. I do not know whether one has excluded the possibility of ATP $\rightarrow$ ADP type mechanism.

4. It is not clear what happens at the level of energetics. In ZEO picture the opening of K^+ ion channels would make possible a transfer of K^+ ions by Pollack effect to their dark variants possibly forming Cooper pairs at MB at the other side of neural membrane. If this requires metabolic energy, it is not provided by ATP.

   In NET picture Gibbs free energy should decrease if the process is spontaneous as suggested by the absence of ATP. This could be the case also now at least approximately. There could be quantum criticality in the sense that there is large number of states of neuron with essentially same energy or with energies differing only slightly but with different membrane potential.

   The increase of the membrane potential reduces the rate for the spontaneous generation of nerve pulses. Nerve pulse generation is expected to release energy but the regeneration of membrane potential back to its original value requires energy. Hence one expects that the anesthetic state saves metabolic energy as also sleep state is expected to do. Note that the feed of metabolic energy could corresponds quite generally to dissipation in opposite time direction. Could the MB of PIP2 cluster live in opposite time direction - as also GM1 cluster when active - and get its metabolic energy making possible the transfer of K^+ ions in this manner?

5. What is the role of the anesthete? Meyerton-Overton hypothesis states that the potency of anesthete correlates with its liquid solubility. The anesthete dissolved into the 2-D liquid-crystal formed by lipid layer should somehow induce the decay of GM1 cluster: the dissolved

anesthete could force the reduction of density of 2-D liquid crystal if the total pressure is preserved. Could this decay liberate provide the metabolic energy needed in Pollack effect? Anesthete dissolves spontaneously. In standard picture the interpretation would be that this reduces Gibbs energy G. Does this liberate energy or is the increase of entropy enough to reduce G?

Questions

The foregoing speculative picture raises several questions.

1. The falling to sleep could involve similar transition. What happens to conscious experience in anesthesia and sleep. Sensory input from cell membranes to MB disappears and also motor control from MB becomes impossible but does this really mean loss of consciousness? Could the experience be nearer to a meditative state?

2. The arrow of time changes inside EZs assignable to negative charge in Pollack effect. Could PIP2 cluster be contained in EZ and thus have also reversed arrow of time. Could EZ property be tested? Could also the GM1 cluster have reversed arrow of time and be responsible for the transfer of different kind of ions?

   In ZEO "big" (ordinary) state function reduction (BSFR) corresponds quite universally to death and re-incarnation with opposite arrow of time for conscious entity involved. Could falling asleep be BSFR at some level of self hierarchy. Could GM1 clusters as conscious entities die and could their decay be analogous to ordinary decay process and provide both building bricks (PLD2) and metabolic energy for PIP2 clusters? Could this be interpreted as a kind of birth or wake-up for PIP2 clusters? Could the re-incarnated GM1 clusters live in opposite arrow of time?

3. K^+ channels represent only one particular kind of ion channel and there are many ways to control the ion flux. Could all ion channels rely to Pollack effect? What about on pumps. Could ion pumps be channels but with opposite arrow of time?

4. Quantum consciousness theorists like Hameroff have speculated about the role of microtubules in the action of anesthetes. The proposal is that the anesthete could bind in the hydrophobic pocket of microtubule. The recent findings seem to exclude this option.

   Microtubules however carry large negative charge density due to the presence of GTP molecules (analogous to ATP molecules), which strongly suggests the existence of magnetic flux tubes parallel to them and carrying dark protons or possibly some other positive ions. Microtubules are highly dynamical in quantum critical phase. Could their varying negative charge control the membrane potential by generating opposite varying charge at MB outside cell membrane by Pollack effect (I have discussed anesthetes in several sections of [K80]). Could the transition to sleep be controlled by the microtubular level using a variant of the mechanism discussed as a tool?

   Concerning the possible the source of metabolic energy, it is known that $GTP \to GDP$ cycle occurs [?] (`https://tinyurl.com/yapdcotf`). Could this mechanism serve as an analog of $ATP \to ADP$ with metabolic energy stored in metabolites replaced with the metabolic energy carried by dark photons transforming to bio-photons?

5. What is interesting is that at the endogeneous magnetic field with value $B_{end} = .2$ Gauss assigned with monopole flux tube part of Earth's magnetic field with nominal value of $B_E = .5$ Gauss the cyclotron frequency of K^+ ion (and Cooper pair) is 7.5 Hz. Could dark Schumann resonance photons induce cyclotron transition of B-E condensate of K^+ Cooper pairs? A magnetic field oscillating frequency of with 7 Hz frequency not too far from the lowest Schumann resonance frequency and cyclotron frequency of K^+ ions appears also in the experiment of Montagnier *et al* [L59] strongly suggesting remote replication of DNA.

12.5 Many-Sheeted Neuron

TGD approach allows to make educated guesses concerning the interpretation of various phenomena in neuronal level. This section has been written much before the input from DNA as TQC and the realization that microtubule-cell membrane braids could serve as quantal sensory memory storage based on the braiding of the magnetic flux tubes emanating from the amino-acids of tubulin molecules. This implies obvious updatings of the text of this section left to the reader.

12.5.1 Neuronal Consciousness

The fractality of consciousness encourages the view that neurons and corresponding magnetic bodies are conscious organisms having receiving sensory input and forming sensory representations at their magnetic bodies, and generating motor actions. One can see associations at neuronal level as a process in which neuronal sub-self induces mental images inside the postsynaptic neuronal self. Neuron could be seen as a fractally scaled down version of a sensory pathway.

The sensory input of a neuron is determined by the inputs from active pre-synaptic neurons. Postsynaptic receptors are analogs of ordinary sensory receptors and they determine the sensory qualia and primary sensory mental images of the neuron about external world (also ordinary cells have sensory receptors and sensory representations but only about nearby environment). Micro-tubuli inside dendrites are the analogs of sensory pathways, and cell membrane and cell nucleus could play the role of the neuronal skin and brain. Both could give rise to sensory representations. Sensory representations at the magnetic body of nucleus could be generated by DNA or directly by the communications from cell membrane. Neurons would have sensory qualia and neuronal receptors and receptors at the surface of any cell could give rise to the analogs of tastes and smells. Cells could also see and hear at some wave length ranges and the micro-tubuli associated with the cilia span a length scale range containing visible frequencies.

The general model of how cell membrane acts as a sensory receptor [K35] allows to make this vision much more detailed and also allows to understand how the qualia experienced by us emerge.

1. DNA as topological quantum computer model plus certain simplifying assumption leads to the conclusion that the spectrum of net quantum numbers of quark antiquark pair define the primary qualia assignable to a nucleotide-lipid pair connected by a magnetic flux tube. The most general prediction is that the net quantum numbers of two quark pairs characterize the qualia. In the latter case the qualia would be assigned to a pair of receptor cells.

2. Composite qualia result when one allows the nucleotide-lipid pairs of the membrane to be characterized by a distribution of quark-antiquark pairs. Cell membrane -or at least the axonal parts of neurons- would define a sensory representation in which is a pair of this kind defines a pixel characterized by primary qualia. Cells would be sensory homunculi and DNA defines a sensory hologram of body of or of part of it. Among other things this would give a precise content to the notion of grandma cell.

3. Josephson frequencies of biologically important ions are in one-one correspondence with the qualia and Josephson radiation could re-generate the qualia or map them to different qualia in a one-one and synesthetic manner in the neurons of the sensory pathway. For large values of Planck constant Josephson frequencies are in EEG range so that a direct connection with EEG emerges and Josephson radiation indeed corresponds to both bio-photons and EEG. This would realize the notion of sensory pathway which originally seemed to me a highly non-realistic notion and led to the vision that sensory qualia can be realized only at the level of sensory organs in TGD framework.

4. At the level of brain motor action and sensory perception look like reversals of each other. In zero energy ontology motor action this analogy can be justified so that the model of sensory representations implies also a model for motor action. Magnetic body serves as a sensory canvas where cyclotron transitions induced by Josephson frequencies induce conscious sensory map entangling the points of the magnetic body with brain and body.

12.5.2 Functions Of Nerve Pulse

Nerve pulses inducing generalized motor action represent pushes and pulls in spin glass energy landscape of brain. These pushes and pulls induce motion in the spin glass landscape and generate somehow both neuronal and our emotions. Transmitters mediate nerve pulses from presynaptic neuron to postsynaptic neuron and modify the properties of the synapse and of the postsynaptic neuron. Fast neurotransmitters controlling directly ion channels are involved with the process and the relevant time scale is one millisecond. No long term change of the postsynaptic neuron is involved. Slow neurotransmitters involving second messenger action are involved with the modulation of the response of the postsynaptic neuron, and the time scales can be of order of minutes. In this case the properties of the postsynaptic neuron are changed. Emotional reactions involve typically slow transmitters and their effect can be regarded as a generalized motor action inducing motion of the neuron in the spin glass energy landscape of the neuron.

What the specialization of sensory pathways to sensory modalities means?

Sensory pathways are specialized to produce some specific sensory qualia. How this specialization correlates with what happens at the neuronal level?

1. If one accepts the notion of magnetic body, it is not too difficult to accept the idea that the magnetic bodies associated with the sensory organs are the seats of the sensory representations whereas higher levels of CNS are responsible for symbolic and cognitive representations accompanying sensory representations. TGD based view about long term memories makes it possible to defend this view against standard objections such as phantom limb phenomenon, projected pain, and the stimulation of sensory hallucinations electrically. One cannot exclude the possibility that even the sharing of mental images with the objects of external world contributes to the conscious experience.

2. An almost diametrically opposite view is that qualia are like colors of a map and coloring is decided at quite high level of sensory processing.

   These views need not be mutually exclusive. Sensory qualia seated at sensory organs can serve as the colors of the map if sensory receptors and brain form single quantum system in which entanglement with and back projection to the structures defined by sensory receptors is essential. This back projection could transform the primary mental images. This view would also explain the rapid eye movements during REM sleep and oto-acoustic sounds.

   In this picture association areas could be seen not as cognitive areas, where sensory input is transformed to cognitive output, but areas in which the mental images associated with various symbolic and cognitive pathways fuse to a single mental image. Therefore the term association would be somewhat misleading. A genuine association can be seen to result when a sub-self wakes up sub-self by nerve pulse patterns and is experienced by a higher level self as two subsequent mental images.

Could nerve pulse patterns realize the memetic code?

TGD based model of cognition allows to construct a model for memetic code in which sequences of 126 cognitive neutrino pairs of total duration of about .1 second correspond to Boolean statements or also integers in the range $\{1, 12^{126}\}$ in binary representation. The model for the physical realization of the memetic code is discussed in more detail in [K41] and here only the basic idea will be described.

   The model for the memetic code assumes that antineutrinos resides in the strong Z^0 magnetic field associated with the cell membrane and having the direction of the axon. The antineutrinos have suffered spontaneous Z^0 magnetization. Memetic codons consisting of (almost) 127 bits are realized as temporal sequences of spontaneous Z^0 magnetization of antineutrinos at $k = 151$ cell membrane space-time sheet. The ground state with all bits in the direction of the Z^0 magnetic field does not represent consciously anything so that the number of representable bit sequences is $M_{127} = 2^{127} - 1$ which corresponds to almost 127 bits.

   Memetic codons are generated by Z^0 magnetic pulses reversing the direction of local Z^0 magnetization. The magnetic transition frequency is energy difference for states $(n + 1, up)$ and

$(n, down)$ for cognitive antineutrinos of opposite spin in the strong Z^0 magnetic field of the axonal membrane. There is however a "miracle" involved. The magnetic transition frequencies of muonic and tau neutrinos for the transitions between states $(n + 1, up)$ and $(n, down)$, are in the range of ELF frequencies and that for the largest possible value of the axonal Z^0 magnetic field this frequency is slightly higher than the maximal frequency of nerve pulses. Hence the duration of nerve pulse implies automatically that it generates harmonic perturbation giving rise to spin flips of neutrinos [K41, K79].

The basic objections against the idea that nerve pulses generate memetic codons are following.

1. The minimum time interval between nerve pulses is slightly longer than required by memetic codon.

2. The prediction would be that high level linguistic cognition is everywhere in brain. Rather, higher level cognition should be associated with the neurons at multi-modal associative regions of cortex [K41] or with cognitive neural pathways leading to these areas. Only humans possess the parietal-occipital-temporal association region combining somatosensory-, visual- and auditory inputs into associations and giving meaning to the objects of the perceptive field. Perhaps the emergence of this associative region associating Boolean statements with sensory features has led to Homo Sapiens.

3. Ordinary nerve pulse patterns suggest strongly frequency coding rather than refined memetic code. In the case of memetic code it would mean roughly 64 nonequivalent codons. This in fact might be enough to understand the basic phonemes of language as expressions of memetic codons.

These arguments suggest that nerve pulse patterns give rise only to a frequency coding such that only the frequency of the bits differing from the standard value is of significance. The intensity of sensory input, motor output, and emotional expression could be coded in this manner. MEs can generate also oscillations of the membrane potential and it is known that this kind of oscillations accompany hearing. These oscillations could also induce reversal of Z^0 magnetization and could allow to realize memetic code in full complexity.

Generation of declarative long term memories at micro-tubular level

The TGD based model of declarative long term memories is based on the mirror mechanism with brain and body effectively serving as time like mirrors from which negative energy MEs are reflected as positive energy MEs. Long term memories would be coded to subjecto-temporal changes of the micro-tubular conformations [K47] which allow a huge number of almost degenerate configurations, and the transitions between these configurations generate MEs with ultra-low frequencies determined by the time span of the long term memory. The natural first guess is that the nerve pulse patterns accompanied by MEs are an essential part of the process of building long term memories by inducing the motion of the axonal micro-tubuli in the spin glass energy landscape. Nerve pulse could be also accompanied by a separate wave propagating along the axonal micro-tubuli and containing much more detailed information about the sensory input specifying the content of declarative long term memories. This would mean huge information storage capacity and also explain why the axonal lengths associated with the sensory pathways are maximized.

A model for the cognitive code associated with with micro-tubuli is discussed in [K66]. The model is based on $13 \times 13 = 169$ bits defined by single full turn for 13 helical tubulin strands consisting of 13 tubulins each. Since only the changes of tubulin conformations contribute to the micro-tubular conscious experience, only $2^{169} - 1$ patterns code for conscious experiences. Therefore the code represent only 168 full bits and the remaining almost bit could define some kind of parity bit. The presence of a sufficiently strong external electric field along the micro-tubule would imply that the change of bit is replaced with a pattern of $b \to b + 1 \to b$ transitions leading from the ground state to excited state and back to the ground state.

An interesting possibility is that micro-tubuli define a cognitive code above the memetic code in the hierarchy of cognitive codes so that biology would not reduce to neither genetic nor memetic code. The changes of the micro-tubular conformation patterns could be coded to 2^{126}

memetic codons represented by field patterns associated with MEs. The $64 \to 21$ correspondence for DNAs and amino-acids would be generalized to $2^{169} - 1 \to 2^{127} - 1$ correspondence such that 168 full bits would be mapped to 126 full bits. The degeneracy would be $6log(2)/log(21) \simeq 1.39$ for the genetic code and $168/126 = 1.33$ for the micro-tubular code.

12.5.3 Functions Of Transmitters

It is an interesting challenge to try to understand the role of various information molecules, in particular neurotransmitters, in TGD inspired conceptual framework.

Information molecules as quantum links in quantum web?

One particular challenge is to find convincing "reason why's" for what happens in the synaptic contacts. Why myriads of neurotransmitters are needed: inhibition, excitation and neuro-modulation could indeed be carried out in much simpler manner?

1. Information transfer is certainly in question and a natural assumption is that the information is conscious quantum information. If so, it is not the transfer of the neurotransmitter molecules which is essential but the transfer of bound state entanglement of these molecules with the environment and thus of conscious information. This is in accordance with the computer metaphor: neurotransmitters would be like links to different pages in the web activated in the transfer process analogous to sending an email containing a list of links plus text. Also a transfer of usable energy could be involved: the positive energy MEs transferred could provide their energy to the postsynaptic cell unless they are used to energize the transfer process. Besides neural transmitters blood cells and various molecules transmitted by blood and lympha could be carriers of quantum links and hormonal action at the deeper level would be quantum communication in this sense.

2. When information molecules and receptors form a quantum bound state, macro-temporal quantum coherence is generated and this correspond at the level of conscious experience a multi-verse state of "one-ness" and from the point of information processing a quantum computation like process [K47]. One could also see information molecules and receptors as representative of opposite molecular sexes. The resulting non-entropic mental image corresponds to sensory qualia of the neuron analogous to smells and tastes. In principle, each neurotransmitter gives to a distinct neuronal taste or smell. Also neuronal analogs of vision and hearing are possible. Micro-tubuli indeed give rise to infrared vision in the case of bacterial cells.

3. This picture is consistent with the interpretation of neurotransmitter induced experiences as kind of chemical qualia analogous to tastes and odors and giving rise to emotions at our level of self hierarchy.

Excitation and inhibition

Excitation and inhibition are seen as basic functions of neurotransmitters. More precisely, the attribute excitatory/inhibitory can be assigned with a given transmitter-receptor combination. Gardener metaphor states that brain is a gardener allowing particular plants, now mental images having neural firing patterns as neurophysiological correlates, to flourish. One could argue that this kind of selection is reasonable in order to use metabolic resources optimally. One must be however very cautious here. Paradoxically, the metabolism during synchronous firing does not seem to increase [**?**]. This finding has two mutually non-exclusive explanations.

a) Remote metabolism involving the generation of negative energy MEs received by glial cells serving as a storage of metabolic energy is involved.

b) Inhibition could require actually more energy than excitation: neural firing would occur spontaneously when the energy feed to the system is subcritical. At least for the inhibition caused by hyper-polarization this view might make sense. One can say that the gardener would actively prevent the growth of some plants. Inhibition would be censorship preventing a spontaneous generation of mental images in accordance with the vision of Huxley about brain as a filter which

prevents conscious experience rather than creates it. The hypothesis that bio-control is quite generally based on this principle is attractive since it is easier to prevent a complex process to occur spontaneously than to force a complex process to occur in a desired manner.

Option b) would explain several paradoxical looking findings about the correlation of inhibition with the level of self control. The amount of inhibition increases and the behavior becomes more controlled and "civilized" as one climbs up in the evolutionary tree being highest for humans. Inhibition is higher for adults than for children as is also the level of self control. Inhibition is dramatically reduced during the process of physical death. In all these cases the reduced inhibition would naturally correlate with the reduction of the metabolic feed. Inhibition is also reduced during several altered states of consciousness and these states of consciousness involve also a high level of relaxation.

If the reduced inhibition means a reduction of energy feed, a depletion of energy resources is an unavoidable outcome. This leads to a spontaneous generation of negative energy MEs by starving neurons making possible remote entanglement and remote metabolism. In particular, synchronous neural firing would involve also remote metabolism so that option a) is not excluded by b). The generation of episodal long term memories and various kinds of remote mental interactions would be an automatic side product. The memory feats of synesthetics indeed correlate with a dramatic reduction of metabolism in left cortex; various remote mental interactions are reported to occur during altered states of consciousness; and there are reports about the association of telepathy, precognition and poltergeist type phenomena with the physical death of a close relative or intimate friend.

On the other hand, if inhibition means heightened metabolic energy feed, it also reduces the need to generate negative energy MEs. The reduction of entanglement with the environment means among other things fewer shared mental images. Therefore the increase of inhibition would be a correlate for the increasing privacy of conscious experience. Ironically, the physical well-being would more or less unavoidably lead to the alienation and unhappiness suffered by so many members of post-modern society.

12.5.4 Negentropic Entanglement And The Role Of Neurotransmitters

Soon after starting to develop TGD inspired theory of consciousness, I somehow ended up to an email correspondence with Gene Johnson who insistently emailed me links to abstracts about neuroscience. I read the classic Bible about brain by Kandel *et al* [?] and tried to make sense of it in my own conceptual framework. This was of course hopeless task since I had only the notions of quantum jump and self. The feeling that something very simple -about which I do not and perhaps cannot ever have a slightest clue- must be behind this incredible complexity made the situation really frustrating. The deeper meaning of EEG, nerve pulse neurotransmitters, hormones- actually of entire brain chemistry and also biochemistry- remained a total mystery.

Development of ideas

After the required number of years however some concrete ideas began to emerge.

1. The notion of magnetic body with fractal onion-like structure meant a decisive step of progress. Also the hierarchy of Planck constants and dark matter as controller of visible matter in living systems emerged. The function of EEG as communication and control tool of magnetic body using biological body as a motor instrument and sensory receptor looked very natural. This led also to a proposal that there is an entire hierarchy of EEGs and their variants. After several trials a vision about nerve pulses as concomitants of quantum level communications emerged as also a vision about DNA as topological quantum computer based on the flux tubes connecting DNA nucleotides with the lipid layers of cell membrane emerged and providing a function for the intronic portions of genome as carriers of quantum computer programs [K2].

2. Also a vision about the biochemical role of dark matter evolved. In particular, phase transitions reducing Planck constant for a magnetic flux tube would induce its contraction and force biomolecules near to each other. This would explain the miracles of DNA replication,

translation, and transcription and quite generally the processes known as aggregation of proteins. The reconnection of magnetic flux tubes changing the topology of the biological Indra's net would be also a central mechanism.

3. The model of nerve pulse and the vision about living matter as a kind of dynamical Indra's net led to a first clear idea about the role of neural transmitters. Transmitters are classified to inhibitory or excitatory depending on whether they increase or reduce the magnitude of the membrane potential. This property is however a property of the receptor rather than that of the transmitter. The same transmitter can have both excitatory and inhibitory receptors although often either receptor type dominates. The proposal was that neural transmitters are associated with the ends of the links of the 4-dimensional web connecting neurons to each other. Neurotransmitter attaches to the plug defined by the receptor connecting the communication wire from presynaptic neuron to the flux tube leading to the passive portion of postsynpatic DNA strand acting as sensory receptor. This would make possible rapid communications to DNA. The corresponding active portion of DNA strand could then respond by generating an activity at the level of cell membrane. This conforms with the general idea that proteins represent only one particular outcome of the gene expression. This left open the question whether the excitatory-inhibitory dichotomy could have some deeper meaning.

4. Also it became clear the emotions and information are closely related and that peptides acting both as neurotransmitters and hormones are crucial for emotions [**?**]. I proposed that emotions are "entropic" qualia. Although I realized the importance of negentropic entanglement I did not have time or I was not able to realize how far reaching this notion actually is.

Is genome a fractal counterpart of brain?

Fractality replaces standard reductionism in TGD Universe. An old idea inspired by p-adic length scale hypothesis is that the binary structures associated with p-adic scales $L(k) \propto 2^{k/2}$ and $L(k+2)$ define a fractal hierarchy. Brain hemispheres would represent one example of this kind of pair, lipid layers ofe cell membrane second one, and DNA double strand third one. Just for fun one could assume that the structure and functions of brain hemispheres have fractal analogs at the level of DNA double strand and vice versa and look what kind of questions this inspires.

1. Could the identical structures of DNA strands correspond to the anatomical similarity of right and left brain and could the functional asymmetry of the strands correspond to the laterizalization of brain function? Could the genome act as the brain of cell? Could various brain areas have counterparts at the level of DNA? Could the hydrogen bonds between nucleotides serve as the counterpart of corpus callosum? Could the splitting of these bonds during transcription and replication correspond to what happens to a split brain patient?

2. Before continuing it must be made clear that the global identification of right-left dichotomy with holistic-reductionistic dichotomy is wrong. One can however consider its local variant with holism and reductionism assigned do the pairs of right and left brain areas. For instance, in contrast to the naïve rule the emotional right (left) brain (amygdala) would be reductionistic (holistic, negentropic) whereas the intellectual right (left) would be holistic (reductionistic, entropic). The practical reason to the division to the entropic and negentropic pieces could relate to the metabolism. The entropic regions could provide the binding energy as a usable energy to the positive energy negentropic entanglement. Good is not possible without Evil! There are no winners without losers! One must be however very cautios in making conclusions since second law might break down for dark matter.

Right brain is specialized in spatial thinking and left brain to verbal thinking and arithmetics: the geometry-algebra division of mathematics! Right brain is not so good in motor actions as left brain as any right-handed person knows. Right brain is however better in tactile sensing: right handed persons tend to use left hand for touching objects to get an idea about their shape. Also this can be understood in holistic-reductionistic picture.

3. Apart from reflex actions almost all activities of the body seem to be controlled to a high degree by brain. Could also the activitities of cell be regarded as motor actions of the genome

acting as the brain of cell receiving sensory imput from the cell membrane? Could one identify the analogs of sensory areas receiving information from cell membrane, processing, and sending it to the association areas? Could the analogs associative areas be identified as intronic portions of DNA performing topological quantum computations and communicating the outcome to the higher motor areas at the intronic portions of the of the complementary strand, wherefrom they would be communicated to the primary motor areas identifiable as the regions of DNA expressing themselves either chemically (RNA and proteins), as activities generated directly at the level of cell membrane, or electromagnetically? For instance, could neurotransmitter in the receptor generate the feed of sensory input to the genome inducing the change of the membrane potential as the counterpart of motor action. Could prokaryotes without introns be analogous to brain with only primary sensory and motor areas or to mere ladder-like nervous system?

One could argue that the analogy between DNA are brain fails because second DNA strand is completely passive whereas both brain hemispheres express themselves via motor actions. This is not the case! Both DNA strand has regions expressing themselves but the transcription takes place in opposite directions. Hence DNA strands have motor and sensory areas as also brain does, and the natural guess is that primary motor areas correspond to the areas expressing themselves in terms of RNA, proteins, and possibly also as actions at the level of cell membrane. Primary sensory areas would correspond to to regions complementary to the primary motor regions.

4. What right brain sings-left brain talks metaphor could mean in this picture? Pitch-rhythm dichotomy is more technical expression for this dichotomy. Function providing local data and its Fourier transform providing global data is more abstract representation for this dichotomy and Uncertainty Principle for momentum and position relates closely to these two representations of information. This dichotomy could reflect the presence of two different natural time scales and millisecond time scale for nerve pulses and.1 second time scale for moments of sensory experience are the natural candidates.

If so, this dichotomy could directly reflect the different time scales assignable to u and d type quarks (1 millisecond) and to electron (100 ms) and reduce to the level of elementary particle physics. This dichotomy would also have fractally scaled up variants made possible by the hierarchy of Planck constants. The analog of Fourier transform would be the negentropic un-entanglement of sub-CDs (assignable to quarks) to single mental image inside electron's CD. The analog of function itself would be a collection of sub-CDs representing separate unentangled mental images assignable to individual nerge pulses in millisecond time scale. Also the topological quantum computations assigned to the intronic portions correspond to different time scales due and reflect quark-lepton dichotomy. The quarks in question could be the quarks assigned to the ends of flux tubes in the model of DNA as topological quantum computer.

5. This raises some questions. Could the gene expressions of the two strands somehow reflect this dichotomy? For instance, could the flux tube structures assignable to the amino-acid sequences correspond to the millisecond and 100 ms scales assignable to quarks and electron have the property that also the functioning of these proteins is characterized by these typical time scales? According to [I63] the time scales of protein folding vary from.1 s to 10^3s. According to Wikipedia [I7] the typical time scale is 1 millisecond which suggests that the time scales correspond to two ranges beginning from ms and 100 ms respectively. There are also short proteins for which the folding takes place in microsecond time scales which might relate to the CD of proton.

What can one say about the function of neurotransmitters?

Can one say anything interesting about the function of neurotransmitters if one combines this highly speculative picture- which can be defended only by the belief on fractality as universal principle- with the idea that bound state and negentropic entanglement make possible the fusion of mental images.

1. Suppose that the fusion of neuronal mental images is required to build higher level mental images that we experience. Suppose that neuronal mental images involve DNA in an essential manner. Suppose that magnetic flux tubes serve as correlates for the entanglement so that the transmission of nerve pulse from pre-synaptic neuron to post-synaptic one creates a flux tube connection between neurons possibly extending to the genome of the post-synaptic neuron. The transmitter at the end of flux tube attached to the receptor acting as a plug would build this connection to some part of DNA specialized to receive particular kind of sensory data from a particular region of cell membrane with complementary strand activating as a response a motor function inducing gene expression at cell membrane level. Gene expression as build-up of proteins would not be necessary and is also too slow for neural activities.

2. Suppose that the entanglement between neurons generated in this process is always negentropic as the interpretation as the idea about neural correlate for a conscious association suggests. One could also ask whether the neurons could entangled entropically and whether the entropic-inhibitory association could make sense. This does not lead to anything interesting and entropic entanglement between neurons should be regarded as a pathological condition. Note that neuron-neuron entanglement would be naturally time-like and in this case only negentropic entanglement might be meaningful.

   (a) To gain some perspective consider the activation of cell in general by some external perturbation from the resting state to the active state (here I have learned a lot from email correspondence with Vladimir Mateev) In the resting state the proteins inside cell are passive -or rather, forced to be passive- as one might expect on basis of the general vision about homeostasis. The unfolded proteins and unfolded portions of the folded proteins are connected by hydrogen bonds to ordered water so that the folding occurring otherwise spontaneously is prevented. One can say that the cellular winter prevails. The situation is however nearly critical and if external perturbation occurs cell liberates metabolic energy melting the ice and spring comes. Also the outer surfaces of globular proteins are hydrogen bonded and when the ordered water melts, spontaneous melting of the protein takes place leading to a partial unfolding.

   The resulting folded proteins and partially unfolded globular proteins interact by forming aggregates and this activity would naturally involve $\hbar$ reducing phase transitions and flux tube reconnections. In TGD based model the mechanism of both folding and melting would be the liberation of metabolic energy destroying the hydrogen bonds and the energy for this comes from the ATP containing positive energy negentropic bond between O=s of phosphates.

   (b) Similar situation could prevail at the cell membrane. One can imagine that cell membrane is like a particle at the bottom of a small potential well. At the other side there is a deep well representing the generation of nerve pulse and at the other side a high wall corresponding to hyper-polarization requiring energy. Both polarization and hyper-polarization are prevented by the freezing of protein activities needed to induce them. The flux tubes connecting the presynaptic neuron and receptor and possibly genome are always negentropic and their formation can as such serve as the signal leading to the partial melting of the ordered water making possible to generate action leading to either de-polarization or hyper-polarization. The signal could be just the additional metabolic energy making it possible for these transitions to occur.

   (c) This picture does not require any communications from the receptor to the genome and in the simplest situation the resulting action could be seen as the analog of reflex action. These communications could of course be present and the negentropic entanglement could make it easier to induce de-polarization also now. Also the question whether excitatory-inhibitory dichotomy for the receptors has some deeper meaning apart from taking the neuron nearer to or farther from criticality for firing remains unanswered.

12.6   Relating The Model Of Nerve Pulse With The Micro-Tubular Level

The relationship of the presumed quantum dynamics of the cell interior to the nerve pulse is the basic topic of quantum consciousness theories. Micro-tubular conformational dynamics; gel-sol phase transition of the cytoplasmic water inducing the de-polymerization of the actin polymers; the parallelization of micro-tubuli possibly making possible a coherent generation of infrared em radiation; and Mg^{+2} and Ca^{+2} ions as controllers of polymer stability, are some of the most important pieces of the jigsaw. The hierarchical model of Alex Kaivarainen emphasizing these aspects provided crucial pieces of information [**?**] allowing to construct many-sheeted view about this process. The hierarchy of condensed matter excitations introduced by Kaivarainen corresponds in TGD framework to the hierarchy of space-time sheets whereas the molecular Bose-Einstein condensates of Kaivarainen correspond to BE condensates of various bosonic ions and Cooper pairs at various cold space-time sheets. The classical article of Nanopoulos summarizing basic facts and various ideas about micro-tubuli [**?**] has been a continual source of information and inspiration and is warmly recommended.

One important element are negative energy IR MEs having phase conjugate laser beams [D12] as physical counterparts. First of all, they make possible intentional action at the micro-tubular level: even the TGD based model of mRNA-protein translation involves intentional aspects. Negative energy MEs are crucial for the understanding of the macro-temporal quantum coherence and have inspired the notions of remote metabolism and quantum credit card. The notion also leads to what might be called seesaw mechanism of energy metabolism, and allows to understand how micro-tubular surfaces provide dynamical records for the cellular sol-gel transitions and thus define fundamental micro-tubular representation of declarative long term memories.

The vision about dark matter hierarchy brings in perhaps the most decisive new elements.

1. Dark matter hierarchy leads to the identification of big leaps of evolution in terms of the emergence of new levels of dark matter hierarchy. Magnetic bodies are the intentional agents in this picture and it is possible to understand the control of logistics and declarative memory as basic functions associated with micro-tubules.

2. Synchronous neuron firing involves parallelization of microtubules. This coherent action can be understood in terms of macroscopic quantum coherence realized in terms of super-genes and the more general notion of multi-neuron with neurons organized to linear structures analogous to the lines of text on the pages of book defined by magnetic flux sheets.

3. Ca^{+2} and Mg^{+2} ions are known to be important for the de-polymerization of microtubules and actin molecules occurring during nerve pulse. This conforms with the central role of the Bose-Einstein condensates of dark bosonic ions Ca^{+2} and Mg^{+2} and their exotically ionized counterparts in the generation of pulse in the proposed model, and more generally, in quantum bio-control based on charge entanglement between cell and magnetic body.

4. The ordered water associated with gel phase was earlier modelled in terms of dropping of protons to $k = 139$ space-time sheets. In the new framework this phase can be identified as a partially dark water. The response of cells to IR radiation is maximal at photon energy.1 eV. What makes bells ringing is that the model of high T_c conductivity based on dark matter hierarchy leads to the identification of the cell membrane as a Josephson junction generating ordinary IR photons with energy $2eV = .1$ eV at the membrane potential corresponding to threshold for nerve pulse generation kicking protons to $k = 139$ space-time sheet associated with ordered water.

   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. In the following only the "dropping" option is discussed.

This section was written much before the breakthrough induced by the model of DNA as TQC and the inspiration coming from the model of nerve pulse as acoustic soliton by Danish researchers [**?**]. Hence a lot is lacking and the contents of section are not necessarily completely consistent with the new vision. For instance, the phase transitions changing the value of $\hbar$ and TQC using 4-colored braids provide a general explanation for the selectivity of the catalytic action [K2]. I have however decided to leave the section as it is.

12.6.1   Dark Matter Hierarchy And Big Leaps In Evolution

Dark matter hierarchy leads to an amazingly concrete picture about evolutionary hierarchy allowing to identify the counterparts for concepts like mineral, plant, and animal kingdom that we learned during schooldays and ceased to take seriously as students of theoretical physics as we learned that other sciences are just taxonomy. Even more, a view about what distinguishes between prokaryotes, eukaryotes, animal cells, neurons, EEG, and even about what makes cultural evolution, becomes possible. This view is also very useful when one tries to understand the role of microtubules.

The appearance of CDs scaled up in size by $r = \hbar/\hbar_0$ and space-time sheets scaled up in size by $\sqrt{r}$ means the emergence of new levels of structure and it is natural to identify big leaps in evolution in terms of emergence of new larger matter carrying space-time sheet magnetic flux sheets and corresponding magnetic bodies. If magnetic flux quanta are scaled by r magnetic flux quantization conditions remain unaffected if magnetic field strengths scale down by $1/r$ so that the energies of cyclotron photons are not affected. The thickness of flux tubes can remain unchanged if the currents running at the boundaries of the flux quantum cancel the magnetic flux. As already found, this mechanism must be at work inside living organisms whereas in far away region flux quanta are scaled up in size.

The attractive hypothesis is that the leaps in evolution correspond to the emergence of dark variants of weak and possibly also color interactions in dark p-adic length scales which correspond to ordinary p-adic length scales characterized by Mersenne primes. These leaps would be quantum leaps but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by r as the new level of dark matter hierarchy emerges. The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

Certainly also other scalings of Planck constant than those summarized in tables are possible but these scalings are of primary interest. This intuition is supported by the observation that electron is completely exceptional in this framework. Electron's dark p-adic length scales corresponds to p-adic length scales $L(k)$, $k = 167, 169$, assignable to atomic and molecular physics and to the Gaussian Mersennes $M_{G,k} = (1 + i)^k - 1$, $k \in \{151, 157, 163, 167\}$, assignable to the length scale range between cell membrane thickness 10 nm and nucleus size 2.58 μm. The corresponding p-adic length scales, the number of which is 23, are excellent candidates for the scales of basic building bricks of living matter and vary from electron's p-adic length scale up to 1.25 m ($k = 167$ defining the largest Gaussian Mersenne in cell length scale range) and defining the size scale of human body. The corresponding p-adic time scales are also highly interesting and vary from.1 seconds for electron defining the fundamental biorhythm to 9.6×10^{14} years which is by 4-5 orders longer than the age of the observed Universe. For $k = 167$ the time scale is 1.1×10^{11} years and is by one order of magnitude longer than the age of the observed Universe estimated to be 1.37×10^{10} years [E1].

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a more detailed vision about big evolutionary leaps. Note that in the sequel only the general option is considered: the justification for this is that for this option electron appears as a dark particle for all length scales defined by Gaussian Mersennes as well as in atomic length scales. The basic vision in nutshell is that evolution means the emergence of dark weak and gluonic physics in both dark and ordinary length scales and that the size scales of the basic biostructures correspond to Mersenne primes and their Gaussian variants.

A sketch about basic steps in evolution

The vision about evolution depends on what one assumes about the initial state.

1. If one assumes that weak bosons with ordinary value of Planck constant were present in the beginning, evolution would mean a steady growth of k_d. Note that the hypothesis is $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. The problem is that small values of $k_d = k_1 - k_2$ correspond to the Gaussian Mersennes defining cellular length scales. If these exotic weak physics were present from the beginning, large parity breaking in cellular length scales would have been present all the time.

2. An alternative and perhaps more realistic view is that the evolution means the emergence of exotic weak physics corresponding almost vacuum extremals in increasingly longer length scales. A possible mechanism could have been the induction of exotic $\hbar_0$ variant of weak physics at the nearest Mersenne length scale k_{next} by the dark variant of weak physics at level k so that one would have $k_d = k_{next} - k$. The simplest induction sequence would have been $89 \to 107 \to 113 \to 127 \to 151 \to 157 \to 163 \to 167$ corresponding to $k_d \in \{18, 6, 14, 24, 6, 6, 4\}$. A possible interpretation of exotic $\hbar_0$ physics is in terms of almost vacuum extremals and non-standard value of Weinberg angle: also weak bosons of this physics would be light. This sequence defines the minimal values for k_d but also larger values of k_d are possible and would correspond to steps between neighbours which are not nearest ones.

The following sketch about the basic steps of evolution relies on the latter option.

1. Elementary particle level

Magnetic bodies with size scale defined by the sizes of CDs assignable to quarks and leptons and possibly also weak bosons (already now the size of big neuron emerges) corresponds to the lowest level of hierarchy with the sizes of the basic material structures corresponding to the Compton lengths of elementary particles. The fundamental bio-rhythms corresponding to frequencies 10, 160, and 1280 Hz appear already at this level in zero energy ontology which suggests that elementary particles play a central and hitherto unknown role in the functioning of living matter.

2. $89 \to 107$ step with $k_d = 18$

The first step would have been the emergence of $k_{eff} = 107$ weak bosons inducing $\hbar_0$ weak physics in $k = 107$ length scale characterizing also ordinary hadrons. This in turn would have led to the emergence of exotic nucleons possibly corresponding to almost vacuum extremals. The reduction of the model for the vertebrate genetic code to dark hadron physics [K114] is one of the most unexpected predictions of quantum TGD and assumes the existence of exotic- possibly dark- nucleons whose states with a given charge correspond to DNA, RNA, mRNA, and tRNA. The $\hbar_0$ variants of these nucleons would interact via weak bosons with hadronic mass scale. The exotic variants of the ordinary $k = 113$ nuclei would correspond to the nuclear strings consisting of exotic nucleons [K28, K114] and define nuclear counterparts for DNA sequences. Their dark counterparts could define counterparts of DNA sequences in atomic physics length scales. Therefore a justification for the previous observation that genetic code could be realized at the level of hadron physics and that chemical realization would be higher level realization finds justification. The anomalous properties of water could be also partly due to the presence of dark nucleons and the proposal was that the presence of exotic nuclei is involved with water memory [K42]. The possible existence of the analog of DNA-RNA transcription between ordinary DNA and its nuclear counterpart would have dramatic implications. For instance, one can imagine a mechanism of homeopathy based on this kind of transcription process which would also allow a modification of genome by using dark nuclei to communicate the DNA sequences through the cell membrane to the target nuclei.

3. $107 \to 113$ step with $k_d = 6$

The next step would have been the emergence of $k_{eff} = 113$ weak bosons inducing $\hbar_0$ weak physics in $k = 113$ length scale characterizing also ordinary hadrons. Exotic variants of the ordinary nuclei possibly corresponding to almost vacuum extremals could have emerged interacting weakly (or actually relatively strongly!) via the exchange of weak bosons with mass scale of order

100 MeV. Also dark variants of the exotic $k = 107$ nucleons could have have emerged and formed exotic nuclei of size scale $k = 119$.

4. $113 \rightarrow 127$ step with $k_d = 14$

At this step weak bosons in electron mass scale would have emerged. Whether these weak bosons could have induced large parity breakings in atomic and molecular length scales is not clear. Viruses, which do not yet possess cell membrane could correspond to this level of hierarchy.

5. $127 \rightarrow 151$ step with $k_d = 24$

This step would have been fundamental since weak bosons in cell membrane length scale would have appeared. Note that by $113 - 89 = 24$ this step also leads from $k = 89$ weak bosons to $k = 113$ weak bosons. The weak bosons assignal to $k = 151$ could correspond to the weak interactions associated with almost vacuum extremals and $sin^2(\theta_W) = .0295$ could correspond to the weak physics in question.

$k_d = 24$ step for $k = 113$ $\hbar_0$ weak bosons would have produced them in $k_{eff} = 137$ atomic length scale with $L(137) \simeq .78$ Angstrom This could have naturally led to large parity breaking effects and chiral selection.

Dark $k_{eff} = 151$ electrons appearing in the TGD inspired model of high T_c super-conductivity would have been a by-product of this step. Whether dark electrons could have transformed to light $\hbar_0$ electrons (of mass.25 keV) with a common mass scale of order 10^2 eV with exotic weak bosons is an interesting question. The model of high T_c super-conductivity predicts the presence of structures analogous to cell membrane. This would suggest that cell membranes emerged and chiral selection emerged at this step so that one could not distinguish the emergence of molecular life as a precedessor for the emergence of cell membrane like structures. This would conform with the fact that DNA molecules are stable only inside cell nucleus. Note that for $k_{eff} = 151$ electron's CD has time scale $2^{24} \times .1$ seconds -that is 19.419 days (day=24 hours).

The smallest nanobes [I5] appearing in rocks have size 20 nm and could have emerged at this step. The size of the viruses [I9] is between 10-300 nm covers the entire range of length scales assignable to Gaussian Mersennes, which suggests that smallest viruses could have emerged at this step. Also the smallest [I4] [I4], which by definition have size smaller than 300 nm could have appeared at this stage.

6. The remaining steps

The remaining steps $k = 151 \rightarrow 157 \rightarrow 163 \rightarrow 167$ could relate to the emergence of coiling structure DNA and other structures inside cell nucleus. $k = 167$ would correspond to $k_d = 167 - 89 = 68$ to be compared with the value $k_d = 47$ required by 5 Hz Josephson frequency for the neuronal membrane for -70 mV resting potential. Note that $k_d = 48$ (state 1-2 of deep sleep) corresponds to $k = 163$.

By their smallness also double and triple steps defined by $k_d = k_{i+n} - k_i$, $n > 1$, are expected to be probable. As a consequence, electrons can appear as dark electrons at all the Gaussian Mersenne levels. At these steps the dark electrons corresponding to primes $k_{eff} = 137, 139$ would appear. For $k = 137$ dark electron appears with CD time scale equal to 128 seconds- rather precisely two minutes. The model for EEG suggests that the exotic weak bosons appear in the scales $k_{eff} = 136, 137, 138$.

Further multisteps from the lower levels of hierarchy would give structures with size scales above the size of cell nucleus possibly assignable to organs and structural units of brain. The dark levels assignable to electron are expected to be of special interest. It is encouraging that the longest scale assignable to electron in this manner corresponds to $k = 205$ and length scale of 1.28 m defining body size. As a consequence dark electrons are predicted at levels $k = 137, 139, 141, 143, 145, 147$ coming as octaves.

Prokaryotic cells (bacteria, archea) without cell nucleus for which cell membrane is responsible for metabolic functions and genome is scattered around the cell could have emerged at this step. This would mean that the emergence of the cell membrane thickness as a fundamental scale is not enough: also the size scale of membrane must appear as p-adic length scale. The sizes of most prokaryotes vary between 1 μm and 10 μm: the lower bound would require $k = 163$. There also prokaryotes with sizes between.2 μm ($k = 157$ corresponds to.08 μm) and 750 μm. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes

in this framework. The sizes of eukaryote cells are above 10 μm and the fact that multicellular organisms are in question strongly suggests that the higher multisteps giving rise to weak bosons and dark electrons in length scales above $L(167)$ are responsible for multi-cellular structures.

This scenario leaves a lot of questions unanswered. In particular, one should understand in more detail the weak physics at various length scales as well as various exotic nuclear physics defined by dark nucleons and dark variants of nuclei.

Division of the evolution to that of biological body and magnetic body

Electron's Mersenne prime M_{127} is the highest Mersenne prime, which does not correspond to a completely super-astrophysical p-adic length scale. In the case of Gaussian Mersennes $M_{G,k}$ one has besides those defined by k in $\{113, 151, 157, 163, 167, \}$ also the ones defined by k in $\{239, 241, 283, 353, 367, 379, 457, 997\}$ [A2]. The appropriately extended model for evolution allows to distinguish between three kinds of values of k_{eff}.

1. The values of k_{eff} for which electron can appear as dark particle and thus satisfying $k_{eff} \leq 205$ (Table 5). These levels would correspond to structures with size below 1.25 m defined roughly by human body size and it is natural to assign the evolution of super-nuclear structures to the levels $167 < k_{eff} \leq 205$.

2. The values of of k_{eff} for which dark gauge bosons are possible in the model. This gives the condition $k_{eff} \leq 235$. These levels correspond to structures in the range 1.25 m-40 km. The identification as parts of the magnetic body can be considered.

3. The values of k_{eff} obtained by adding to the system also the Gaussian Mersenne pair $k \in \{239, 241\}$ allowing also the dark electrons. The lower size scale for these structures is 640 km.

4. The higher levels corresponding to k_{eff} in $\{283, 353, 367, ...\}$. The lower size scale for these structures is 3 AU (AU is the distance from Earth to Sun).

$k_{eff} > 205$ levels would correspond to the emergence of structures having typically size larger than that of the biological body and not directly visible as biological evolution. This evolution could be hidden neuronal evolution meaning the emergence of extremely low Josephson frequencies of the neurons modulating higher frequency patterns and being also responsible for the communication of long term memories.

Biological evolution

In principle the proposed model allowing multisteps between hierarchy levels defined by Mersenne primes and their Gaussian counterparts could explain the size scales of the basic structures below the size scale 1.25 m identified in terms of the $k_{eff} \leq 205$ levels of the hierarchy.

1. The emergence of cells having organelles

The appearance of the structures with $k_{eff} > 167$ (possibly idetifiable as magnetic body parts) should correlate with the emergence of simple eukaryotic cells and organisms, in particular plant cells for which size is larger than 10 μm, which could correspond to $k_{eff} = 171$ for electron and dark variants of weak gauge bosons. $k_{eff} = 177$ is the next dark electron level and corresponds to 80 μm scale. It seems natural to assume that these dark weak bosons do not transform to their $\hbar_0$ counterparts at these space-time sheets.

Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles would live in symbiosis by topologically condensing to $k_{eff} \geq 171$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell before becoming mature to replicate. A possible

interpretation is that they are also life forms and that magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

Cytoskeleton would act as a counterpart of a central nervous system besides being responsible for various logistic functions such as transfer of proteins along microtobuli. Centrioles give also rise to basal bodies and corresponding cilia/flagella used by simple cells to move or control movement of air or liquid past them. Centriole pair would be also used by the magnetic body to control cell division.

The logistic functions are the most obvious functions of microtubules. Magnetic body would control cell membrane via signals sent through the cell nucleus and communicated to the cell membrane along microtobuli. Basal bodies below the cell membrane and corresponding cilia/flagella would serve as motor organs making possible cell motion. Tubulin conformations representing bits would allow microtubule surface to represent the instructions of the magnetic body communicated via via cell nucleus to various proteins moving along the microtubular surface so that they could perform their functions.

TGD based view about long memory recall as communication with geometric past allows also the realization of cellular declarative memories in terms of the conformational patterns. Memory recall corresponds to a communication with geometric past using phase conjugate bosons with negative energies reflected back as positive energy bosons and thus representing an "image" of microtubular conformation just like ordinary reflected light represents ordinary physical object. There would be no need for a static memory storage which in TGD framework would mean taking again and again a new copy of the same file.

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on Josephson radiation consisting of photons, weak bosons, and gluons defining the counterpart of EEG associated with the level of the dark matter hierarchy in question.

3. The emergence of organs and animals

The emergence of magnetic bodies with k_{eff} in the range $(177, 181, 183, 187, 189, 195, 201, 205)$ allowing both dark electron and weak bosons could accompany the emergence of multicellular animals. Magnetic body at this level could give rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtobuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

k_{eff} in the range $(187, 189, 195, 201, 205)$ allowing dark electrons and weak bosons gives size scales $(.25, .5, 4, 32, 128)$ cm, which could correspond to the scales of basic units of central nervous system. What would be of special interest would be the possibility of charged entanglement based on classical W fields in macroscopic length scales. The emergence of the new level means also the integration of axonal microtobuli to "text lines" at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

The evolution of magnetic body

For mammals with body size below 1.25 m the levels $k_{eff} > 205$ cannot correspond to biological body and the identification in terms of magnetic body is suggestive. The identification of EEG in terms of Josephson frequencies suggests the assignment of EEG with these levels.

1. The emergence of EEG

EEG in the standard sense of the word is possessed only by vertebrates and one should

understand why this is the case. The value of Josephson frequency equal to 5 Hz requires only $k_d = 47$ so that something else must be involved. A possible explanation in the framework of the proposed model comes from the following observations.

1. Besides the maximal p-adic scale $k = 205$ for which electron and weak bosons appears as dark variants the model allows also levels at which only gauge bosons appear as dark particles. From Table 9 one finds that levels $k \in \{207, 211, 213, 217, 219, 221, 223, 225, 229, 235\}$ are allowed. Could it be that these levels and possibly some highest levels containing both electrons and gauge bosons as dark particles are a prerequisite for EEG as we define it. Its variants at higher frequency scales would be present also for invertebrates. The lowest Josephson frequency coded by the largest value of $\hbar$ in the cell membrane system determins the Josephson frequency.

2. The membrane potentials -55 mV (criticality against firing) correspond to ionic Josephson energies somewhat above 2 eV energy ((2.20, 2.74, 3.07, 2.31) eV, see **Table 12.4**). For 2 eV the wavelength 620 nm is near to $L(163) = 640$ nm. Therefore the Josephson energies of ions can correspond to the p-adic length scale $k = 163$ if one assumes that a given p-adic mass scale corresponds to masses half octave above the p-adic mass scale so that the opposite would hold true at space-time level by Uncertainty Principle. Josephson frequencies $f_J \in \{5, 10, 20, 40, 80, 160\}$ Hz correspond to $k_d \in \{47, 46, 45, 44, 43, 42\}$ giving $k_{eff} \in \{210, 209, 208, 207, 206, 205\}$.

   (a) Cerebellar resonance frequency 160 Hz would correspond to $k = 205$ -the highest level for for which model allows dark electrons (also 200 Hz resonance frequency can be understood since several ions are involved and membrane potential can vary).

   (b) The 80 Hz resonance frequency of retina would correspond to $k_{eff} = 206$ -for this level dark electrons would not be present anymore.

   (c) 40 Hz thalamocortical frequency would correspond to $k_{eff} = 207$.

   (d) For EKG frequencies are EEG frequencies below 20 Hz 12.5 and heart beat corresponds to .6-1.2 second cycle (the average.8 s corresponds to $k_{eff} = 212$).

3. Even values of k_{eff} are not predicted by the model based on Mersenne primes allowing only odd values of k_{eff} so that the model does not seem to be the whole truth. The conclusion which however suggests itself strongly is that EEG and its variants identified as something in the range 1-100 Hz, are associated with the levels in at which only dark weak bosons are possible in the proposed model. Note that the size scales involved with EEG would be above the size scale of human body so that we would have some kind of continuation of the biological body to be distinguished from the magnetic body. The time scales assignable to the dark CDs would be huge: for instance, $k = 205$ would correspond to $T = 2^{42} \times .1$s making about 1395 years for electron.

   2. Does magnetic body correspond to the space-time sheets carrying dark weak bosons?

   The layers of the magnetic body relevant for EEG have have size of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and the basic building blocks of our sensory experience corresponds to a fundamental period of.1 seconds. This scale appears already at $\hbar_0$ level for electron CD. The natural question concerns the relationship of the magnetic body to the $k > 205$ space-time sheets carrying only gauge bosons in the model and having size scale larger than that of biological body. Do they correspond to an extension of biological body or should they be regarded as parts of the magnetic body? The following observations suggest that they could correspond to layers of the magnetic body responsible for the fractal variant of EEG.

1. The primary p-adic time scales (Compton times) $T(239)$ and $T(241)$ correspond to frequencies, which are $2^{\pm 1/2}$ kHz. The geometric average $k = 240$ corresponds to kHz frequency. Is the appearance of kHz scale a mere accident or do the frequencies assignable to the quark CDs correspond to Compton times $\propto \sqrt{2^{k_{eff}/2}}$?

k_d	f_1/Hz	f_2/Hz	f_3/Hz
0	707	1000	1412
4	177	250	354
6	89	1250	177
10	22.1	31.3	44.2
12	11.1	15.6	22.1
14	5.5	7.8	11.1
16	2.8	3.9	5.5
18	1.4	2.0	2.8
20	0.7	1.0	1.4
24	0.2	0.2	0.3

Table 12.4: The Compton frequencies obtained by scaling $2^{k_d/2}$ from the basic triplet $k_{eff} = (239, 240, 241)$. The values of k_d correspond to those predicted by the model based on Mersenne primes.

2. One can apply scalings by 2^{k_d} to the triplet $(239, 240, 241)$ to get a triplet $(239 + k_d, 240 + k_d, 241 + k_d)$. The results are summarized in **Table 12.4**. Clearly the frequencies in question cover also the EEG range. Note that these frequencies scale as $\sqrt{1/r}$ whereas Josephson frequencies scale as $1/r$.

Also ZEG and WEG would appear but in much shorter scales dictated by k_{eff} and might accompany EEG. Somehow it seems that the effective masslessness of weak bosons below given scale is highly relevant for life. One can of course ask whether some larger Gaussian Mersenne could change the situation. There is a large gap in the distribution of Gaussian Mersennes after $k = 167$ and the next ones correspond to $M_{G,k}$, with k in $(239, 241, 283, 353, 367, 379, 457, 997)$ [A2]. The twin pair $k = (239, 241)$ corresponds to a length scales $(1.6, 3.2) \times 10^2$ km and the minimum value for k_d are $(72, 74)$ ($167 \rightarrow (239, 241)$ transition).

3. Long term memory and ultralow Josephson frequencies

What determines the time scale associated with long term memory is a crucial question if one really wants to understand the basic aspects of consciousness.

1. Does the time scale correspond to the size scale of CD assignable to electron scaled by $r = \hbar/\hbar_0$? In this case relatively small values of r would be enough and $r = 2^{47}$ would give time scale of 10^{13} s for for electron's CD, which is about 3×10^5 years. This does not make sense.

2. Does Josephson frequency define the relevant time scale? In this case the long term memory would require the analog of EEG in the time scale of memory span. $k_{eff} = 205$ would give 6 ms time scale for memory from the assignment of $k_{eff} = 163$ to the Josephson photons at V=-50 mV implying $k_d = 42$. Minute scale would require $k_{eff} = 217$. The highest level $k_{eff} = 235$ allowed by the model involving only Gaussian Mersennes with $k \leq 167$ would correspond to a time scale of 77.67 days (day is 24 hours). For Gaussian Mersennes defined by $k_{eff} = (239, 241)$ the time scales become about $(41.4, 82.8)$ months (3.4 and 6.8 years). These scales should also define important biorhythms. The claimed 7 years rhythm of human life could relate to the latter rhythm: note that the precise value of the period depends on the membrane potential and thus varies. The presence of the scaled up variants of the by $k_d \leq 78$ allows longer time spans of long term memory and the scaling defined by $k_d = 167 - 163 = 4$ scales up the span of long term memories to $(54.4, 108.8)$ years.

4. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the nucleotides involved. The development of speech faculty is certainly a necessary prerequisite for this break-

through. Already EEG seems to correspond to dark layers of biological body larger than biological body so that one can cask whether the weak bosons and dark electrons in the length scales $k = 239, 241, 283, 353, 367, ...$ could be relevant for the collective aspect of consciousness and cultural evolution. Maybe the size scales $(175, 330)$ km and their scaled up variants by $k_d \leq 78$ might have something to do with the spatial scale of some typical social structure (not city: the area of New York is only 790 km^2).

12.6.2 Some TGD Inspired New Ideas About Biochemistry

TGD provides several new physics concepts whose role in biochemistry is now relatively well understood thanks to the insights provided by the construction of the model of pre-biotic evolution [**?**]. Hence there are hopes of understanding the basic principles of cellular control at macromolecular level, and to apply these principles to understand what happens during nerve pulse in the interior of neuron. It is not possible to overestimate the importance of the fact that p-adic length scale hypothesis makes the model quantitative and reduces the number of alternatives dramatically.

Increments of zero point kinetic energies as universal metabolic currencies

The protons and also various other ions and possibly even electrons liberate their zero point kinetic energy while dropping to larger space-time sheets. This process and its reversal define metabolism as a universal process present already during the pre-biotic evolution rather than as an outcome of a long molecular evolution [**?**]. ATP-ADP transformation, polymerization by dehydration, and its reversal are key examples of the many-sheeted dynamics involving the dropping of protons from $k = 137$ space-time sheet liberating about.4-.5 eV of zero point kinetic energy and the reversal of this process. In TGD framework metabolism generalizes to a fractal metabolism involving a large number of metabolic currencies.

Negative energy MEs make possible remote metabolism realizing what might called quantum credit card. This makes energetic economy extremely flexible. F-actin polymerization [**?**] is an interesting application of this notion.

1. Each G-actin unit of F-actin is stabilized by Ca^{+2} ion and contains one ATP molecule. The polymerization of G-actin molecule is accompanied by an ATP-ADP transformation involving the dropping of a proton to a larger space-time sheet.

2. The fact that F-actin polymerization does not require energy [**?**] suggests that the zero point kinetic energy liberated in this manner is used to kick one proton to an atomic space-time sheet in G-actin molecule needed in dehydration inducing the polymerization.

3. This is achieved if the G-actin molecule emits a .4−.5 eV negative energy photon inducing the hopping of proton to an atomic space-time sheet associated with G-actin. The negative energy photon is received by the ATP molecule and induces the dropping of proton from atomic space-time sheet associated with the ATP molecule. This energetic seesaw could be controlled by a precisely targeted intentional action of the G-actin molecule by the generation of p-adic ME transformed then to negative energy ME. The seesaw mechanism can be generalized to a mechanism controlling the occurrence of sol-gel transitions.

A natural guess is that the emergence of larger space-time sheet with sizes characterized by p-adic length scales is a correlate for the evolution of more refined control and information processing structures utilizing smaller energy currencies. The situation is essentially quantal: the longer the length scale, the smaller the quantum of the metabolic energy. Micro-tubuli and other intracellular organelles represent excellent candidates for this kind of higher level metabolism refining the standard metabolism based on.4-.5 eV energy currency.

Since negative energy MEs with energies above thermal energy scale cannot induce transitions to lower energy states, a good guess is that negative energy MEs corresponding to metabolic currencies above the thermal energy $T_{room} \sim .03$ eV can be utilized for entanglement purposes. This is only a rough rule of thumb since the energy spectrum of systems at a given space-time sheet is expected to have an energy gap. Therefore negative energy MEs, even those below the ELF frequency range, are expected to be important.

Allowing n-ary p-adic length scales, this would mean in the case of hydrogen atom the upper upper bound $L(3, 47)\backslash = "L(141) = 2L(139)$ for the p-adic length scales in the hierarchy of water clusters. For electron the upper bound is cell membrane thickness $L(151) \simeq 10$ nm, which corresponds to the effective axonal electronic super-conductivity with the metabolic currency $.025 - .03$ eV. Interestingly, the water at room temperature contains flickering structures of size of order 20-30 nm with lifetime of order.1 ns [D46]. MEs at energy $\simeq .03$ eV could stabilize these structures by kicking the dropped Cooper pairs back to k=151 space-time sheets. One can also ask whether micro-wave MEs at GHz frequency, perhaps generated in the rotational transitions of water molecules, modulate the generation of .03 eV MEs and are thus responsible for the flickering.

Liquid crystal phase of water as a stabilizer of biopolymers

The second key element is the understanding of the role of the liquid [F12] [D4] water in the stabilization of various bio-polymers. The reason is that the water molecules making possible de-polymerization by hydration (also other means, say by the addition of heavy water or the increase of salt concentration, of reducing water activity have a stabilizing effect) are frozen to the liquid crystal. Thus the control at the level of bio-polymers could reduce to the control of whether cellular water is in sol or gel phase and to the understanding of what sol-gel difference means in the many-sheeted space-time.

Local gel-sol transitions could also provide a fundamental mechanism of cellular locomotion applied by, say, amoebae. Quite generally, various conformational changes needed in the cellular control are made possible by a local melting of the gel to sol followed by the conformational change in turn followed by a local sol-gel transition stabilizing the resulting conformation. The technological counterpart of this process is welding. The ME-controlled local melting and solidification of metals might in future technology make possible machines changing their structure routinely.

Local sol-gel transitions could also make possible the control of the conformations of the tubulin dimers expected to be sensitive to the di-electric constant of the water between the alpha and beta tubulin. This would mean that sol-gel phase transition and its reversal could define the bit of the declarative long term memory. Em MEs inducing gel-sol phase transition could provide a precisely targeted control of this kind. This would mean that coherent BE condensed photons associated with MEs could induce the sol-gel phase transition.

What distinguishes between sol and gel phases?

Sol-gel transition is crucial for the polymerization of actin molecules and micro-tubuli, and this dynamics probably involves something more refined than the molecular $k = 137$ metabolism. The dropping of protons/hydrogen atoms or of protonic Cooper pairs from $k = 139$ space-time sheet to larger space-time sheets is thus a unique candidate for what is involved with sol-gel transition.

The liberated zero point kinetic energy would be.1 eV for the dropping of proton or hydrogen atom (if.4 eV is the fundamental metabolic quantum whose value varies roughly in the range.4-.5 eV). For protonic Cooper pairs the energy would be.05 eV. According to the findings of Albrecht-Buehler [I38], the response of cells to IR radiation at.1 eV photon energy is maximal.

The presence of protonic Bose-Einstein condensate at $k = 139$ space-time sheet might thus distinguish between the liquid-crystalline gel phase from sol phase. The particles of this effectively 2-dimensional liquid would be loosely bound tubular structures having a radius of about $L(139)$ and the BE condensate of the dropped proton would bind the water molecules to form this structure. Ordinary water would result when protons at $k = 139$ space-time sheet drop to larger space-time sheets. $k = 139$ space-time sheets would be also associated with small sized water clusters.

This phase could be interpreted in terms of the partially dark water whose existence is suggested by the empirical finding that the chemical formula of water seems to be $H_{1.5}O$ in atto-second scale in the sense that neutron diffraction and electron scattering see only 1.5 protons per oxygen molecule [D60, D58, D70, D36]. As proposed in [K36], every fourth proton would be in dark phase, the lowest dark matter phase and protons would form string like structure which could be regarded as scaled up nuclei consisting of protons (also ordinary nuclei correspond to nuclear strings in TGD framework and exotic $k = 127$ quarks play a key role in the model [K97]).

Attosecond suggests itself as the scale for the average time T_d spent by proton in dark phase in this case. In ordered water the lifetime of this phase might be considerably longer. If a dark

variant of $k = 139$ space-time sheet is in question, T_d is scaled up by $r = \hbar/\hbar_0$. Zero point kinetic energy and the energy of photons would remain invariant, which makes possible quantum coherent control in multi-neuron length scale.

IR radiation as a stabilizer of gel phase?

The model for the effective electronic super-conductivity generalizes to the case protonic Cooper pairs and ionic Bose Einstein condensates, and allows to develop a more precise picture. At the room temperature the thermal photons have energy lower than the zero point kinetic energy .1 eV so that the BE condensate can be maintained only by feeding IR photons kicking the hydrogen atoms back to $k = 139$ space-time sheet with a high enough rate. Therefore the stabilization of the gel phase requires an expenditure of metabolic energy. The simplest view is that in the ground state the entire interior of the cell is in gel phase so that the cell interior would have tonus analogous to muscular tonus.

By stopping the feed of the energy by IR photons to a particular region of cell, gel-sol transition with its various outcomes would occur spontaneously. A faster and energetically more economic manner to achieve the same outcome is to generate negative energy IR photons which induce the dropping of the hydrogen atoms from $k = 139$ space-time sheets. This mechanism also guarantees the stability of polymers by making hydration impossible. A more clumsy manner to guarantee this is to feed protons back to $k = 137$ space-time sheet where they induce dehydration: this process would probably cost much more energy.

Note that the gel-sol transition of the peripheral cytoskeleton assumed to occur during nerve pulse would rely on different different mechanism. Ca^{+2} ions act as cross links between actin molecules and the lengthening of the cytoskeleton-membrane flux tubes in $\hbar$ increasing phase transition makes possible the flow of dark monovalent ions from cell exterior to peripheral cytoskeleton and induces gel-sol phase transition. This phase transition is initiated with the voltage over membrane is reduced to very small value inducing quantum criticality. The proposal is that dark ionic currents from microtubules to axonal membrane induces this reduction.

One can of course ask whether the mere influx of monovalent ions is enough to induce the gel-sol phase transition in the required millisecond time scale. The reduction of cell potential to about .05 V, quite near to the value inducing action potential, implies that the photons of Josephson radiation have energy .05 eV. At this energy a resonant absorption of phase conjugate IR photons by the peripheral cytoskeleton inducing in turn the dropping protons to larger space-time sheet could induce the gel-sol transition.

Cell membrane Josephson junction as a generator IR coherent light

What is then the mechanism generating IR MEs acting as space-time correlates for coherent IR photons? The crucial observation is that the Josephson energy $E_J = ZeV$ for $Z = 2$ for cell membrane Josephson junction is .1 eV at threshold $V = 50$ mV for nerve pulse generation. The value of the metabolic energy quantum varies in certain range and the value .13 eV for the resting potential 65 mV would correspond to .052 eV metabolic quantum. Hence Josephson radiation could take care of kicking protons back to $k = 139$ space-time sheet thus stabilizing gel phase above the threshold for nerve pulse generation. The IR photons generated by Josephson current tend to propagate parallel to the axon and axon could act as a waveguide. When nerve pulse is generated at axonal hillock the frequencies of Josephson radiation are reduced below the threshold allowing stability of gel phase in region near axonal hillock and gel-sol transition should occur.

During nerve pulse the Josephson frequency varies in a wide range and has also negative values during the period when membrane voltage is positive (below 35 meV). A possible interpretation is that a phase conjugate IR radiation with energies $|E| < .07$ eV is generated. These photons could draw protons to large space-time sheet but with kinetic energy $E_0 - E$ rather than at rest.

The scaled up variants of IR photons at higher levels of dark matter hierarchy de-cohering into ordinary IR photons could make possible coherent quantum control in length scales given by $\lambda^n \times \lambda_{IR}$. For instance, EEG photons with frequency of about 5 Hz would correspond to the large $\hbar$ variants of IR photons with the same energy.

What happens in gel-sol phase transition?

The minimal model for the gel-sol transition could be following. When the membrane potential falls below the threshold value, Josephson radiation does not take anymore care of the stability of gel phase in the zone in the radiation zone directed parallel to the axon and gel-sol phase transition is generated in cellular water. The gel-sol transition occurs also at the level of micro-tubules and de-stabilizes them unless they take care of themselves by generating negative energy IR radiation received by cellular water. This might quite well occur.

How Ca^{+2} ions are involved with gel-sol phase transition?

Besides IR MEs also Ca^{+2} ions are involved with the gel-sol transition and if these ions act as cross links between proteins in gel, their role can be understood. Ca^{+2} waves are indeed known to be a fundamental cellular control mechanism. Ca^{+2} ions are known to induce a de-polymerization of micro-tubules even in micro-molar concentrations whereas Mg^{+2} ions having much smaller ionic radius are known to favor the polymerization of the actin molecules [**?**]. Ca^{+2} ions which are more abundant in the cell exterior have a large ionic radius of order .099 nm whereas Mg^{+2} ions, which are abundant in the cell interior, have much smaller ionic radius. This supports the view that these ions have dual roles in cellular control.

As positive ions both Ca^{+2} and Mg^{+2} ions tend to increase the probability of the dropping of protons from the atomic $k = 139$ space-time sheets by repelling the protons from $k = 139$ space-time sheets to larger space-time sheets. This could mean gel-sol phase transition and the transformation of ordered water to ordinary water and the increase in the rate of de-polymerization by hydration. On the other hand, both Ca^{+2} and Mg^{+2} tend to bind with themselves water molecules which lowers de-polymerization rate. For Mg^{+2} with a small ionic radius the latter tendency wins: one can also say that Mg^{+2} is too small to act as a seed for de-polymerization.

Bose-Einstein condensates of bosonic ions are key element of the proposed quantum control mechanism involving charge entanglement induced by W MEs connecting magnetic body and cell interior or exterior. The question is whether de-polymerization involves the charge entanglement of Ca^{+2} and Mg^{+2} ions. One could argue whether the low amount of Ca^{+2} (Mg^{+2}) in cell interior (exterior) actually means that most of Ca^{+2} (Mg^{+2}) ions are in dark phase in cell interior (exterior). If so then at least sol-gel phase transition would be initiated by Josephson radiation and only at the later stages as Ca^{+2} rush into neuronal interior Ca^{+2} take the lead.

12.6.3 Nerve Pulses And Microtubules

As an application of above general view one can consider a model for what might happen during the nerve pulse inside axon and neuronal soma (this time interval can be as long as.5 seconds). The known pieces of information [**?**] indeed fit nicely with the above general principles and one ends up with the following scenario. Note again that this scenario has not been updated to correspond to the most recent view about nerve pulse.

Propagating sol-gel transitions as representations of declarative memories

The propagation of nerve pulse along axon means a propagation of gel-sol-gel phase transition along microtubule. Declarative long term memories could correspond to the temporal sequences of nerve pulses represented as propagating gel-sol-gel phase transitions. The representation of memories would be rather rough as compared to the capacity of microtubular conformations to represent bits: for a conduction velocity $v = 10$ m/s and duration of pulse about 1 ms single pulse would correspond to an axonal length of 10^{-5} meters meaning that 10^3 conformational bits would lumped to single bit

What happens inside neuron soma as nerve pulse is generated?

Consider first what could happen inside neuronal soma as nerve pulse is generated.

1. The positive energy Josephson radiation at IR frequency generated by cell membrane Josephson junction ceases temporarily and induces gel-sol transition in cellular water. Ca^{+2} ions

flowing into the neuronal interior favor further the de-polymerization of actin molecules. The micro-tubules of cytoskeleton receive the stabilizing IR radiation still from parts of neuronal membrane other than the throat of axon. They can also take care of themselves by sending phase conjugate IR radiation received by cellular ordered water.

2. The hydration of actin molecules in the vicinity of axonal hillock means that the activity of the water is reduced inside cell and water molecules from the cell exterior rush to the cell interior. The resulting swelling of the cell tears the positively charged ends of the micro-tubuli from the cell membrane. The micro-tubuli are now free to change their conformations and the micro-tubuli associated with different cells can arrange themselves in parallel configurations temporarily. Therefore they could act as quantum antennas generating coherent IR light needed to re-establish the gel phase very effectively: in an ideal case the power radiated is proportional to N^2, N the number of synchronously firing neurons. Also the return of membrane potential to the resting value brings back the IR radiation stabilizing the gel phase.

3. Gel phase is re-generated. Actin molecules re-polymerize and micro-tubuli stick again to the cell membrane. Synaptic contacts and the distribution of the ionic channels in neuronal membrane are re-structured in the process and this means that learning occurs in the sense that cell begins to respond slightly differently to neuronal inputs. This does not correspond to conscious long term memories, which are represented as temporal conformational patterns of tubulin dimers. These memories are in the geometric past, and can change, and are re-experienced by sharing of mental images or communicating the memories classically as field patterns associated with MEs using memetic code.

4. Tubulin dimers are electrets and can be regarded as miniature capacitor plates containing 18 Ca^{+2} ions at the other plate and 18 electrons at the other plate [**?**, **?**]. The average increments of WCW zero modes in the quantum jump sequence giving rise to the change of the conformation defines a two-valued geometric quale characterizing single bit of the long term memory. In [K66] a micro-tubular spatial cognitive code based on 13×13 bits is discussed. Temporal pattern extends this code to $13 \times 13 \times 126$ bit code.

Could micro-tubule-axon system perform topological quantum computation?

The proposed picture is consistent with the model of DNA as a topological quantum computer [K2] and with the idea that also micro-tubules could be involved with TQC. The model of DNA as TQC in its basic form assumes that DNA is connected to the nuclear membrane and cell membranes associated with the cell body by magnetic flux tubes such that each nucleotide is connected to single lipid. Tqc programs are coded to the temporal braiding patterns of lipids. This requires that lipid layer is liquid crystal and thus below the critical temperature. The flux tube connecting DNA to inner lipid layer and that beginning from outer lipid layer can form single flux tube or be split. If they form single flux tube braiding and TQC are not possible. During TQC the braid strands going through cell membrane are split and the dance of lipids induced by water flow defining time like braiding (hydrophilic lipid ends are anchored to the cellular water) induces braiding of the magnetic flux tubes which write the TQC program to memory. Furthermore, the lifetimes of flux tubes in the connected state must be short enough to prevent the generation of a nerve pulse. This is the case if the temperature is sufficiently below the critical temperature. The ionic supra currents are identifiable as the observed quantal non-dissipative currents flowing through the cell membrane when TQC is not on.

Centrioles have their own genetic code realized in terms of RNA and they play key role during gene replication when DNA is out of the game. This encourages to think that micro-tubules make possible an independent TQC like process. The question is how micro-tubule-axon system could perform TQC assuming that the recent picture about DNA as TQC [K2] is roughly correct. The assumptions of the model relevant for the recent situation are following.

1. Flux tubes consists of pieces between standard plugs represented by hydrogen bond acceptors ($O =$, aromatic rings, ...). For instance, XYP molecules, $X = A, T, C, G$, $Y = M, D, T$ would represent standard plugs and that the transformation $XTP \rightarrow XDP + P_i$ represents

the splitting of the flux tube and thus of braid strand. The XMPs associated with DNA would represent the ends of the braid strands. The formation of hydrogen bond between water molecule and $O =$ associated with phosphates at the hydrophilic ends of phospholipids would initiate TQC [K2].

2. In the model for protein folding [K5] free amino-acid corresponds to a codon XYZ in the sense of wobble base pairing meaning that the third nucleotide corresponds to a quantum superposition of colors of nucleotides coding for the same amino-acid. Hydrogen bonds correspond flux tubes also and hydrogen bonds between $N - H$ and $O =$ groups in alpha helices and beta sheets mean a shortcut making it impossible to continue the flux tube from $O =$ further. Only the continuation of the flux tube through non-hydrogen bonded $O =$ acting as a plug is possible. $Y = Z$ rule holds true for the $O = -N - H$ hydrogen bonds and defines folding code. Inside proteins amino-acids correspond to code YZ part of the codon XYZ and inside alpha helices and beta sheets the flux tubes from DNA would end to amino-acids and for them one could have only braiding between DNA and tubulins. Only in the case of non-hydrogen bonded amino-acids the flux tube connection from DNA could continue to the lipid layer and only in this case one could have the generalization of DNA TQC with flux tubes connecting DNA via tubulins to the axonal lipid layer.

Taking this picture as a starting point one can consider several options. For two first options tubulins are basic units. For the third one DNA nucleotides and amino-acids would have this role.

Option I: Tubulins could be connected to the lipid layer of the axonal membrane by flux tubes and the melting of the axonal membrane would induce braiding during the propagation of nerve pulse. α tubulins are accompanied by stable GTPs analogous to single DNA nucleotide so that α tubulin could takes the role of DNA nucleotide with braid strands to lipids having only single color. Compared to DNA TQC this computation would represent much rougher resolution. β tubulins are accompanied by unstable GTPs able to suffer a hydrolysis to GDP. Also this process would correspond to the splitting of flux tube but the connection to TQC remains unclear. One can imagine one/two connected flux tubes to lipid layer represents bit.

Option II: For some years ago I considered the possibility of a gel-sol-gel phase transition proceeding along the surface surface of the micro-tubuli, accompanying nerve pulse, perhaps inducing nerve pulse, and coding for long term sensory memories in terms of 13 13-bit sequences defined by the tubulin helices with bit represented as a conformation of micro-tubule. This hypothesis might be easily shown to be wrong on basis of the available experimental facts already now. Suppose however that this phase transition happens and that the braid strands do not continue from the micro-tubular surface to the cell nucleus. In this case the braiding could be induced by a gel-sol-gel transition accompanying and perhaps generating the nerve pulse at the micro-tubular level and inducing the disassembly of the microtubule to tubulins followed by re-assembly inducing the braiding. Also this braiding would contribute to TQC like process or at least to a memory storage by braiding and options I and II would provide the complete story.

Option III: What about the variant of DNA-membrane TQC for axons? In the model of DNA as TQC these flux tubes continue back to the nucleus or another nucleus: the flux tubes must be split at cell membrane during TQC and this splitting induces the required isolation from the external world during TQC. During nerve pulse the situation would be different and the flow of lipids in liquid phase could induce DNA-lipid layer braiding: the isolation could however fail now. Tqc would explain why the axon melts during nerve pulse.

There are objections against this option.

1. By previous argument only Y-codons of DNA and only non-hydrogen bonded $O =$s of amino-acids would contribute to the braid strands. This does not look nice.

2. The idea about magnetic flux tubes emanating from DNA and flowing along micro-tubules interiors and radiating to the axonal membrane looks also ugly: in any case, this would not affect TQC and nerve pulse could be seen as a direct gene expression not conforming with the idea that microtubules define an independent computational system.

3. One can wonder why also the magnetic flux tubes from DNA could not end to the space-time sheet of the cell exterior if they do so in the case of axon. The justification for "No" (besides

isolation) could be that also cell soma would possess standing soliton sequence like waves and standing nerve pulses in this kind of situation.

The following considerations do not depend on the option used.

1. What comes first in mind is that the braiding codes memories, with memories understood in TGD sense using the notion of 4-D brain: that is in terms of communications between brain geometrically now and brain in the geometric past. In standard neuroscience framework braiding of course cannot code for memories since it changes continually. Nerve pulse sequences would code for long term sensory memories in a time scale longer than millisecond and micro-tubular phase transition could have a fine structure coding for sensory data in time scales shorter than nerve pulse duration. The fact is that we are able to distinguish from each other stimuli whose temporal distance is much shorter than millisecond and this kind of coding could make this possible. Also the direct communication of the auditory (sensory) input using photons propagating along MEs parallel to axon could also explain this.

2. In the model of DNA as TQC nucleotides A, T, C, G are coded into a 4-color of braid strand represented in terms of quarks u, d and their antiquarks. An analogous coding need not be present also now: rather, all braid strands could have same color represented by G of GTP. Tubulins could be seen as higher level modules consisting of order hundred 500 amino-acids. This corresponds to a DNA strand with length of about .5 μm corresponding to the p-adic length scale $L(163)$ which is one of the four magic p-adic length scales ($k = 151, 157, 163, 167$) which correspond to Gaussian Mersennes. This higher level language character of micro-tubular TQC programs would conform with the fact that only eukaryotes possess them.

3. Cellular cytoskeleton consists of micro-tubules. Could micro-tubular TQC -in either of the proposed forms- take place also at the cell soma level? Could DNA-nuclear membrane system define the primordial TQC and micro-tubular cytoskeleton-cell membrane system a higher level TQC that emerged together with the advent of the multicellulars? Is only the latter TQC performed at the multicellular level? The notions of super- and hypergenome encourage to think that both TQCs are performed in all length scales. One can imagine that ordinary cell membrane decomposes into regions above and below the critical point (the value of the critical temperature can be controlled. Those below it would be connected to DNA by flux tube bundles flowing inside the micro-tubular cylinders. Micro-tubular surfaces would in turn be connected to the regions above the critical point. One should also understand the role of $M_{13} = 2^{13} - 1$ 12-bit higher level "genetic code" assignable naturally to micro-tubules. For instance, could the bit of this code tell whether the module defined by the tubulin dimer strand bundle participates TQC or not?

12.6.4 Magnetic Bodies, MEs And Microtubules

It would seem that magnetic bodies are the intentional agents and the most natural assumption is that micro-tubuli are used by the magnetic body of cell for logistic purposes as well as to represent memories. First p-adic MEs representing the intention to suck energy and momentum from a particular part of the gel phase and transformed then to negative energy IR MEs by p-adic-to-real transition. Negative energy IR MEs would also serve as space-time correlates for the bound state quantum entanglement responsible for the generation of a multi-neuron macroscopic and -temporal quantum state.

Phase conjugate laser beams are the most plausible standard physics analogs for negative energy MEs and the coherent photons generated and Bose-Einstein condensates of photons contained by them. Since the energy .1 eV is above the range of the thermal energies, one can argue that negative energy photons can be absorbed only resonantly and thus very selectively. This view is supported by the demonstration of Feinberg showing that it is possible to see through chicken using phase conjugate laser beam [D6].

Still an open question is whether laser beams actually correspond to dark photons having thus large value of $\hbar$ and scaled up wavelength. Scaled up wave lengths for .1 eV IR photons would be very natural concerning the control in length scales longer than that of single neuron and synchronous neuronal firing might involve the de-coherence of these dark photons to ordinary IR photons.

Could memes express themselves in terms of modulated IR radiation?

In TGD framework cell nucleus is the brain of the cell and acts as the fundamental controller of the cellular dynamics. Genetic expression is the slow part of this dynamics analogous to a rebuilding of the computer hardware. Software corresponds to memes, sequences of memetic codons realized as sequences of 21 DNA triplets in the intronic part of the DNA. Memetic codons would be the language with which the cellular programs are written. Super-genes or at least hyper-genes would naturally correspond to the sequences of memetic codons.

Memes could express themselves as temporal patterns of IR radiation amplified by micro-tubuli of length ~ 12.4 micrometers. Of course, in accordance with the fractality, also wavelengths corresponding to other metabolic currencies are probably realized. Single memetic codon carries 126 bits and single bit has a duration of about $1/1026$ s, the basic time scale of the neuronal dynamics. Both the frequency for the occurrence of sol gel transition and the duration of memetic codon in turn corresponds to 10 Hz frequency in alpha band, which suggests that $k_d = 46$ hierarchy level of dark matter hierarchy is involved with the periodically occurring sol-gel phase transition. The general framework would suggest that this phase transition occurs with this frequency only in vertebrate neurons.

These patterns of IR radiation at $\sim .1$ eV energy induce temporal sequences of sol-gel transitions representing memes physically. The beauty of MEs is that as topological field quanta of radiation they allow a precisely targeted local control not possible in Maxwellian electrodynamics. In particular, temporal sequences of micro-tubulin conformations could represent long term declarative memories expressed in a universal language using memetic codons as basic units.

Seesaw mechanism as a general manner to generate long term memories?

Micro-tubuli can act as quantum antennae producing IR photons by the dropping of proton Cooper pairs and amplified resonantly, when the micro-tubule has a length of about 12.4 micrometers. The absorption of these photons would in turn re-establish the gel phase in receiving system. This energetic gel-sol seesaw would be obviously ideal for the minimization of the dissipative losses.

The seesaw mechanism for the cellular control by micro-tubuli means that sol-gel transition in tubulin induces a gel-sol transition in the controlled part of the cell. Thus it would automatically construct micro-tubular declarative long term memory representation as a record about sol-gel transition history in various parts of the cell or cell substructure coded by the positions of tubulin dimers at the tubulin cylinder.

These dynamical maps about the active structures in the cell interior would be analogous to neuronal maps in cortex. If cell nucleus is the fundamental controller, also chromosomes might be seen as structures analogous to brain hemispheres forming dynamical sensory and motor maps about the interior of the cell. The static conformations would not represent memory bit. Rather, the changes of the conformations would represent the bit in accordance with the view that moments of consciousness correspond to quantum jumps between histories, and that the sequence of quantum jumps effectively integrates to a single quantum jump during macro-temporal quantum coherence.

12.7   Are lithium, phosphate, and Posner molecule fundamental for quantum biology?

I encountered a very interesting Facebook link (see `http://tinyurl.com/zyy3b4l`) to the work of Mathew Fisher [**?**] (see `http://tinyurl.com/hd3t6sr`) related to quantum biology, in particular to the possible role of Posner molecules. Posner molecules (see `http://tinyurl.com/ya2vura9`) are not some bio-chemical rarity. Betts and Posner, while examining the x-ray crystal structure of the bone mineral hydroxyapatite $Ca_{10}(PO_4)_6$ (see `http://tinyurl.com/y7quv997`), found that within each unit cell there were two calcium-phosphate clusters with atomic constituents $Ca_9(PO_4)^6$.

I attach below the abstract of the first article [**?**] of Fisher.

> *The possibility that quantum processing with nuclear spins might be operative in the brain is proposed and then explored. Phosphorus is identified as the unique biological element with a nuclear spin that can serve as a qubit for such putative quantum processing - a neural qubit - while the phosphate ion is the only possible qubit-transporter.*

We identify the ■, $Ca_9(PO_4)^6$, as the unique molecule that can protect the neural qubits on very long times and thereby serve as a (working) quantum-memory.

A central requirement for quantum-processing is quantum entanglement. It is argued that the enzyme catalyzed chemical reaction which breaks a pyrophosphate ion into two phosphate ions can quantum entangle pairs of qubits. Posner molecules, formed by binding such phosphate pairs with extracellular calcium ions, will inherit the nuclear spin entanglement. A mechanism for transporting Posner molecules into presynaptic neurons during a ■ exocytosis, which releases neurotransmitters into the synaptic cleft, is proposed. Quantum measurements can occur when a pair of Posner molecules chemically bind and subsequently melt, releasing a shower of intra-cellular calcium ions that can trigger further neurotransmitter release and enhance the probability of post-synaptic neuron firing. Multiple entangled Posner molecules, triggering non-local quantum correlations of neuron firing rates, would provide the key mechanism for neural quantum processing. Implications, both in vitro and in vivo, are briefly mentioned.

The model of Fisher [**?**] (see `http://tinyurl.com/hd3t6sr`) for how phosphate ion and calcium phosphate known as Posner molecule could play a central role quantum neural processing is described. Fisher assumes that the nuclear spin $S = 1/2$ of phosphate ions could make possible long range correlations and allow long decoherence lifetimes in these degrees of freedom. Fisher emphasizes also the possible role of Lithium in quantum biochemistry.

About two years after writing the first version of this article, I learned about a second article about Posner molecules by Fisher, Swift and Van de Walle [**?**] (see `http://tinyurl.com/ycyu5bj9`) describing a detailed study of Posner molecules. The abstract of the article gives idea about what is done.

We investigate ■, calcium phosphate clusters with chemical formula $Ca_9(PO_4)^6$. Originally identified in hydroxyapatite, Posner molecules have also been observed as free-floating molecules in vitro. The formation and aggregation of Posner molecules have important implications for bone growth, and may also play a role in other biological processes such as the modulation of calcium and phosphate ion concentrations within the mitochondrial matrix. In this work, we use a first-principles computational methodology to study the structure of Posner molecules, their vibrational spectra, their interactions with other cations, and the process of pairwise bonding. Additionally, we show that the Posner molecule provides an ideal environment for the six constituent ^{31}P nuclear spins to obtain very long spin coherence times. In vitro, the spins could provide a platform for liquid-state nuclear magnetic resonance quantum computation. In vivo, the spins may have medical imaging applications. The spins have also been suggested as ■ in a proposed mechanism for quantum processing in the brain.

I also learned about the finding of M.Y. Simmons *et al* [D42] (see `http://tinyurl.com/ydx6v7xa`) about electronic qubits realized with phosphorus atoms serving as donors. This inspires the question whether also electronic qubits might be realized by using the valence electrons of P.

About two years after writing the first version of this article I ended up with a model of valence bond [L47] (see `http://tinyurl.com/ycg94xpl`) assuming that the electrons at valence bonds can have non-standard value of Planck constant $h_{eff} = n \times h$ (the hierarchy of Planck constants characterizing dark matter as phases of ordinary matter comes as a basic prediction of adelic TGD [L52, L51]). The starting point of the model was the surprisingly weak variation of the bond energy along the rows of the periodic table.

The model provides a vision about the role of valence bonds in biology and provides a precise identification for the notion of metabolic energy. The binding energies of bonds decrease with the value of $h_{eff}/h = n$ increasing along the rows of the periodic table, and the reduction of the binding energy can be identified as potential metabolic energy liberated in catabolism. The bonds involving atoms towards the right end of the rows of the periodic table have highest metabolic energies, and are indeed the bonds appearing in nutrient molecules. Phosphate ion has especially high bond energy so that Posner molecules could be also ideal for storing metabolic energy.

In the sequel I will consider the proposal of Fisher from TGD view point. I will describe first the Lithium mystery, which served as a motivation of Fisher and also TGD view about the

role of Lithium. I also present TGD view about the situation suggesting that Posner molecule might indeed have a deep role but perhaps also in different sense to that in Posner's proposal. ELF radiation at frequencies equal to multiples of 15 Hz cyclotron frequency for Calcium ion in endogenous magnetic field $B_{end} = .2$ Gauss was found by Blackman and others to have effects on vertebrate brain. Furthermore, the cyclotron frequency of phosphate ion in endogenous magnetic field B_{end} corresponds to the 10 Hz alpha resonance frequency defining a fundamental biorhythm. This suggests that Ca ions and phosphate ions might form two separate cyclotron Bose-Einstein condensates at different magnetic flux tubes so that cyclotron energies. I will also represent a brief comment about the realization of electronic qubits with P atom serving as a donor.

12.7.1 Lithium mystery

The starting point of Fisher was a very interesting finding challenging the hypothesis about life as mere bio-chemistry. Already in 1986, scientists at Cornell University examined the effects of the two isotopes of Lithium on the behavior of rats. Pregnant rats were separated into three groups. One group was given Li^7, one group was given the isotope Li^6, and the third served as the control group. Once the pups were born, the mother rats that received Li^6 showed much stronger maternal behaviors, such as grooming, nursing and nest-building, than the rats in either the Li^7 or control groups.

Li^6 therefore as has a positive effect on maternal behaviour unlike Li^7. The chemistry is exactly the same. According to the popular article, Fisher believes that the higher nuclear spin of Li^6 could give it special role.: in the article he talks about nuclear spin $J = 1/2$ which cannot be true since the spin must be even. As a matter fact, according to my Nuclear Physics by Howard Li^7 has nuclear spin of $J = 3/2$ units whereas Li^6 has nuclear spin $J = 1$ so that neither of the above claims is correct. Could the bosonic character of Li^6 nucleus provide an alternative explanation? In any case, the finding strongly suggests that magnetic fields are involved.

Lithium - presumably Li^6 - has also other positive effects. If the positive effects are indeed due to Li^6 isotope, the dose of Lithium could be reduced by using only Li^6 isotope. I attach here the abstract of the article that I wrote as a reaction to discussions with my friend Samppa who told about Lithium [L36] (see `http://tinyurl.com/j44epwp`).

> Lithium has been used for more than 50 years as a mood stabilizer in manic depression. During last years Lithium has been studied intensively and found that it can be used also in treatment of schizophrenia and many other brain disorders. The effectiveness of Lithium is however difficult to understand in the standard framework of biology. In TGD framework organism-environment pair of standard biology is replaced with the triplet magnetic body - organism -environment. Magnetic body uses biological body as sensory receptor and motor instrument. This suggests that the re-establishment of communications of brain with some level of the magnetic body is how lithium causes its positive effects. Magnetic body does not receive information about brain and cannot control it since dark Lithium ions and correspond- ing cyclotron radiation are not present. The disorders caused by the lack Lithium and other biologically important ions would therefore be something totally new from the perspective of standard neuroscience.

TGD explanation for the effects of Lithium relies on the notions of magnetic body and dark large $h_{eff} = n \times h$ photons, electrons, and ions and relies on cyclotron frequencies as frequencies assignable to the dark photons responsible for the communications between magnetic body and biological body. In this picture the charge of the ion and its total magnetic moment would be relevant rather than only nuclear magnetic moment characterizing also neutral atoms (which could also contribute to the magnetic moment of ion). Cyclotron frequencies would replace Larmor frequencies.

1. For Li^6 the cyclotron frequency is about 50.0 Hz in the endogenous magnetic field $B_{end} = .2$ Gauss explaining the quantal effects of em fields at ELF frequencies on vertebrate brain reported by the pioneers of bio-electromagnetism such as Blackman [**?**] to occur at multiples of cyclotron frequency in this magnetic field for Calcium ion and also for other biologically important ions. For Ca^{+2} ion the cyclotron frequency is 15 Hz. Thanks to the large value

of $h_{eff} = n \times h$ dark photons would have energies above thermal threshold. An attractive hypothesis is that the energies are in the range of bio-photon energies (visible and UV).

2. In the case of Li^6 the dark photons would make possible communication to and control by the magnetic body relevant for maternal behaviors. Magnetic fields oscillating at 50 Hz frequency are known to have biological effects [K77]. The size of the corresponding magnetic body part would be obtained from the wavelength $\lambda = 2\pi R$ (R denotes the radius of Earth) of the lowest Schumann frequency 7.8 Hz as $L = (7.8/50) \times R = .98 \times R$. This suggests that dark magnetic flux tubes assignable with Earth are involved: not however that the field strength is $2B_E/5$.

3. For Li^7 the dark photons would have cyclotron frequency about 42.9 Hz, which brings in mind the thalamocortical resonance with frequency around 40 Hz assigned to consciousness at the time when the use of the word "consciousness" ceased to be pseudo-science. The more abundant Li^7 (92.5 per cent) should be also important but could be associated with other kinds of biological functions.

12.7.2 Phosphate, Posner molecule, and cognition

Fisher as also other quantum biologists tries to understand quantum biology as an improvement of biochemistry. One assumes that standard quantum theory brings in small effects allowing to optimize biological functions. In the case of the avian navigation and also in many other situations the problem is that Earth's magnetic field is only 2 per cent of the minimum magnetic field at which the proposed radical-pair mechanism is found to work [L32] (see `http://tinyurl.com/jnxvdmf`). To my opinion much more radical approach challenging the basics of quantum theory itself is necessary.

Fisher wants to identify the quantum mechanism behind neural activity assumed to rely on nuclear spins. This is quite a demanding challenge. One should understand long coherence time for nuclear spins representing the qubits, discover a mechanism transporting the qubit through the brain to neurons, identify a molecular scale quantum mechanism entangling qubits, identify a chemical reaction inducing quantum measurement of the qubits dictating the subsequent neuron firing, and understand what happens in nerve pulse transmission from pre- to post-synaptic neuron at quantum level.

1. Fisher assigns fundamental qubit and the ability to develop lon lasting quantum entanglement with phosphate ion (see `http://tinyurl.com/zgbgtwy`). Phosphate ion would be qubit transporter. The transfer of phosphate ion from APT to a molecule is fundamental part of metabolism and the TGD proposal is that a transfer of negentropic entanglement (NE) (purely TGD based notion involving p-adic physics as correlate for cognition) is in question.

2. Enzyme catalyzed qubit entanglement would emerge in the reaction ATP$\rightarrow$ AMP+PPi. PPi is diphosphate ion with entangled phosptate and the reaction PPi$\rightarrow$ Pi+Pi would create two entanglement phosphates. The reaction rate is proposed to depend on whether the 2Pi state is spin single or spin triplet.

3. Quantum memory is assigned with so called Posner molecule $[(PO_4)^{-3})]_6Ca_9^{+2}$ made of 6 phosphate ions and 9 calcium ions would be the key player. Posner molecule belongs to a family of calcium phosphates having as building bricks PO_4^{-3} and Ca^{+2} ions (see `http://tinyurl.com/jftjmro`). Calcium phosphate is the principal form of calcium found in bovine milk and blood. 70 percent of bone consists of hydroxyapatite, a calcium phosphate mineral known as bone mineral. Tooth enamel is composed of almost ninety percent hydroxyapatite.

   Posner molecule is neutral since the charges of 9 Ca ions and 6 phosphate ions cancel each other: $9 \times 2 - 6 \times 3 = 0$. Geometrically Posner molecule can be described as a cube with Calcium ions at corners and center and phosphate ions at the centers of faces. The nuclear spin of the Posner molecule assignable to phosphates is 0, 1, 2, or 3. Posner molecule has also reduced rotational degrees of freedom characterized by group Z_3 giving rise to pseudospin. Posner molecule would be a carrier of phosphate qubits giving rise to (working) quantum-memory realized in terms of entangled Posner molecules.

4. Fisher proposes the notion of quantum entangled chemical reactions. This notion does not make sense if one identifies chemical reactions as processes involving state function reduction as assumed in chemical kinetics. The notion could make sense if chemical reactions are identified as unitary time evolutions for entangled systems such as Posner molecules. In TGD framework the notion of entangled time evolutions could make sense in zero energy ontology (ZEO).

5. Nerve pulse tranmission from pre- to postsynaptic membrane would entangle neurons by entangling Posner molecules. Biochemistry is complex but to my opinion the proposed model is too complex to be feasible. My view is that the enormous complexity of the description based on biochemical reaction pathways reflects the failure to realize the presence of control level - magnetic body. Situation would be like trying to understand the functioning of computer program regarding it as mere physical phenomenon without any idea about its purpose.

12.7.3   TGD view

In TGD framework both nuclear spins and angular moment of dark nuclei in the magnetic fields assignable to dark magnetic flux tubes would be important: Larmor frequencies would be replaced with the sums of Larmor - and cyclotron frequencies assignable to (usually) charged particles. It is interesting to look whether the cyclotron frequencies of phosphate and Posner molecule could teach something about their possible role.

1. Phosphate PO_4^{-3} with mass number $31 + 4 \times 16 = 95$ has cyclotron frequency 9.5 Hz in the endogenous magnetic field $B_{end} = .2$ Gauss assumed in TGD model and therefore in alpha band. For smaller charges -2 and -1 one has frequencies 6.26 Hz and 3.13 Hz. In TGD framework the transfer of phosphate from ATP to the acceptor bio-molecule could be at the fundamental level transfer of NE from metabolites [K48, K49]. This could reduce to the transfer the ends of the associated flux tubes between the molecules.

2. Posner molecule is neutral since the charges of 9 Ca ions and 6 phosphate ions cancel each other: $9 \times 2 - 6 \times 3 = 0$. Being neutral Posner molecule as a whole does not couple to the magnetic field except through its total magnetic moment. TGD proposal that ions form Bose-Einstein condensates encourages however to consider the possibility that the building bricks of Posner molecule form separate Bose-Einstein condensates. One can ask whether this is possible also more complex calcium phosphates: could bones be much more than just passive building bricks?

   The simplest possibility is that 3 Cooper pairs of fermionic PO_4^{-3} molecules (as is easy to check by noticing that phosphorus and oxygen atoms are bosons and there are surplus 3 electrons: note that phosphorus nucleus is fermion and oxygen nucleus a boson) form a Bose-Einstein condensate a their own circular portion of flux tube. 9 bosonic Ca^{+2} ions would form similar Bose Einstein condensate at their own flux tube portion.

3. The value of h_{eff} proportional to the mass of the ion if $h_{eff} = h_{gr}$ hypothesis is accepted. The formation of Cooper pairs of phosphate ions would conform with the conjecture of Fisher that two phosphate ions can entangle.

   These observations put the bells ringing - with a frequencies of 10 Hz and 15 Hz, one might say. Unfortunately this frequency is not directly audible, so that I cannot hope that colleagues would hear the ringing! There are however some hopes: also 10 Hz and 15 Hz can be made audible as difference of frequencies fed to right and left ear! Maybe some experimentalist could get interested!

4. A further intriguing observation is that the Larmor frequency of P for B_{end} is 10.96 Hz. This is marginally in alpha band. This suggests that also Larmor frequency of P is indeed important in bio-control by magnetic body.

5. An alternative and more realistic sounding hypothesis is $h_{eff} = h_{em}$. $h_{eff} = h_{em}$ 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 NE or be accompanied by dark magnetic flux tube.

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.

6. The cyclotron frequencies of these Bose-Einstein condensates would be 9.5 Hz *resp.* 15 Hz in $B_{end} = .2$ Gauss. This model could allow to improve the understanding about why the radiation at harmonics of 15 Hz has effects on vertebrate brain and also about the realization of alpha rhythm as a control signal from magnetic body. Fisher proposes that in nerve pulse transition two Posner molecules fuse temporarily and produce a spray of Ca^{+2} ions. This could make sense also in TGD framework.

12.7.4   A new step of progress after two years

Roughly two years after writing the first version of this article I ended up with a model of valence bond [L47] (see `http://tinyurl.com/ycg94xpl`) assuming that the electrons at valence bonds can have non-standard value of Planck constant $h_{eff} = n \times h$ (the hierarchy of Planck constants characterizing dark matter as phases of ordinary matter comes as a basic prediction of adelic TGD [L52, L51]). The starting point of the model was the surprisingly weak variation of the bond energy along the rows of the periodic table and the observation that the heating of Ruthenium leads to a mysterious disappearance of valence electrons known for decades: the interpretation would be that they are transformed to dark electrons [L50].

The model provides a vision about the role of valence bonds in biology and provides a precise identification for the notion of metabolic energy. The binding energies of bonds decrease with the value of $h_{eff}/h = n$ increasing along the rows of the periodic table, and the reduction of the binding energy can be identified as potential metabolic energy liberated in catabolism. The bonds involving atoms towards the right end of the rows of the periodic table have highest metabolic energies, and are indeed the bonds appearing in nutrient molecules. Phosphate ion has especially high bond energy so that Posner molecules could be also ideal for storing metabolic energy.

Posner molecule would be ideal for both control purposes and for metabolism.

1. There are 9 Ca^{2+} ions and 6 PO_4^{3-} ions with cyclotron frequencies of 15 Hz and 9.5 Hz respectively in the endogenous magnetic field $B_{end} = .2$ Gauss explaining the observations of Blackman [?] about the quantal effects of ELF em fields on vertebrate brain: thus these molecules are ideal for control by and communication to magnetic body.

   Also the fact that the Larmor frequency of P is 10.96 Hz and marginally in alpha band, suggests that MB uses spin flips for control purposes. MB could control and coordinate all phosphate containing biomolecules usign this Larmor transition of P. This includes ATP, DNA, RNA, the tubulins of microtubules containing GTP and all biomolecules to which phosphate is attached. This would conform with the frequencies in alpha band as a universal biorhythm used by magnetic body to keep metabolism in synchrony in body scale.

   P nuclei serve as qubits and 6 qubits in Posner atom could realize genetic code with 64 code words. Could our bone marrow be performing massive quantum information processing?!

2. The 6 phosphates with high energy phosphate bonds are in turn ideal for metabolism: P and O related valence bonds indeed have nearly maximal metabolic energy content in the

proposed model of valence bonds based on $h_{eff}/h = n$ hierarchy [L47] (see `http://tinyurl.com/ycg94xpl`).

Remark: Totally unrelated association: the magic number 6 appears also in the structure of cortex: could the six layers represent qubits and realize genetic code?

This suggests that bones might also serve as energy storages and - of course - as nutrients. Interestingly, in the evolution of humans the discovery of stones as tools to break down bones of prey animals to get bone marrow has been seen as a critical step leading to the growth of cortex requiring a lot of metabolic energy (to generate large n valence bonds providing ability to generate negentropy).

What is interesting that ATP molecule - the basic metabolic currency - has triphosphate with total charge -4 as a building brick. Triphosphate is characterized by cyclotron frequency 4.8 Hz which is one half of the alpha band frequency. The diphosphate in ADP has cyclotron frequency 5.2 Hz. Note that the cyclotron frequency of Fe^{2+} ion central in oxygen based metabolism is 10.7 Hz and in alpha band as also the Larmor frequency of P.

Note that in DNA the singly charged phosphates in XMPs, X = A, T, C, G, have cyclotron frequency, which is one third of this, that is 3.1 Hz. This frequency appears in EEG as a kind of resonance frequency during deep sleep. DNA nucleotides as whole have cyclotron frequencies around 1 Hz. In microtubules the phosphate of GTP can have three different charge states allowing frequencies 3.1,6.2 and 9.4 Hz. I have proposed that these charge states together with two different tubulin conformations give rise to a realization of the genetic code.

The proton cyclotron frequency 300 Hz has been already earlier assigned with ATP and the models for the lifelike properties of a system consisting of plastic balls involved cyclotron frequency of Ar^+ ion which is same as that of Ca^{2+} ion and cyclotron frequency 300 Hz of proton [L49] (see `http://tinyurl.com/yassnhzb`). Also the two important frequencies associated with honeybee dance [L60] correspond to the cyclotron frequencies of Ca^{2+} and proton (see `http://tinyurl.com/ycnst4z5`).

12.7.5 Phosphorus electrons as qubits

M.Y. Simmons *et al* [D42] (see `http://tinyurl.com/ydx6v7xa`) have found that P atoms can serve as donors of electrons giving rise to very long-lived qubits (see `http://tinyurl.com/y88d7vhf`). I attach the abstract of the article here.

Substitutional donor atoms in silicon are promising qubits for quantum computation with extremely long relaxation and dephasing times demonstrated. One of the critical challenges of scaling these systems is determining inter-donor distances to achieve controllable wavefunction overlap while at the same time performing high fidelity spin readout on each qubit. Here we achieve such a device by means of scanning tunnelling microscopy lithography. We measure anti-correlated spin states between two donor-based spin qubits in silicon separated by 16±1nm. By utilising an asymmetric system with two phosphorus donors at one qubit site and one on the other (2P1P), we demonstrate that the exchange interaction can be turned on and off via electrical control of two in-plane phosphorus doped detuning gates. We determine the tunnel coupling between the 2P1P system to be 200MHz and provide a roadmap for the observation of two-electron coherent exchange oscillations.

A controllable exchange interaction between electron spins is needed for the realization of 2-qubit quantum gate. The valence electron of P atom rather than P nucleus serves as a qubit. The qubits have unexpectedly long relaxation times (measured in seconds) and dephasing times. $2P$ (2 P atoms) and $1P$ serve as electron donors. The distance of 2P and 1P is rather long - 16 ± 1 nm - 1.6 times the p-adic length scale $L(151)$ (p is Gaussian prime $M_{G,151} = (1+i)^{151} - 1$ assignable to neuronal membrane. Exchange interaction occurs if there is an overlap between electron wave functions.

In TGD framework the electrons donated by phosphorus atoms and forming the qubits could be actually dark electrons with $h_{eff}/h = n$ larger than for atoms or normal valence bonds. This would scale up the domain of electron wave functions by n^2 and make possible the overlap. This also increases relaxation and dephasing times.

Remark: In living matter negatively charged phosphate ions for which P atoms have received electrons (negative oxidation number) are important. In the experiment discussed P atom loses electron and becomes a positive ion.

12.8 DMT, pineal gland, and the new view about sensory perception

The recent discussions with artist Sini Kunnas [L39] about perception as creation of an artwork inspired additional insights about how sensory perception, imagination as almost sensory perception, dreams and hallucinations as virtual percepts, and their motor analogs relate to each other.

What distinguishes TGD from neuroscience is that sensory receptors are assumed to serve as carriers of sensory percepts. Zero energy ontology (ZEO) providing new view about time and memory allows to solve the basic objections related to phantom limb phenomenon: pain in phantom limb would be sensory memory.

The assumption that sensory percepts are artworks rather than passive records of sensory input requires virtual sensory input from brain to sensory organs and build-up of the final percept by pattern recognition - an iterative procedure involving very many forth-and back signals. Nerve pulse transmission is quite too slow process to allow this and signals propagating with maximal signal velocity are suggestive.

Nerve pulses and neurotransmitters would not represent real communication but give rise to temporary intra-brain communication lines along which communications as dark photon signals would take place with maximal signal velocity using dark photons (characterized by $h_{eff}/h = n$) transforming to biophotons in an energy conserving manner [K22, K12]. Neurotransmitters and also other information molecules (hormones, messengers) attached to receptors would serve as bridges fusing permanent but disjoint communication lines along axons to a connected temporary communication line for dark photons to propagate. Nerve pulses would also generate generalized Josephson radiation allowing communications between biological body (BB) and magnetic body (MB) using EEG. Meridian system would be permanently connected system of communication lines.

This picture leads to a concrete proposal about the roles of DMT and pineal gland concerning imagination and dreams and hallucinations.

12.8.1 Zero energy ontology (ZEO)

Zero energy ontology distinguishes TGD from standard model, and this distinction plays a key role in TGD based view about consciousness and sensory perception.

1. In ZEO quantum states are pairs of positive and negative energy states. Positive energy states are analogous to the usual quantum states assignable to time=constant section of space-time. Time=constant section is replaced with a pair of 3-surfaces located at the opposite boundaries of causal diamond (CD) defined as the intersection of future and past directed light-cones of M^4 with each point replaced with CP_2. CDs form a hierarchy with CDs within CDs. In consciousness theory CD is identifed as the perceptive field of self and sub-CDs correspond to subselves defining mental images of self.

   Space-time surfaces are preferred extremals of certain action serving as analogs to Bohr orbits having 3-surfaces at the opposite boundaries of CD as their "ends". Quantum states are quantum superpositions of preferred extremals. Holography is realized in the sense that 3-D data (3-surfaces) at the boundaries of CD fixes the space-time surface. In fact, preferred extremal property implies what I call strong form of holography (SH): 2-D data at string world sheets and partonic 2-surfaces is enough to fix the preferred extremals.

2. ZEO forces a modification of the standard quantum measurement theory. One must allow moduli space for CDs corresponding to a varying temporal distance between the tips of CDs. Lorentz transformations leaving the second tip of CD invariant generate new CDs. Besides this the position of the tip of CD can vary: one has full Poincare group transforming CDs to each other.

During unitary time evolution the passive boundary of CD and members of state pairs at it are unaffected: they represent prepared state. The sequence of unitary time evolutions of this kind gives rise to a generalization of Zeno effect or what is called weak measurement.

Active boundary becomes delocalized in moduli space of CDs with fixed passive boundary and also the states at it are affected in given unitary evolution. "Small" state function reduction localizes the active boundary in the moduli space. The distance between the tips of CD increases during sequence of "small" reductions.

The observables measured in "small" state function reduction must commute with the observables, whose eigenstates the states at the passive boundary are. It sooner or later happens that all possible observables are measured and "big" reduction occurs and changes the roles of the boundaries of CD.

3. From the point of view of consciousness theory "big" reduction means death of the self assignable to a given choice of passive boundary and re-incarnation of self with opposite arrow of geometric time: active and passive boundaries of CD change their roles.

The state function reduction sequence defining experienced time is mapped to a clock time defined by the increasing temporal distance between the tips of CD maps defined by sequences of unitary evolutions followed by "small" reductions. Only correlation would be in question. The identification of these times would lead to the well-known problems both in the philosophy of free will and in quantum measurement theory.

4. Since zero energy states are 4-D in well-defined sense, one can say that also the geometric past changes in state function reductions - this gives a connection with Libet's findings about active aspects of consciousness [**?**]. Signals can propagate in both time directions, which allows to fuse sensory percepts and memories to single 4-D perception: CD and sub-CDs represent the 4-D perceptive field.

Sensory input would be localized in good approximation near the active boundary of CD whereas the other aspects of 4-D percept would be interpreted as memories - mental images (subselves) located in geometric past. Symbolic representation of memories (only cognitive mental images) would allow to distinguish sensory "Now" from past. Sensory memories are in principle possible and can be indeed induced by electric stimulation of temporal lobes. Some people with cognitive defects might be more or less permanently in a state of consciousness in which sensory input is 4-D (memory feats of autists). Memories could be also seen as communications with geometric past inside CD. Motor actions could be seen as sensory perceptions in non-standard direction of time.

12.8.2 A new view about the role of nerve pulses in sensory perception

Sensory perception would in TGD generate sensory mental images at sensory organs: this would solve a basic problem of neuroscience due to the similarity of neural tissue in various sensory areas. The new view about time and memory implied by ZEO solves the problem cause by the phantom limb. The pain in phantom limb is sensory memory of pain. The stimulation of temporal lobes indeed generates sensory memories, and people with cognitive inpairment are known for memory feats such as being able to draw some building seen in past with every detail or to learn music pieces with single listening. These feats can be understood if memories correspond to "seeing" in time direction with beam of dark photons travelling to past reflected back. ZEO allows this.

Also Libet's findings about active aspects of consciousness [**?**] involving subject person deciding to raise his index finger and reporting it to experimetner can be understood in ZEO without giving up the notion of free will. In the quantum jump also the geometric past would be affected and this would explain why neural activity begins fraction of second before the conscious decision the subject person decides to raise his index finger.

Since perception involves a lot of processing this would require forth-and back signaling between brain and sensory organs. There would be virtual sensory input from brain or via brain. Sensory percept would be an artwork, standardized mental image, resulting as pattern recognition assigning to sensory input standardized mental image nearest to the input.

1. Nerve pulses would not mediate information inside brain. They would only build short connections between existing flux tube connections parallel to axons. Same happens in old fashioned telephone network by relays: it would be energy consuming to keep the connections on all the time.

   The velocity of nerve pulse conduction is quite too slow to realize the iteration leading to a standardized sensory mental image. If the signal velocity is light velocity, duration of order 1 ms for nervepulse also for 10 cm neural pathway about 10^6 forth and back travels between sensory cortex and retina.

   Communications would occur by dark photons signals with $h_{eff}/h = n$ and with maximal signal velocity allowing for an iteration leading to standardized percepts as near as possible to the sensory input and representing only the essential features. Dark photons could transform in energy conserving manner to biophotons with energies in visible and UV range (at least) and thus above thermal energy and therefore having effects not masked by thermal radiation. Brain is known to emit biophotons and they are also associated with axons [K22, K12].

2. All information molecules (neural transmitters, hormones, messengers) would be connection builders so that the view of neuroscience would be badly wrong here. I have discussed this idea earlier but in slightly different form: the proposal was that information molecules are attached to the end of a flux tube getting longer as the molecule travels to its target. This is possible but un-necessary since it is enough to build just the bridge between existing connections.

   Remark: The view of neuroscience might be very different if information technologies would have been known century ago. Same applies to homeopathy and water memory [K42], which still remains curse words in mainstream science, although a lot about the mechanisms involved is known.

   The standard view about learning as strengthening of synaptic connections would translate to a gradual build-up of permanent flux tube connections so that communications with dark photon signals would be possible all the time. This would lead to fusion of sender and receiver to single quantum entangled system.

   If the meridians of acupuncture network correspond to this kind of permanent network, they would not require nerve pulses, transmitters, nor information molecules.

3. Nerve pulse patterns would however generate Josephson radiation at EEG frequencies propagating from brain to its MB from axonal membranes serving as Josephson junctions. EEG would code the nerve pulse patterns as frequency modulated Josephson radiation [K35].

This picture leads also to a more precise vision about how anesthetes act on human brain. The popular article "Scientists Just Changed Our Understanding of How Anaesthesia Messes With The Brain" (see http://tinyurl.com/y8vxuorf) tells about the [?] finding that anesthetes weaken the communications between neurons (see http://tinyurl.com/y976p94b). It is found that an anesthete known as propofol restrics the movement of protein syntaxin 1a appearing as neurotransmitter at synapses and neurons.

The TGD inspired explanation for the loss of consciousness would be following. Nerve pulse activity is needed to generate neurotransmitters attaching to the receptors of post-synaptic neuron and in this manner forming connections between pre- and post-synaptic neurons giving rise to networks of active neurons. The transmitter would be like a relay in old-fashioned telephone network. Propofol would prevent the formation of the bridges and therefore of the networks of active neurons serving as correlates for mental images. No mental images, no higher level consciousness. At deeper level flux tube networks would accompany the networks of active neurons as already explained.

The earlier TGD inspired proposal was that anesthetes induce a hyperpolarization reducing the nerve pulse activity. How anesthetes could induce hyperpolarization [L26] (see http://tinyurl.com/yatfreqe): the model involves microtubules in an essential manner. Hyperpolarization would have same effect as the restriction of the movement of syntaxin 1a. This mechanism might be at work during sleep and also some anesthetes (but not propofol) could use it.

12.8.3   The role of DMT and pineal gland

Concerning sensory perception, dreams, hallucinations (psychedelic experiences), and imagination the roles of DMT and pineal gland are extremely interesting and suggests a unified view about these aspects of consciousness.

1. Pineal gland is third eye in quite concrete sense for some amphibians and reptiles. This suggest that it still has some function: biology does not invest metabolic energy without return. Could pineal gland serve as the eye of imagination?

   Dark photons would arrive from brain or via brain to pineal gland and give rise to imagined sensory experiences (almost seeing, almost hearing, ... thoughts as internal speech, etc...). All these signals would be realized in terms of dark photons in different wave length ranges for various sensory qualia and the entire energy range of biophotons could be involved: visible light involves one octave in good approximation. At this level perception would be basically "seeing".

2. DMT (N-N dimethyltryptamine, see `http://tinyurl.com/osfg9r3`) is the only psychedelic manufactured by brain itself: in pineal gland (see `http://tinyurl.com/86joshm`) in the case of rodents and therefore also in the case of higher mammals.

   Remark: In "DMT" "N-N" refers to two nitrogen atoms; "Dimethyl" refers to two CH_3 groups replacing H; ttryptamine is the only amino-acid having two aromatic rings.

   Endogenous DMT could have same role as psychedelics and could induce dreams. The state between wake-up and sleep is somewhat analogous to REM sleep and characterized by hallucination like sensory percepts. This cold be due to DMT. During wake-up state dreams would be intefere with genuine sensory percepts and would be replaced by imaginations. It would seem that the virtual sensory percepts associated with the build-up of sensory percept and via pineal gland must be independent.

3. The binding of DMT to receptors in pineal gland would give rise to small bridges connecting disjoint dark photon carrying flux tubes to connected flux tubes going down to sensory organs, where the dark photon signals would give rise to dreams and hallucinations. What would be needed is that dark photons induce sensory stimulus at sensory organ.

   Remark: Interestingly, the inverted structure of the lense in eye is optimal for receiving virtual visual input.

4. Also motor actions would be prepared by iterative process analogous to the build-up of sensory percept but in reverse direction of time as Libet's findings [**?**] about active aspects of consciousness (volition) suggest. Motor action would be sensory perception in opposite direction of time: this makes sense in ZEO one makes distinction between experienced and geometric time. Imagined motor actions would be mediated by similar mechanism involving DMT and pineal gland.

   A further fascinating possibility is that the flux tube connections extend even to outer space, to the brains of members of advanced civilization in distant galaxies. Could the experiences about encounters with ETs or god-like creatures reported by the uses of psychdeles could be real?

1. This is in principle possible since in TGD Maxwellian fields are topologically quantized. Magnetic field decomposes into flux tubes represented as flux sheets in many-sheeted space-time. One can say that any system has field identity, field body.

2. Dark photons can travel along the flux tubes of MB to arbitrary distances without weakening of the signal as in Maxwellian world.

3. ZEO allows also signals in non-standard time direction so that it is possible to send signal which is time-reflected back as signal in opposite time direction: this can happen almost instantaneusly so that finite light-velocity ceases to be a restriction to communications.

12.8.4 Your eyes are the mirrors of my soul!

A fascinating finding again (see `http://tinyurl.com/yabyjbp6`): neuroscientist Giovanni Caputo reports that staring into someone's eyes for 10 minutes induces an altered state of consciousness.

This findings seems to provide direct support for one of the most radical predictions of TGD based quantum view about brain (see `http://tinyurl.com/yczv2o5b`). Neuroscientists assume that nerve pulse pattern generate in brain sensory mental images, in particular visual mental images. In TGD framework brain would build cognitive representations and decompose perceptive field into standard objects in this manner but would not produce sensory qualia. The sensory mental images would be realized at the level of sensory organs. This would involve repeated feedback by using virtual sensory input from brain (or even magnetic body of brain) to build standardized sensory mental images giving rise to pattern cognition. During REM sleep the virtual sensory input would form the entire sensory input. Nerve pulses are quite two slow to achieve this and they would only generate sensory patways, kind of wave guides, along which dark photons with non-standard value $h_{efff} = n \times h_0$ of Planck constant would propagate forth and back.

This view allows to avoid the problem due to the fact that neuronal networks in various sensory areas look very much the same so that it is difficult to understand why they give rise to so different sensory qualia. The obvious objection is phantom limb phenomenon, which could be however understood is the pain in phantom limb is sensory memory of pain. It is indeed possible to produce sensory memories by an electrical stimulation of brain. In TGD the perceptive field would be 4-D and only sensory percepts would be localized to approximate time=constant snapshot having actually a finite duration of about .1 seconds. Memories (as distinguished from learned skills and conditionings) would correspond to contributions to memories from the geometric past.

Staring into eyes experience provides an opportunity to test the idea about virtual sensory input. A fusion of two conscious entities, call them A and B, at some level of self hierarchy might occur. This would involve entanglement, which in TGD framework would accompany the generation of magnetic flux tubes or actually flux tube pairs (by reconnection of flux loops) connecting the eyes of the experiencers and the propagation of the dark photons along flux tubes between the brains of A and B so that visual consciousness would be shared. For instance, A could see the virtual sensory input representing her own face at the face of B. This indeed happened! Volunteers had also out of body experiences (OBEs), had hallucinations of monsters, and saw besides themselves their relatives.

One particular fascinating question is what seeing one's own relatives could mean. The answer depends on whether the subject persons knew each other or not. If not, then the information about relatives of say A would have been transferred from A to B and then returned as virtual sensory input via eyes of B to eyes of A. This is of course possible also when the persons know each other. A would be looking into consciousness mirror defined by B! This experiment would be the first direct realization of fusion of two selves by quantum entanglement. The revolution in neuroscience is now in full swing!

12.9 How did language emerge?

I encountered in FB a link to an article titled "*Unique mix of brain chemicals separates humans from other primates*" (see `http://tinyurl.com/y7vrjflv`). The article inspired the following comments as a reaction, which are not so much about the chemistry but about what to my view goes outside chemistry.

Cultural evolution is what distinguishes us so sharply from our cousins. The evolution of social structures made possible by the emergence of language is certainly crucial for it. To me it is far from obvious whether this can be explained in terms of chemistry alone. My views are based on TGD inspired theory of consciousness and quantum biology and involve notions like magnetic body and hierarchy of Planck constants.

In the sequel I will consider a scenario in which language as internal speech preceded ordinary spoken language. At gene level this language was based on the expression of DNA as "m"usic of light with codons represented as allowed 3-chords in given harmony [L12]. It would have later found neural expression and via a mechanism analogous to a generation of sensory hallucinations led first to genuine hearing of internal voices. The mimicry of these internal voices would have served as the evolutionary pressure leading to the evolution of speech and speech organs.

12.9.1 The notion of magnetic body and the emergence of language and cultural evolution

1. The notion of magnetic body (MB) as intentional agent using biological body as motor instrument and sensory receptor is central in TGD based view about biology and neuroscience. Flux tubes serving as correlates of attention and making possible quantum entanglement and communications by dark photons give quite concretely rise to bonds between systems in various scales. In TGD Universe the notion of magnetic body in crucial for understanding life in general. The emergence of collective levels of consciousness involving large scale MBs would make possible cultural evolution and allow to understand the dramatic difference between humans and other animals.

2. The hierarchy of Planck constants $h_{eff}/h = n$ would be crucial. The larger the value of n, the larger the scale of quantum coherence. Cultural evolution would involve increase of n leading to a formation of large MBs characterizing collective levels of consciousness. The MBs of DNAs consisting of flux sheets going through DNA would combine to bigger structures assignable to organs, organisms, and even populations. This could make possible cultural evolution as emergence of higher level conscious entities with collective genome and collective gene expression.

3. There might be also other deep differences at DNA level not visible at the level of chemistry. The braiding of magnetic flux tubes emanating from the intronic part of DNA could make possible topological quantum computations and a new kind of memory and this might led to the quantum leap to real cultural evolution: the portion of introns is largest for humans.

12.9.2 What internal speech could be?

The emergence of language and speech organs is certainly a revolutionary step in evolution. What language is at quantum level? What thoughts as internal speech are at deeper level.

1. My own proposal is that internal speech has as neuronal correlates linear structures of activated neurons giving names for things and having linear flux tube sequences and corresponding quantum states as correlates at the level of MB. This does not however tell what internal speech is at deeper quantum level.

2. Did thinking as internal speech precede ordinary speech or vice versa? If internal speech came first, one avoids the problem of understanding why only certain sounds have meaning as words. Assume that this is the case.

3. Genes are fundamental in biology. Did internal speech evolve as one particular form of gene expression? TGD inspired model for music harmony based on 12-note scale realize as Hamilton's cycle at icosahedron [L12] (see `http://tinyurl.com/yad4tqwl`) leads to a model of genetic code predicting correctly the numbers of codons coding for given amino-acid and to the proposal that genes express themselves are controlled by signals consisting of sequences of 3-chords allowed by a particular bio-harmony with 64 3-chords (256 of bio-harmonies) [L61] (see `http://tinyurl.com/ydhxen4g`). Given harmony would define an emotional state, mood.

   Gene would be represented as a sequence of 3-chords - accompaniment for a song, melody. Melody would be a sequence of single notes of 12-note scale consistent with the bio-harmony. The sequence of 3-chords allowed by the harmony would define the emotional character of the "music piece". Harmony would be something which chemistry cannot explain.

4. How the accompaniment and song were represented at gene level? The most natural guess is that both the notes of 3-chords of the harmony defining the mood and the melody were represented as dark light. This would be music of light consisting of dark photons rather than phonons: notes would have been analogs of laser beams along flux tubes characterized by frequency and duration.

   How singing was represented at neuronal level? My proposal is that it was represented as 2-D structure of activated neurons having connected magnetic flux tube network as correlate

and representing the mental image. Perhaps the pitch and duration of the note served as 2 discrete coordinates in neuronal lattice [L42] (see `http://tinyurl.com/yczv2o5b`).

5. It is said that right brain sings and left brain talks. These two modes of expression relate like function and its Fourier transform. Did (internal) singing precede (internal) speech? At neuronal level this is suggested by the fact that Alzheimer patient who has lost understanding of language and ability to talk can still understand singing and also sing. Indeed, 1-D linear flux tube structures representing thoughts splits as amylose splits the neuronal connection so that speech is not possible. 2-D structures survive even if some connections are split [L48] (see `http://tinyurl.com/ybq6r3xu`). Note that these two modes relate to cognition and emotion. Emotion came first as indeed evolution of nervous system demonstrates.

12.9.3 How did spoken language emerge?

How do the words of spoken language transform to internal speech and vice versa? What distinguishes words from ordinary sounds?

1. The piezoelectric property of bio-matter makes possible the transformation of light to sound: now light would consist of dark photons with energies $E = h_{eff} f$ in bio-photon range (visible and UV) and frequencies f in the range of audible sound frequencies. Did this transformation somehow give rise to genuine auditory experience of internal song/speech? Did internal singing/speech transform to heard singing/speech by virtual sensory input from brain to ears?

   In TGD based model for sensory perception, hallucinations/psychedelic experiences, and imagination [L42] (see `http://tinyurl.com/yczv2o5b`) this kind of virtual sensory input is essential since sensory qualia are at the level sensory organs and the objects of perceptive field are standardized mental images, kind of artwork requiring resulting from pattern recognition involving a lot of forth-and-back signalling between brain and sensory organs by dark photons).

   We would experience mere virtual sensory input in dreams (REM), hearing voices from head, etc... Pineal gland ("third eye") receiving dark photons signals would receive internal speech and in presence of DMT would channel it to ears producing heard internal song/speech. Jaynes argues that what he calls bicameral consciousness preceded modern consciousness and was like that of schizophrenic and people heard their thoughts as voices in head and interpreted these voices as voices of Gods.

2. Did speech and speech organs evolve from the attempts to mimic this genuinely heard internal singing/speech. This would answer the question why only certain kind of sounds have meaning as words. Did this attempt provide evolutionary pressure leading to the emergence of genes coding for speech organs and speech as a motor activity?

   Remark: An amusing analogy pops in mind: internal speech viz. internal song is like rap viz. ordinary singing dropping out much of the emotional content.

   This cannot be the whole story. Language learning is a social phenomenon involving mimicry. Modern human cannot learn to speak by listening only voices in his head! One can however ask whether languages have some universal pattern. For instance, could very primitive languages depend only on species? What is the role of the collective consciousness: does it talk in the same manner to individuals of the group who then mimic this talk. Was the God of the bicamerals the collective consciousness of the group?

12.10 Revolution in neuroscience: Hebb's rules updated?

A group of scientist, led by Prof. Ido Kanter, of the Department of Physics and the Gonda (Goldschmied) Multidisciplinary Brain Research Center at Bar-Ilan University [**?**] (see `http://tinyurl.com/ydb2awmt`), has published an article Scientific Reports, which could have revolutionary implications for neuroscience.

Kanter *et al* claim that the old Hebb that learning takes place in synapses, is mistaken. Instead, the learning would take place in dendrites and much nearer to the neuron and only few parameters would determine the outcome unlikes in Hebbian approach in which thousands of parameters - synaptic strengths determine the outcome. Furthermore, weak synaptic connections - most of synaptic connections are weak - would be more significant as believed.

What the new view about learning could mean from the viewpoint of quantum brain paradigm according to TGD? In this vision magnetic tube pairs having define connections of a dynamical network having neurons at nodes. The connectivity/topology of this network is changing all the time. At deeper level supra currents and dark photons would be responsible for signalling and the function of nerve pulses would not be communication but to change the topology of the network via the activation of synaptic contacts. Neurotransmitters would be like relays in old fashioned telephone network.

If Kanter *et al* is right, dendrites would learn instead of synapses. Should one talk about dendritic strengths instead of synaptic strengths? Also weak synapses - most synapses are weak - would be important. What happens to "neurons that fire together wire together" paradigm?

Consider first as background TGD vision about neuroscience. The following article summarize the recent developments [L40, L42, L48, L61] (see `http://tinyurl.com/y75246rk`, `http://tinyurl.com/yczv2o5b`,`http://tinyurl.com/ybq6r3xu`, and `http://tinyurl.com/ydhxen4g`).

1. In TGD picture axons and dendrites would be accompanied by pairs of flux tubes carrying opposite magnetic fluxes. This is required by their super-conductivity based on spin zero Cooper pairs - this is quite general model of high Tc superconductivity in which the flux tube pairs are made possible by anti-ferromagnetism.

2. Reconnection of flux tubes is the basic topological mechanism changing the topology of the network. It corresponds in string theory the basic vertex for closed strings.

What does this give?

1. One can represent axon and dendrite by two parallel lines with opposite directions representing flux tubes with opposite fluxes.

2. Consider first axon and dendrite (or axons and axon, or dendrite and dendrite, etc...). What synaptic connection could mean in this picture? I wis I could draw. One has a pair of lines A_+A_-. One has B_+B_- has U-shape. B_+ simply turns back as B_-.

   Then reconnection takes place. Nothing happens for A_+. A_- splits to two piece $A_-(1)$ $A_-(2)$ and the end cap of B_+B_- U-shape is cut off.

   B_- reconnects with $A_-(2)$ and B_+ reconnects with $A_-(1)$. One obtains V shaped structure with edges of V represented by pairs of lines with opposite directions: nowhere opposite arrows meeting each other. Synaptic strength tells the probablity for the formation of this structure, which represent change in the topology of the network.

   The reconnection for flux tube pairs makes the earlier topological picture more complex. The communication channels defined by flux tube pairs can branch or fuse so that the network structure is much richer. Supra-currents or dark photon signals from two sources can superpose. Also more complex entanglement patterns become possible.

3. What about the new notion of dendritic strength? It should tell the probability that there indeed exists a flux tube pair connection between neuron and the rest of the network. This connection can be however split by reconnection. Parallel lines with opposite fluxes pinch together and transform to two U-shaped structures: two U:s face-to-face.

   Dendrite strengths tells how stable the parallel flux tube pair is against this reconnection. In TGD model of superconductivity it tells how stable supracurrent "wire" is and transition from small scale super-conductivity to genuine super-conductivity occurs when long flux tube pairs become stable.

What can one conclude?

1. The claimed findings would say that the dendritic connections are most important for learning and certainly they are so: without dendritic connection at flux tube level, no signals enters neuron. Neuron becomes a hermit isolated from the rest of the brain.

   But also synaptic strengths are important although not important from the point of view of single neuron but from the point of view of the topology of the entire network: the qualitative features of this topology distinguish between spatial thinking involving 2- or even 3-D networks and verbal cognition involving linear networks: this explains why right brain signs and left brain talks. Dendritic strength as a measure for the stability of the connection of neuron to the network and synaptic strength for the ability to change topology of the network temporarily.

2. Hebb's statement could be rephrased as follows. Distribution of synaptic strengths would determine which neurons can wire together and dendritic strength would determine the probability with which neuron can fire together with others.

Chapter 13

Sensory Perception and Motor Action as Time Reversals of Each Other: a Royal Road to the Understanding of Other Minds?

13.1 Introduction

This article was motivated by article in Quanta Magazine (see `http://tinyurl.com/y8a4puca`) telling about the work of David Poeppel and his student Florencia Assaneo.

13.1.1 Poeppel's criticism of neuro-computationalism

The article inspired the reading of the article "*Neuroscience Needs Behavior: Correcting a Reductionist Bias*" of Poeppel *et al* [**?**] (see `http://tinyurl.com/ybeeetr6`) criticizing the computational theory of behavior assuming that behavior reduces to an algorithm analogous to computer program, the software, implemented by neural circuit serving as a hardware.

Poeppel mentions as an example of Caenorhabditis elegans, the roundworm that is one of the most studied lab animals. This animal has only 302 neurons and its neural circuitry is known very precisely as also its full genome. Despite this there is no understanding about what the algorithm encoding the behavior is and how the neural circuitry implements it. Something is missing.

More generally,o ne cannot deduce the behavior of even simple animals from the neural circuitry regarded as computer. Several programs can give rise to the same behavior or same circuitry to several behaviors. The deduction of hypothetical algorithm from behavior is impossible. Poeppel mentions also an experiment in which one tried to deduce from the behavior of the computer game characters the algorithm behind the game for three games. The attempt failed. This finding can be also seen as a failure of behaviorism not anymore a leading dogma in neuroscience anymore since even simple creatures like Caenorhabditis elegans refuse to believe like doorbells.

From the philosophical point of view the failure of reducing behavior to a deterministic algorithm is obvious to me. There is a thing called free will and round worm is not a deterministic computer. One could model its basic behavioral patters using computer programs as analogs but the choice, which program is run involves free will, and one must construct theory of consciousness allowing free will as something consistent with physics. This requires going beyond the recent view about physics.

Poeppel mentions as an example the determination of the direction of a sound source. Depending on the direction sound signal arrived to ears at different times. This can be used as data allowing to deduce the direction of the sound source. There are however several other algorithms for deducing the direction of the sound source.

There is also philosophical criticism. One assumes that there is a small homunculus inside brain able to write computer programs and implement them. This bit virtuoso has found from

some text book of physics a formula allowing to determine the direction of the sound source from the time lag between ears and then has written a computer code and implemented it. But how this tiny computer programmer can achieve this?: obviously it must have a tiny computer programmer inside. One ends on with infinite hierarchy of computer programmers inside computer programmers - infinite regress.

How to get rid of this hierarchy of homunculi? Could quantum physics alone with measurement theory extended to a theory of consciousness by making observer a part of physical system be enough to define and understand behaviors. No model for the physical world but just the physical world itself. This requires however new physics in which notions like behavior, intentionality, goal directedness, and memory have a well-defined meaning. All this notions refer to time or time evolution somehow. In standard physics quantum states are however time=constant snapshots so that going beyond standard quantum physics seems to be unavoidable.

Poeppel also talks about a hegemony of methods reducing neuroscience to the study of neurons and forgetting behavior and studying only neural circuits. Poeppel argues that one should start from behaviors, study them in detail and only after that start to study algorithms and neural circuits as possible way - not necessary correct way - to realize behaviors. One should also consider neuron groups besides neurons. The recent trend is however just the opposite: there is even an attempt to reduce behavior to the molecular biology in accordance with nothing-but-chemistry paradigm.

The coherent behavior of neuron groups manifesting itself as synchronous firing of neurons would be the natural starting point. Here one encounters EEG. EEG correlates both with the state of brain and contents of consciousness. Why brain should use large amounts of metabolic energy to communicate information to outer space? Just for fun? Biology does not waste metabolic energy. What is the purpose of this action bringing in mind communication? Who is the receiver? This question has led to a considerable progress in TGD framework [K35, K80] by applying the new physics predicted by TGD [L64].

A further important inspiration for this article came from learning of the basic facts about the notion of mirror neuron (see `http://tinyurl.com/d6svmf7`) briefly discussed in the first article of Poeppel *et al* [**?**]. The notion of mirror neuron is extremely attractive because it could allow automatic understanding of the observed goal directed behaviors of living systems. Sensory input about behavior would generate automatically the imagined or even real motor action in some cases and there would be no need for the attempt to understand why sensory input about behavior can be associated to a neural activity representing intention about behavior or imagined behavior.

Mirror neuron hypothesis was deduced by studying macaque monkeys and generalized to higher behaviors of humans without testing it at neuron level since this was not possible ethically. The essential assumption is that understanding reduces to single neuron responses. Synchoronous neural firing is involved and therefore also EEG waves, whose real function is not known, are involved so that this kind of reductionism need not be realistic. One can also ask how neurons learn to be mirror neurons: could mirror neuron activity be understood in terms of sensory-motor associations.

The list of the proposed applications to humans is impressive: understanding intentions, imagination, learning facilitation, learning by imitation, automatic imitation and intentional motor mimicry, understanding and learning of language, empathy, autism, theory of mind, human self awareness. Also not so obvious applications such as understanding of gender difference, sleep paralysis - disinhibition of mirror neuron system, hallucinations, and empathy characterizing schizophrenia. One can however argue that mirror neuron hypothesis is not realistic in its strong form stating that observed behavior (bodily motor action) active mirror neurons, which induce the motor action.

The proposed applications of mirror neuron hypothesis in its strong form lead to many inconsistencies. Poeppel mentions [**?**] what he calls merological fallacy: psychological properties assignable to entire organism are assigned to single neuron. Behavior is used to deduce hypothesis that mirror neurons understand - a more realistic approach would rely in neuron groups and this again brings in EEG and the questions raised by its unknown function. There are critical articles about mirror neurons describing in detail various failures [**?**, **?**, **?**] (see `http://tinyurl.com/y7jqljwv`, `http://tinyurl.com/y8pelhhl`, and `http://tinyurl.com/y7vhyfe6`). The most intriguing anomalies from TGD point of views relate to time anomalies: mirror neurons would act too fast, considerably faster than simple estimates based on the rate of nerve pulse conductions and neural information processing allow.

13.1.2   Brain wave synchrony between brain regions related to speech understanding and speech production

The popular article (see `http://tinyurl.com/y8a4puca`) that inspired this article mentioned also an article [?] (see `http://tinyurl.com/y79r62v9`) by David Poeppel and his student Florencia Assaneo. The frequency f for syllables of understandable speech varies between 2 and 7 Hz and the average frequency of the syllables in various languages is about 4.5 Hz. Auditory region related to the understanding of speech - Wernicke's area - entrains with the frequency for the rate for syllables in the range 2-7 Hz.

The discovery was that speech motor region - Broca's area- at opposite brain hemisphere - entrains with the auditory region in the range 4-5 Hz and resonance occurs around 4.5 Hz. Therefore the synchronous firing and associated brain waves could play an essential role in the understanding of speech. The interpretation could be that the speech input at these frequencies generates internal speech as imagined motor action not propagating to the level of speech organs (usually).

13.1.3   Time mirror relation and mirror neuron hypothesis

TGD based model for behavior and also mirror neurons relies on TGD inspired theory of consciousness [L54] in which zero energy ontology (ZEO) plays a crucial role. ZEO predicts that the arrow of time can vary and indeed does so in living matter. A natural conjecture is that sensory perception and motor action are time reversals of each other so that motor action would be sensory perception in reverse time direction. Sub-selves of self - mental images - would form an analog of monad network introduced by Leibniz long time ago. They would however reflect each other time direction rather than spatial directions: ...-sensory-motor-sensory...

Time mirror hypothesis explains surprisingly many time-related anomalies in living matter and neuroscience such as the classical discovery of Libet [?] that neural activity precedes conscious decision by a fraction of second: physicalistic explanation would be forced to give up free will. The study of mirror neurons has revealed further anomalies of this kind: in particular, mirror neurons react much faster than the estimates based on the conduction velocities of nerve pulses and the rates of information processing in brain would suggest. If motor action is sensory perception in reversed time direction, one could get rid of these anomalies. Quite generally, sensory perception of B by A and its time reversal as motor action would be fundamental building brick in conscious information processing and would allow to use memory storages in geometric past to generate planned responses in much shorter time than velocities of nerve pulse conduction would suggest.

Besides the sensory-motor duality as time reversal, the TGD based view about space-time and classical fields predicts that any system has field identity - field body or magnetic body (MB) and that MB can be seen as an intentional agent using biological body as a sensory receptor and motor instrument. A further piece in TGD story is the identification of dark matter as a hierarchy of phases of ordinary matter labelled by the value of $h_{eff} = n \times h_0$ of effective Planck constant and residing at MB. In this framework the observed entrainment of left and right language regions around 4.5 Hz can be seen as additional support for the idea that EEG is involved with communication from brain to MB possessing a hierarchical onion-like structure corresponding to analogs of EEG at in various frequency ranges.

This vision allows to build a model of sensory memories with motivation coming from the findings [?] challenging the standard view about them. This model in turn inspires a very general model of motor action applying also to basic biochemical processes such as transcription, replication, and translation as being induced by topological quantum computer programs running in non-standard time direction.

13.2   TGD based model for sensory-motor consciousness

TGD based model for sensory-motor consciousness relies on the hypothesis that sensory perception and motor action are time reversals of each other. Second assumption is that sensory percept and therefore also motor action is constructed by an iterative process involving forth-and-back communications by dark photons between sensory areas and sensory organs at which sensory

qualia are assigned in TGD framework (this is possible assuming ZEO based view about time). The outcome of this iteration is standardized mental image as near as possible to the sensory input picking up only the features relevant for survival.

This process could correspond to single sub-self representing mental image and communications in single direction of geometric time. A more general view is that this process corresponds to a sequence of this kind of iterations as sequence of re-incarnations of mental images so that communications in both directions of time would be involved. The prediction is that sensory consciousness is not a continuous stream but contains black spots.

13.2.1 Basic ideas of TGD related to consciousness and biology

It is good to start by listing the basic assumptions of TGD inspired quantum theory of consciousness and of biology.

MB is central for TGD inspired biology.

1. A first key notion appearing at the level of TGD inspired quantum biology is due to the differences between Maxwellian and TGD based view about classical em fields. In Maxwellian world the em fields of separate systems superpose and the information is lost much like in the formation of sum 7= 3+4: one does not know whether '7' is the outcome of 7+0, 6+1,5+2, or 4+3. Now one does not know what the fields in the superposition are. In TGD framework many-sheeted spacetime stores the information since the fields of given system are at their own space-time sheets defining field identity, field body or MB.

   MB has hierarchical onion-like structure corresponding to different lengths scales. The communications from biological body to EEG and vice versa are possible by the generalization of EEG. Josephson radiation assignable to cell membrane mediates information about sensory input and MB controls BB by using cyclotron radiation as a tool.

   One can say that MB serves as an intentional agent using biological body as a sensory receptor and motor instrument. Biochemistry would be controlled by MB and represent a kind of shadow dynamics. The MB of DNA is conjectured to realize genetic code in terms of dark proton sequences with entangled state of 3 protons defining genetic codon. Similar picture applies also to other basic biomolecules. This encourages the hypothesis that inheritance is basically realized at the level of MB and genes code for 4-D dynamical patterns - biological functions - rather than only for 3-D structures.

2. MB can be seen as 4-D entity rather than 3-D object. The biological interpretation of 4-D MB would be as the classical correlate for behavior. In WCW picture the second end of MB at the active boundary of CD cannot be fixed like the end at the passive boundary to single state. For the cognitive representations with finite measurement resolution to be discussed below this could be the case so that one could speak of unique classical space-time in fixed measurement resolution in accordance with everyday thinking. In fermionic degrees of freedom one cannot fix the state at active boundary.

   MB is preferred extremal of the action and satisfies extremely powerful additional conditions so that it represents kind of archetypal field pattern. 4-D MB is also analogous to a computer program and the superposition of time evolutions of MB could be regarded as quantal computer program running. State function reductions as acts of free will put a new program running.

   Adelic physics is second central part of TGD.

1. Number theoretic vision about physics - adelic physics [L51, L52] leads to the hypothesis about hierarchy of effective Planck constants $h_{eff} = n \times h_0$ defining a hierarchy of phases of ordinary matter identified as dark matter. n corresponds to the dimension of extension of rationals and for Galois extensions to that of Galois group. The larger the value of n, the larger the maximal value of p-adic entanglement negentropy so that n serves as a kind of IQ. The energies of quantum states as function of n increase and the increase of n requires a feed of metabolic energy.

2. The preferred p-adic primes p are tentatively identified as ramified primes for which the ordinary primes do not decompose to a maximal number of primes of extension but there are less than the maximum number of them and some primes occur several times. There is a direct analogy with the decomposition of polynomials to a product of monomials. At criticality some roots co-incide and power of monomial appears. The natural interpretation would be in terms of quantum criticality.

3. p-Adic length scale hypothesis [K64] emerged via p-adic mass calculations already before I had not realized that p-adic physics is an excellent candidate for the physics of imagination, intention, and cognition and is in central role in concrete applications. For instance, the length scale range between 10 nm and 2.5 μm especially relevant for biology contains four Gaussian Mersenne primes - this is a number theoretical miracle [K51].

4. In adelic physics imagination would correspond to the failure of strict determinism of p-adic differential equations due to the existence of p-adic pseudo constants - functions depending on finite number of pinary digits but having vanishing derivative. The challenge is to find concrete examples in which this p-adic vision about cognition, imagination, and intention is be realized. The challenge is not easy since p-adic number fields represent mathematics completely new for even physicists.

TGD inspired theory of consciousness [L54] relies on zero energy ontology (ZEO).

1. ZEO based theory of quantum measurement allowing to solve the basic paradox of the standard quantum measurement theory make observer part of the physical. The nondeterministic causality of free will and deterministic causality of unitary time evolution and of classical field equations are not in conflict anymore. The basic outcome is the notion of self as a conscious entity.

   Causal diamond (CD) and zero energy state are the key notions of ZEO. Zero energy state is a superposition of pairs of ordinary quantum states at opposite boundaries of CD with members having opposite total quantum numbers to guarantee classical conservation laws for the time evolutions connecting the members also classically. These pairs are analogous to events with members of zero energy state defining analogs of initial and final state of both classical and quantal time evolution.

2. Evolution of self can be seen as a sequence of unitary evolutions leaving the passive boundary of CD and members of states at it unaffected but inducing dispersion of the active boundary in the moduli space of CDs. This is followed by "small" state function reduction defining an analog of weak measurement (see `http://tinyurl.com/zt36hpb`) inducing localization of the active boundary of CD in the moduli space, in particular meaning measurement of clock time identified as temporal distance between the tips of CD. As a consequence, the size of CD increases at least in statistical sense and this is experienced as flow of time.

   The process eventually stops since one expects that all observables are eventually measured and further time evolution would require extension of rationals involved if one wants that the eigenstates of density matrix are still in the extension. The proposal is that the extension cannot increase in "small" state function reduction. Next step is "big" state function reduction as analog of ordinary state function reduction in which the roles of boundaries of CD are changed. Self dies and reincarnates in opposite time direction and CD starts to increase in opposite time direction.

3. Since deterministic time evolution of state replaces time= constant snapshot as a basic notion, this leads to a new view about geometric time and its relation to experienced time: one can speak about 4-D brain, about signalling in both time directions, a new view about memory emerges, and various time anomalies such as that found by Libet [?] find an explanation.

4. Motor action as time reversal sensory perception is a conjecture made for years ago. The challenge is to find support for the hypothesis. In this article this hypothesis is studied in more detail and the generalization of mirror neuron hypothesis to time mirror hypothesis is proposed. This generalization would apply to any conscious entity and one could see all conscious entities perceiving each other and interacting as kind of Leibniz monads time mirroring each other.

13.2.2 Challenging ZEO and CDs

In order to proceed it is best to not forget to invent objections against the the new assumptions. The notion of ZEO and CD are the certainly such notions.

There are critical questions related to the definition of the hierarchy of CDs.

1. What determines CD? Somehow the space-time dynamics should do it without any ad hoc assumptions. There are indeed strong indications from $M^8 - H$ correspondence, that CDs emerge naturally from the properties of octonionic polynomials [L43].

   For instance, 8-D Poincare transformation generate different octonion structures and time axis as real axis for octonions must contain the tips of CD. The preferred octonionic coordinates are highly unique and allow only the rotations leaving time axis defining the rest system invariant. Poincare symmetries are real symmetries but change the octonion structure. If the definition of octonion structure involves also the preferred associative subspace as $M^4 \subset M^8$ and the choice $M^2 \subset M^4$ as preferred commutative sub-space, the coordinates are highly unique as required by the number theoretic vision. This uniques corresponds to uniqueness at the level of H.

2. Do space-time surfaces continue beyond CD or do they have naturally ends at boundaries of CD? For instance, could it happen that all the roots for the octonionic polynomials become complex outside CD so that one cannot have real roots. If one requires that space-time surface corresponds to real root rather than projection to a real sub-space of M^8 this cold force CDs. Why the ends would be M^4 light-cones (with points replaced with CP_2? Twistor Grassmann approach [K38, L53] suggests that CDs can contain sub-CDs connected by the analogs of lines of twistor diagrams and represented as 4-surfaces representing mass shall particles in complex sense and having minimal surfaces as space-time correlates.

3. Can CDs intersect and overlap and how to describe this mathematically at space-time level? What would be the physical interpretation for the overlap?

   One can also invent criticism related to conscious experience.

1. CDs would represent kind of spot-light of consciousness defining 4-D perceptive field of sub-self. The size of CD increases reduction by reduction at least in statistical sense. Sub-selves of self would correspond to mental images and have sub-CDs as embedding space correlates.

   The intuitive idea is that mental images can appear and disappear. Does this mean that sub-CDs can also appear and disappear in some sense? Is this natural mathematically?

   Conservation laws force the total quantum numbers at its opposite boundaries to be opposite. The analogy of zero energy state in QFT would be vacuum fluctuations. The CD and corresponding zero energy state would obey the usual evolution giving rise to self. If CD of finite size has vacuum quantum numbers at its both boundaries, its creation from vacuum is allowed by conservation laws. Is this kind of zero energy state for any CD equivalent with having no CD at all? If so then the disappearance of mental images is possible if the mental image contains in its wave function also vacuum-vacuum part carrying no information.

2. It has been assumed that CDs increase monotonously in size during the sequence of "small" state function reductions giving rise to self as a generalized Zeno effect. The assumption about monotonic increase of size is however un-necessarily strong. The reason is that in the moduli space of CDs (determined by the action of Poincare group and size scale of CD) the number of CDs larger than given CD is infinitely larger than those with smaller size so that in statistical sense CD is bound to increase.

3. What about sub-selves of given self? Is self conscious also about its sub-selves with an opposite arrow of time? If one looks at lamp and closes eyes, one finds that the after image appears and disappears periodically. If this corresponds to a periodic re-incarnation of sub-self, the sub-selves with opposite time orientation would not be experienced as mental images by self. The interpretation of sensory percept in opposite time direction as a motor action would make the absence of after image natural.

4. The idea that big state function reductions take place when the density matrix has eigenvalues not belonging to the extension of rationals defining the entanglement coefficients is very attractive number theoretically but can be claimed to be somewhat ad hoc.

13.2.3   ZEO based model for sensory-motor consciousness

Let us summarize the ZEO based view about sensory-motor consciousness.

1. Quantum jumps between superpositions of temporal patterns define selves and therefore also mental images in ZEO. Consciousness is in the quantum jumps - between initial and final worlds - rather than in the world itself so that consciousness is not a property and one should not use "-ness" of physicalist.

   That visual consciousness fades if the pupil is not in saccadic motion relative to the visual field conforms with the prediction that consciousness in the quantum jump replacing the quantum world with a new one.

2. Motor action is identified as time reversal of sensory perception. The interpretation in standard direction of time is as a motor response. During this period there would be not sensory consciousness. The phenomenon of after images supports the vision about sequence of re-incarnations of mental images as sub-selves. Even the prediction of re-incarnation, which certainly tests the patience of physicalist, finds direct support. The temporary absence of after image correspond to an after image living in opposite direction of time and having interpretation as motor action. The mental images with time direction opposite to that of self would not be consciously experienced.

3. In the model proposed earlier [L42] sensory mental images are produced by iteration in which signals travel forth and back between sensory organ and brain (and even MB and sensory organ) and the virtual sensory input adds to the real one to generate standardized mental images containing only the features relevant for survival. This would be essentially pattern recognition, finding the standard mental images nearest to the sensory input by using virtual sensory input.

   The signalling is by dark photons - nerve pulses would be quite too slow for this purpose and they would only generating communication pathways - kind of wave guides - by building transmitter bridges connecting pre- and post-synaptic neurons. The flux tubes of MB would accompany axons and dark photons would propagate along them.

4. One can ask whether the forth-and-back communication is in a fixed direction of time or whether the time direction varies so that one would have a sequence of re-incarnations for mental images: ...-sensory-motor-sensory-...

   It must be emphasized that each step between two time reflections involves a sequence of unitary evolutions followed by weak measurements, and that this period could involve forth and back communications between sensory organ and say brain with single direction of time. Therefore both mechanisms could be involved. One can also argue that the virtual sensory input should contain the component in the standard time direction. If it were in the opposite direction of time only, it is not clear whether it could superpose with the ordinary sensory input.

   The sensory input in opposite time direction is free from the limitations posed by the finite conduction velocity of nerve pulses and light-velocity. In principle, time travel to the layers of MB in distant past providing information about memories could contribute to the eventual motor response. Also now time would grow in the sense that the size of CD grows in statistical sense at least.

   One could also speak of pattern recognition in 4-D sense at classical level. For cognitive representations in terms of common points of real and p-adic space-time surfaces (belonging to an extension of rationals) there could be a complete localization in the "world of classical worlds" (WCW) to a discretized space-time surface. Actually this would be only localization modulo finite measurement resolution.

5. This picture would apply as such to motor action. Also motor action would be generated by a similar sequence using virtual sensory input in opposite time direction to reach standard motor output. Also sensory and motor imagination can be understood in this framework as also hallucinations and psychedelic experiences [L15].

6. The basic prediction is gaps in sensory (say visual) consciousness due to the motor actions inducing a motion of sensory organ or part of it, say pupil. By looking at mirror anyone can indeed verify that eye cannot see the motion of pupil. A general qualitative implication would be that the performance on motor action is optimal when sensory input is minimal and vice versa. It is known that sensory consciousness is not continuous but contains black spots.

   It is known that during attention shift visual consciousness is lost (see `http://tinyurl.com/ych6atb6`), and since saccadic motion means shifting of attention, one can argue that visual awareness is lost during the motion of pupil.

   Saccadic motions (see `https://en.wikipedia.org/wiki/Saccade`) induced by an unexpected stimulus normally take about .2 seconds to initiate, and then last from about 20–200 ms (20–30 ms is typical in language reading). The estimate for the duration of the sensory mental image is about .1 seconds as cronon of sensory subjective time. If the unexpected stimulus emerges during visual mental image it does not affect it since attention is not directed towards it yet. Mental image must die and re-incarnate in reversed time direction as motor action inducing saccadic motion. After that reincarnation in the original time direction as visual mental image would occur. This would take about .2 s at least.

   Attention blinking (see `https://www.verywellmind.com/what-is-attentional-blink-2795017` is an analogous phenomenon. The subject person perceives a rapid series of numbers in monitor and is asked to report when she sees numbers 2 and 7 in successions. It turns out that if the numbers follow each other within time interval about .5 seconds, the subject does not notice their appearance. This suggests that the duration of sensory percept is about .5 seconds and longer than the time scale about .1 seconds providing estimate for the lifetime of visual mental image. A hierarchy of time scales is predicted and attention blinking would correspond to a considerably longer time scale in the hierarchy.

   Pieces of evidence for this vision emerge from various time anomalies of consciousness.

1. Libet's findings [?] about neural activity preceding conscious decision are so familiar that there is no need to repeat them. The reaction times of boxers are of order 60 ms and are too fast to be understood in terms of neuroscience. Penrose has also described similar strange findings in the case of tennis players. There are also strange findings in the case of mirror neurons. All these findings can be understood if motor action is sensory perception in reversed time direction.

2. The observed de-synchrony of motor neurons after motor action came as a news to me. Synchrony is identifiable as a correlate of quantum coherence at the level of MB controlling the neurons. It has TGD based interpretation in terms of "big" state function reduction changing the roles of motor neurons and of motor organs. Motor organs become quantum coherent passive boundary of CD and neuronal end of CD becomes active boundary and ceases to be in synchrony.

   Motor action as a time reversal of sensory percept inspires fascinating ideas [L15] [?, K115, K84, K46] about communications with geometric past since light-velocity ceases to be a limiting factor and one can visit in distant past. TGD based vision about memories indeed is that the geometric memories are in geometric past, in principle where the events first happened. It is of course possible possible and useful to construct copies of the memories and active memorizing by repeated memory recalls would be one form of learning.

   In this picture sensory percept would be followed by a visit to geometric past or even sequences of visits forth and back to rummage memories. Only the time lapse assignable to the increase of the size of CD would pose limits on the time used. This might revolutionize the picture about sensory and motor consciousness.

13.2.4   p-Adic physics as correlates of imagination, cognition, and intention

The idea that p-adic physics could provide physical correlates of imagination, cognition, and intentionality is very attractive. The challenge is to formulate in more concretely and perhaps even find direct applications in neuroscience.

Imagination, intention, cognitive representations and real world

p-Adic preferred extremals involve p-adic pseudo constants having vanishing derivative by definition and depending on finite number of pinary digits. For p-adic extremals having interpretation as real preferred extremals the pseudo constants become genuine. Imagination is realized when p-adic pseudo constants are possible.

1. This inspires the general idea is that motor action is generated by a repeated trial and error procedure in which p-adic variant of the preferred extremal is replaced by a more realistic one. The real counter part of p-adic preferred extremal would increase in size scale and eventually connect both boundaries of CD and define a realization of intention as action. I have compared this process to building a four-dimensional statue starting from a rough sketch.

2. One has two interpretations for what this could mean at the level of motor system. Motor action as time reversal of sensory action would suggest that the process begins from muscles as time reversed sensory signal providing a rough sketch of the motion and is reflected back if the completion to full real extremal fails and followed by a new trial. The process would be repeated until full realization would be achieved. In standard direction of time motor action would begin from brain as neuroscience pictures it or even MB. This would conform with the fact that we experience the motor action as starting from muscles rather than brain. The intuitive picture that MB controls brain rather than muscles conforms with the idea of motor action as time reversed sensory perception.

   A similar description would apply to sensory perception in standard time direction. The forth-and-back iteration as trial and error process would proceed gradually to higher and higher levels in the hierarchy starting from sensory organ and continuing via primary, secondary and tertiary sensory areas and eventually possibly reaching MB via EEG.

   There are several descriptions for this completion process giving rise to a full perception or motor action via trial and error process.

1. Continuum picture is based real and p-adic space-time surfaces. Here the notion of "world of classical worlds" (WCW) is essential [K87]. At this level strong form of holography (SH) allows a formulation of the idea about completion of intention to action. One can assign data to 2-D surface and continue so that it gives 4-D space-time surface by strong form of holography.

   In p-adic case this is easy by the existence of p-adic pseudo constants. In the real case the continuation need not be possible. If p-adic pseudo constants can be chosen to be genuine constants then the realization of imagination and intention is realizable.

2. Second view is based on discrete cognitive representations as intersection of p-adicities and reality [L51, L52]. One assigns to real and p-adic preferred extremals common points having coordinates in the extension of rationals considered. The symmetries of the embedding space allow very restricted class of preferred coordinates so that problems with general coordinate invariance can be overcome. This set of points is discrete and perhaps even finite set.

3. $M^8 - H$ duality provides a third view. One must complexify M^8 so that one has complexified octonions M_c^8. This means the addition of imaginary unit i commuting with octonionic imaginary units. The vanishing of real or imaginary part of octonionic polynomial in quaternionic sense ($o = q_1 + Jq_2$) defines the space-time surface. Octonionic polynomial itself is obtained from a real polynomial by algebraic continuation so that in information theoretic

sense space-time is 1-D. The roots of this real polynomial fix the polynomial and therefore also space-time surface uniquely. 1-D line degenerates to a discrete set of points of an extension in information theoretic sense. In p-adic case one can allow p-adic pseudo constants and this gives a model for imagination.

The roots $x + iy$ of the real polynomial need not however be real. There are two options.

(a) I have proposed in [L43, L45] that the *projection* from M_c^8 to real M^4 (for which M^1 coordinate is real and E^3 coordinates are imaginary with respect to i!) defines the real space-time surface mappable by $M^8 - H$ duality to CP_2.

(b) An alternative option, which I have not considered in the original versions of [L43, L45] is that only the roots of the 4 vanishing polynomials as coordinates of M_c^4 belong to M^4 so that m^0 would be real root and m^k, $k = 1, ..., 3$ imaginary with respect to $i \to -i$. M_c^8 coordinates would be invariant ("real") under combined conjugation $i \to -i, I_k \to -I_k$. In the following I will speak about this property as *Minkowskian reality*. This could make sense. Outside CD these conditions would not hold true. This option looks more attractive than the first one. Why these condition can be true just inside CD, should be understood.

4. The first two approaches would be equivalent if $M^8 - H$ duality defines the cognitive representations as roots of polynomials. The use of polynomials or rational functions could be also an approximation. Analytic functions of real variable extended to octonionic functions would define the most general space-time surfaces but the limitations of cognition would force to use polynomial approximation. The degree n of the polynomial determining also $h_{eff} = nh_0$ would determine the quality of the approximation and at the same time the "IQ" of the system.

Consider now the third approach in more detail.

1. One argument against number theoretic vision is that it breaks general coordinate invariance since the choice of cognitive representation depends on the choice of embedding space coordinates. At level of M^8 this objection can be circumvented since the choice is highly unique. 8-D Poincare transformations generate different octonion structures and time axis as real axis for octonions must contain the tips of CD. The preferred octonionic coordinates are highly unique and allow only the rotations leaving time axis defining the rest system invariant. Poincare symmetries are real symmetries but change the octonion structure. Since the definition of octonion structure involves also the preferred associative subspace as $M^4 \subset M^8$ and the choice $M^2 \subset M^4$ as preferred commutative sub-space, the coordinates are highly unique as required by the number theoretic vision. This uniqueness induces uniqueness at the level of H.

2. One can think of starting from one of the 4 vanishing conditions for the components of octonionic polynomial guaranteeing associativity. Assuming real roots and continuing one by one through all 4 conditions to obtain 4-D Minkowskian real regions. The time coordinate of M^4 coordinates is real and others purely imaginary with respect to $i \to -i$. If this region does not connect 3-D surface at the boundaries of real CD, one must make a new trial.

Cusp catastrophe determined as the zero locus of third order polynomial provides an example. There are regions with single real root, regions with two real roots (complex roots become real and identical) defining V-shaped boundary of cusp and regions with 3 real roots (the interior of the cusp).

3. The restriction of the octonionic polynomial to time axis m^0 identifiable as octonionic real axes is a real polynomial with algebraic coefficients. In this case the root and its conjugate with respect to i would define the same surface. One could say that the Galois group of the real polynomial characterizes the space-time surface although at points other than those at real axis (time axis) the Galois group can be different.

One could consider the local Galois group of the fourth quaternionic valued polynomial, say the part of quaternionic polynomial corresponding to real unit 1 when other components are

required to vanish and give rise to coordinates in $M^8 \subset M_c^8$ - Minkowskian reality. The extension and its Galois group would depend on the point of space-time surface.

An interesting question is how strong conditions Minkowskian reality poses on the extension. Minkowskian reality seems to imply that E^3 roots are purely real so that for an octonionic polynomial obtained as a continuation of a *real* polynomial one expects that both root and complex conjugate should be allow and that Galois group should contain Z_2 reflection $i \to -i$. Space-time surface would be at least 2-sheeted. Also the model for elementary particles forces this conclusion on physical grounds. Real as opposite to imagined would mean Minkowskian reality in mathematical sense. In the case of polynomials this description would make sense in p-adic case by allowing the coefficients of the polynomial be pseudo constants.

4. What data one could use to fix the space-time surface? Can one start directly from the real polynomial and regard its coefficients as WCW coordinates? This would be easy and elegant. Space-time surface could be determined as Minkowskian real roots of the octonionic polynomial. The condition that the space-time surface has ends at boundaries of given CD and the roots are not Minkowskian real outside it would pose conditions on the polynomial. If the coefficients of the polynomial are p-adic pseudo constants, this condition might be easy to satisfy.

The situation depends also on the coordinates used. For linear coordinates such as Minkowski coordinates Minkowskian reality looks natural. One can however consider also angle like coordinates representable only in terms of complex phases p-adically and coming as roots of unity and requiring complex extension: at H-side they are very natural. For instance, for CP_2 all coordinates would be naturally represented in this manner. For future light-cone one would have hyperbolic angle and 2 ordinary angles plus light-cone proper time which would be real and positive coordinate.

This picture conforms with the proposed picture. The point is that the time coordinate m^k can be real in the sense that they are linear combinations of complex roots, say powers for the roots of unity. $E_c^4 \subset M_c^8$ could be complex and contain also complex roots since $M^8 - H$ duality does not depend on whether tangent space is complex or not. Therefore would could have complex extensions.

13.3   TGD view about mirror neurons

Mirror neurons provide an application for the TGD view about sensory-motor activity replacing mirror neuron hypothesis with time mirror hypothesis.

13.3.1   Basic facts about mirror neurons

A mirror neuron (see http://tinyurl.com/d6svmf7) is a neuron that fires both when an animal acts and when the animal observes the same action performed by another. Mirror neurons were discovered by studying macaques: the inferior frontal gyrus (region F5) and the inferior parietal lobule were found to contain them. Mirror neurons are motor neurons firing when the animals perceives visually motor action and also when animal itself generates a goal directed motor action. 10 per cent of neurons in inferior frontal and inferior parietal cortex of macaques are mirror neurons. The mirrored motor actions could correspond to heritable genetic factors.

Such neurons have been directly observed in some primate species. Birds have been shown to have imitative resonance behaviors and neurological evidence suggests the presence of some form of mirroring system. For ethical reasons the testing of the hypothesis is not possible at neuronal level for humans and other methods such as fMRI must be used. Bain activity consistent with that of mirror neurons has been however found in inferior frontal cortex, premotor cortex, supplementary motor area, the primary somatosensory cortex and the superior parietal lobe.

The function of the mirror system in humans is a subject of much speculation. Some researchers in cognitive neuroscience and cognitive psychology consider that this system provides the physiological mechanism for the perception/action coupling (see the common coding theory). They argue that mirror neurons may be important for understanding the actions of other people, and for learning new skills by imitation. Some researchers speculate that mirror systems may simulate observed actions, and thus contribute to theory of mind skills, while others relate mirror

neurons to language abilities. Neuroscientists such as Marco Iacoboni (UCLA) argue that mirror neuron systems in the human brain help us understand the actions and intentions of other people. In a study published in March 2005 Iacoboni and his colleagues reported that mirror neurons could discern whether another person who was picking up a cup of tea planned to drink from it or clear it from the table. In addition, Iacoboni has argued that mirror neurons are the neural basis of the human capacity for emotions such as empathy.

In humans mirror neurons would be involved in action knowledge, imitation and pantomime interpretation (not possessed by adult monkeys), and biological motion perception. Supplementary motor area and medial temporal cortex would be also involved. In the case of language interpretation possibly as internal speech speech motor region - Broca's region proposed to be a homologue of monkeys ventral premotor cortex, and Wernicke's are in opposite brain hemisphere responsible for speech perception are especially interesting.

Many functions for mirror neurons have been suggested and some of the are not consistent with what has been found in monkeys or have not been found in monkeys. The list of the proposed applications to humans is impressive: understanding intentions, imagination, learning facilitation, learning by imitation, automatic imitation and motor mimicry, understanding and learning of language, empathy, autism, theory of mind, human self awareness. There are also not so obvious applications such as understanding of gender difference, sleep paralysis - disinhibition of mirror neuron system, hallucination, and empathy characterizing schizophrenia. Mirror neuron hypothesis is however criticized as being too limited in its basic form stating that the strong form stating that observed behavior (bodily motor action) activates mirror neurons, which induce the motor action.

13.3.2 Time mirror mechanism as TGD counterpart of mirror neuron hypothesis

Time mirror hypothesis is a natural generalization of mirror neuron hypothesis in TGD framework. The two systems would to correspond to opposite ends of CD and in big state function reduction their roles would change.

When two systems can be in time mirror relationship?

When two systems can be in time mirror relationship?

1. Speech and its understanding are in very special role as also the results of Poeppel and his student [**?**] show. In TGD framework the time mirror relationship would be between the brain regions involved with the understanding of speech at and those involved with speech production at the opposite hemisphere.

2. The model for the generation of sensory percept as a forth-and-back communication between sensory organ and brain (or even MB) involving dark photon signals propagating with light velocity in same time direction. Time mirror hypothesis applied to sensory organs and brain suggests a generalization of this picture: sensory organ and the sensory cortex are in time mirror relationship making possible a sequence of reincarnations of the mental image so that signals can proceed in both directions of time. This would conform with the fact that the sensory consciousness has gaps.

3. Could any mutually communicating brain regions be in time mirror relationship? The presence of magnetic flux tubes along which dark photons can propagate is assumed to serve as a correlate for directed attention. Could their presence guarantee also the time mirror relationship. For instance, the neuron groups of primary, secondary and tertiary sensory and motor regions, and premotor regions and primary motor regions attend to each other and therefore be in time mirror relationship. This could be true also for the regions of brain and parts of MB. This would conform with the hypothesis that MB both perceives and controls biological body and is responsible for the third person aspect of consciousness [K101]. This would conform with Leibnizian monadology.

4. Could even sensory organs and target of attention be in time mirror relationship? The perceiver could to some degree control the target of her attention. It is known that authoritative

and charismatic persons such as performing artists can have very strong effect to persons that they attend and are attended by. Could also hypnosis be based on the same mechanism [K44]. The motor reaction of the attended target could come come "too fast", even before becoming becoming target of attention.

If directed attention induced by flux tube connections is enough for time mirror relationship then mirroring property is not static and depends on the relationship between two subsystems. Learning of mirror property would be generation of directed attention. This would make the model more flexible.

Time mirror hypothesis and the basic aspects of mirror neuron activity

Time mirror hypothesis allows to understand the basic aspects assigned with mirror neuron activity.

1. The percept of motor activity generates imagined or even real motor activity. Internal speech as almost speech is one example. Also real motor activity is generated by the same neuronal activity but for some reason the activity does not proceed to the muscles.

2. Mirror neuron activity is able to distinguish between biological motion and motion of inanimate matter. Time mirror hypothesis reduces the question to that about which systems can be in time mirror relationship. It is obvious that motor neuron activity cannot induce motion of in-animate matter since it is not under motor control so that the problem disappears.

   An interesting question relates to the possible distinction between actual motion and video about actual motion. If the attention involves formation of flux tubes between target and perceiver, there might be differences.

3. Mirror neuron activity seems to require goal directedness of the action meaning that the action is intentional. Time mirror hypothesis allows to understand also this.

Time mirror hypothesis and criticism of mirror neuron hypothesis

In the following I consider the criticism of mirror neuron hypothesis [?, ?, ?] (see `http://tinyurl.com/y7jqljwv`, `http://tinyurl.com/y8pelhhl`, and `http://tinyurl.com/y7vhyfe6`) from the point of view of TGD.
      There are several time anomalies involved.

1. Typically mirror neurons react "too fast" [?, ?]. Sensory-motor associations are too slow to explain these time anomalies for the same reason so that the question is not about mechanism but about the view about time.

2. Measurements of neuron firing delay seem to be incompatible with standard reaction times [?, ?]. The articles [?, ?] mention boxers an an example. The estimate for the reaction time based on the knowledge of the conduction velocity of nerve pulses and neural processing would be about 200 ms. The actual reaction time is around 60 ms. The boxer cannot automatically perform the mirror the motion of the opponent but must be able to decide what to do on basis of the perceived motion. If mirror neurons are involved, there must be a step involving a reaction to the mirrored bodily movement with different movement.

   One could argue that anticipation based on facial expression realized in terms of mirror neurons is in question. But also now the mirror neuron response would be facial expression, real or imagined! Penrose mentions as similar example about tennis players in "Shadows of Mind" [?]: in this case seeing of the facial expression is not possible.

3. Only the type of action, and not the kinematic force with which models manipulated objects, determines neuron activity. According to [?, ?] it was also significant that neurons fired *before* the monkey observed the human model starting the second motor act (bringing the object to the mouth or placing it in a cup). Therefore, IPL neurons "*code the same act (grasping) in a different way according to the final goal of the action in which the act is embedded*". They may furnish a neural basis for predicting another individual's subsequent actions and inferring intention. How the mirror neurons knew that the action is goal directed and intended to a

particular goal although there was no information about it. Also in this case the same TGD based explanation applies: motor areas received actual information about the goal in by signals in non-standard time direction.

Time mirror hypothesis allows to understand these anomalies. The sensory percept corresponds to one end of CD and its second end corresponds to an action determining motor action as a reaction to the sensory percept. What is remarkable that a lot of processing could be done in geometric past since the signal could continue to the MB of geometric past.

One could also consider an alternative explanation. In TGD framework directed attention would correspond generation of magnetic flux tubes connecting boxers and making possible entanglement and sharing of mental images making possible telepathy. This could be tested: do mirror neurons react to actual motor actions (telepathy) and to a video about motor actions (no telepathy) in a similar manner.

There are also other objections against mirror neuron hypothesis.

1. One can argue that mirror neurons must learn to act as mirror neurons during the development of individual. There is however a problem: a new-born infants can mimic gestures although she has never seen them earlier. One explanation would be that these gestures correspond to fixed action patterns, innate and instinctive behaviors coded by genes.

   What about the situation in TGD framework. The first explanation would be that brain regions of infant direct their attention to the sensory areas considered. This is however more like learning.

   Second explanation would be genetic. One can say that genes code for the 4-D preferred extremals represent magnetic bodies and serve as templates for biochemistry. A basic hypothesis is that DNA and other basic biomolecules are accompanied by parallel flux tubes carrying sequences of dark protons - dark nuclei - realizing also genetic code and communicating between themselves using dark photon triplets - kind of 3-chords for music of light - realizing genetic code too [L12, L65].

   In this picture one could say that dark genes at the MB of DNA associate/code for ordinary genes in turn coding for the biolochemistry of the ordinary biomatter. This would be in accordance with the vision that bio-chemistry is controlled and induced by MB acting as boss and having larger value of h_{eff} and thus higher "IQ".

2. There are also problems with adaptation. Mirror neuron hypothesis in its original form predicts that there should be a complete symmetry between sensory and motor sides. Also adaptation should be completely symmetric. In the experiments [?] (see `http://tinyurl.com/y7jqljwv`) adaptation to motor actions, which were performed and then observed or vice versa. Four cases were studied. Motor actions were repeated, motor actions were repeatedly perceived, motor action was first observed and then carried out, and motor action was first carried out and then observed.

   In the first two cases adaptation was observed. Also in the third case as one expects also in the case that association between sensory percept and motor action is in question. In the fourth case adaptation was not observed and this does not conform with mirror neuron hypothesis. It was however later found that the situation is symmetric in the case of goal directed action.

   In TGD framework the result can be understood if only goal directed actions involve the pairing between its sensory percept and realization and assignable at opposite boundary of CD. This of course is very natural definition of goal directed action.

3. At F_5 premotor regions of monkeys there many neurons, which do not act as mirror neurons in the sense that they would respond to a perception of goal directed motor actions. For instance, there are neurons firing for graspable objects alone. Could the mere sensory percept induce an imagined motor action - grasping the object. Is this sensory-motor association or analog of mirror neuron activity?

   What about the interpretation in TGD? Is sensory-motor association in question or do the boundaries of CD represent the percept of a graspable object and the act of grasping. If the

mirror neurons have learned to direct their attention to the sensory neurons active when the
motor action induced by them is perceived, one could interpret the situation in terms of time
mirror hypothesis. One might also argue that in the case of static perceptions there is no
compelling reason for fast reactions so that sensory-motor association could be enough.

4. According to [**?**], "*Despite its widespread acceptance, the proposal has never been adequately
   tested in monkeys, and in humans there is strong empirical evidence, in the form of physiolog-
   ical and neuropsychological (double-) dissociations, against the claim.*". These dissociations
   would mean that time mirror relationship is not present. As noticed, this relationship is in
   principle dynamical if generated by directed attention mediated by flux tube connections.

13.4 The findings about entrainment of the speech regions of right and left brain

The starting point was the popular article (see `http://tinyurl.com/y8a4puca`) telling about
the findings of David Poeppel and his student Florencia Assaneo [**?**] (see `http://tinyurl.com/
y79r62v9`). The basic question inspiring their work was could be put as "*How sound waves put
ideas into your head?*". The answer provided by their would can be phrased as "*Brain waves surf
on the sound waves*". This work relates also to mirror neuron idea but mirror neurons are not
mentioned in the article and Poeppel is critical about mirror neurons in his article [**?**] discussed
briefly in the introduction.

13.4.1 Findings

The basic characteristic of the speech is the frequency with which the loudness of speech changes.
This frequency is determined as the average rate for syllables. This rate various in the range 2-7
Hz for comprehensible speech. Speech regions entrain to this frequency in the range 2-7 Hz The
average frequency of entrained signals in auditory cortex is commonly about 4.5 Hz, which is also
the men rate at which syllables are spoken in various languages.

In the experiments Assaneo studied people listening non-sense syllables (to avoid indirect
effect on motor areas) with rate varying in the range 2-7 Hz. The idea is that if brain waves in
auditory cortex are not independent on those in speech motor cortex they should entrain. This
indeed occurred but only up to 5 Hz (theta waves are in the range 4-7 Hz and mu waves in the
range 7-12 Hz) . At higher frequencies speech waves dropped out of synchrony. A computational
model allowed to verify that this finding is consistent with the assumption that speech motor cortex
has its own internal oscillator driven with a frequency in the interval 4-5 Hz. There was also a
resonance around 4.5 Hz.

Neural model for the finding was based on a model known as Wilson-Cowan mean-field
approximation treating excitatory and inhibitory neuron populations in speech motor region as
competing synchronous units driven in non-linear manner by the oscillatory input from the auditory
regions. Auditory region drive motor-cortex region with a periodic force. The time constant for
the oscillations telling how fast they attenuate exponentially in absence of driving force was 60 ms,
which happens to be also the reaction time of boxers mentioned earlier and could be assigned with
mirror neurons.

The non-linear driving force was taken to be sigma function approaching value 1 for large
positive values of the argument (saturation) and to zero for small values of the argument. The
argument of sigma function was taken to be sum of various inputs excitatory and inhibitory inputs
with opposite sign, background contribution, and the periodic driving force. For large enough
amplitudes oscillatory input the positive part of the signal gives a considerable input whereas the
negative part is cut away. Therefore the system responds essentially to the syllables but not to the
silent periods between them.

13.4.2 TGD based model

Could the finding of Poeppel and Assaneo be understood in terms of the time mirror mechanism?
If so, motor speech regions and auditory regions would be in time mirror relationship - motor

regions would attend the sensory regions and vice versa. The speech motor response - realized as imagined, inner speech - would in standard time direction appear before the sensory input and be due to the communication by negative energy signals. Maybe this could be tested by using sharp enough pulses as sensory input. The periodic appearance of the syllables is however expected to mask this effect unless one uses different syllables.

In TGD framework speech regions would communicate to a layer of MB with cyclotron frequency which $E_{g,J}$ and generate a resonant response in opposite time direction with this frequency in turn inducing resonant firing at the speech regions. Neuroscientist would assume resonant interaction of brain hemispheres using nerve pulses.

One can make this model more concrete if one accepts the vision about MB as receiver of sensory input from neuronal membranes as Josephson radiation with Josephson energy $E_J = ZeV$ and scaled down Josephson frequency $f_J = ZeV/h_{eff}$. A more general model [K51, K35, K80] assumes generalized Josephson energy supported by the basic facts about nerve pulse generation given by

$$
\begin{aligned}
E_{g,J} &= \Delta E_c + E_J = h_{eff}f_{g,J} \ , \quad f_{g,J} = \Delta f_c + f_J \ , \\
f_c &= \frac{ZeB_{end}}{2\pi m} \ , \qquad\qquad\qquad f_J = \frac{ZeV}{h_{eff}} \ , \\
E_c &= \hbar_{eff}\frac{ZeB_{end}}{m} \ , \qquad\qquad E_J = ZeV \ .
\end{aligned}
\tag{13.4.1}
$$

The generalized Josephson frequency is identified as a sum for the difference of cyclotron frequencies at two sides of the membrane and of the scaled down Josephson frequency. The assumption that scaled down Josephson frequency gives a small perturbation to the dominating difference of cyclotron frequencies and codes nerve pulse patterns as small modulations of $f_{g,J}$. One can however consider also a situation in which only f_J is present.

Here Z and m denote the mass and charge of the charged particle, say ion, or of corresponding Cooper pair, forming cyclotron Bose-Einstein condensate. One has $h_{eff} = n \times h_0$, where h_0 is the minimal value of h_eff and $h = 6 \times h_0$ is the most reasonable estimate for h found hitherto. There are two conditions on the model. The condition that $f_{g,J}$ is 4.5 Hz and the condition that $E_{g,J}$ is in visible and UV range.

The frequencies $f_{J,g}$ at cell membrane and f_c at MB should be roughly the same in resonance. In the applications the "endogenous" magnetic field B_{end} is assumed to have the minimal value $B_{end} = .2$ Gauss, 2/5 of the Earth's magnetic field. B_{end} is with inspiration coming from the p-adic lengths scale hypothesis [K64] assumed to have a spectrum spectrum consists of similar octaves with the frequencies in a given octave corresponding roughly to the spectrum of possible notes in music experience.

1. The expressions

$$
E_{g,J} = \frac{n}{6}\frac{Ze\Delta B_{end}}{2\pi m} + ZeV \ , \quad f_{g,J} = \frac{Ze\Delta B_{end}}{2\pi m} + ZeV \ ,
\tag{13.4.2}
$$

allow to estimate the value of h_{eff} and ΔB_{end} for given Z and m. For the membrane voltage one can use the estimate $eV \simeq .06$ eV. $f_{g,J} = 4.5$ Hz gives one constraint. The condition that the dark photons involved transfrom to bio-photons with energies in visible and UV range gives second constraint. The condition that $E_{g,J}$ is at the lower limit of visible energies gives $E_{g,J} = 1.65$ eV.

The cyclotron frequency for Ca^{2+} in $B_{end} = .2$ Gauss is 15 Hz and from Z/A scaling one can express the cyclotron energy for ion (A, Z) or Cooper pair with mass $(2A, 2Z)$ as $E_c(A, Z) = (20/A)E_c(A, Z) = (20Z/A) \times 15$ Hz. Signalling between hemispheres using radiation along short flux tubes connecting them is not of course excluded.

2. The hypothesis $\hbar_{eff} = nh_0 = \hbar_{gr} = GM_D m/\beta_0$ is central piece of TGD inspired quantum biology. $h = 6 \times h_0$ is the most plausible possibility. $\hbar_{gr}$ is the gravitational Planck constant introduced by Nottale [E3] and M_D corresponds to large dark mass and β_0 is a parameter with dimensions of velocity: for a detailed discussion see [L57]. The hypothesis implies that $h_{eff} \propto 1/A$ where A is mass number of ion so that cyclotron energies do not depend on mass

of the ion and are universal. Josephson frequencies would scale like $f_J \propto 1/A$ and cyclotron times as $\tau_J \propto A$. Different ions would be at flux tubes with different value of $h_{eff} \propto A$.

3. Comorosan effect corresponds to a universal biorhythm of 5 seconds [I58, I18] and recently it was found to relate to the clustering of RNA polymerase proteins in the transcription of RNA [I23] (see `http://tinyurl.com/y9wzt5yl`). The origin of Comorosan effect is not understood, and I have proposed [K122] that it relates to Josephson effect at the level of biomolecules in bio-catalysis. In [L58] I developed a model in which proton's Josephson time for proton in Josephson junctions involved with bio-catalysis equals to 5 s.

   If the cyclotron frequency $f_c = 300$ Hz of proton for $B_{end} = .2$ Gauss corresponds to bio-photon energy of x eV, one obtains in the case of proton the condition [L58]

   $$r = \frac{h_{eff}}{h} = \frac{\hbar_{gr}}{\hbar} \simeq .83 \times 10^{12} x \ .$$

   If cell membrane potentials are Josephson junction consistent with the model, the Josephson times for ions with mass number A would be $\tau_J = A \times 5$ seconds. These scales would obviously correspond to the scales of conscious experience. The cyclotron energies would not depend on the mass number at all. If the spectrum of bio-photon energies has lower bound at the end of visible spectrum at 1.65 eV one has $x = 1.65$ as a natural first guess.

4. One can look for cyclotron frequencies for ions for $B_{end} = .2$ Hz. The frequencies $f_c \in \{4.0, 4.5, 5.0\}$) Hz corresponds to atomic weights $A \in \{75, 67, 60)\}$. Josephson times would be for the above model of Comorosan effect given by $f_J(A) = A \times 5$ seconds. This gives the following table containing data also for iron for which cyclotron frequency is rather near to 10 Hz in alpha band.

ion	A	f_c/Hz	τ_J/s
Cu	63	4.8	315
Zn	68	4.4	340
Se	74	4.1	370
Fe	56	10.3	280

   (13.4.3)

   Josephson times are rouhgly between 5 and 6 minutes for Cu, Zn, and Se. The differences of cyclotron frequencies are expected to have same order of magnitude and therefore also corresponding energies for bio-photons.

   If one assumes that the energies are in IR but above thermal energy of photon at physiological temperatures the scales of cyclotron energies and Josephson times are reduced by a factor $\sim 1/50$: $x \to x/50$. For Fe one would obtain $\tau_J \sim 5$ seconds, which happens to be Comorosan time again.

5. The part of MB associated with motor regions controlling speech receives information at these EEG frequencies and sends control signal, which do not propagate down to speech muscles except in some special cases. Note that the size scale of this layer of MB is from the condition that cyclotron wavelength gives the size scale of MB roughly 1.7 times the circumference of Earth from Schumann frequency 7.8 Hz.

6. The prediction is that right and left speech regions are not conscious simultaneously. Auditory experience is not possible when one speaks or even when internal speech is present. This can however happen only in the time scale defined by the duration of syllable and would be of the order $1/2f \sim .11$ s defining the lifetime of sub-self and its time reversal as duration of syllable. This is roughly the estimated duration $\sim .1$ s of sensory mental image mentioned earlier. Syllable perception corresponds to quantum coherence and synchrony at auditory areas. The real motor action - rather than motor region at the moment of generation of motor action - corresponds to loss of quantum coherence and synchrony at speech motor regions.

13.5 TGD based model for sensory long term memories

There was a highly interesting popular article (see `http://tinyurl.com/yaopecrh`) inspired by the recent findings about long term memory [**?**] in an experiment carried out by Timothy Brady, Talia Konkle, George Alvarez, and Aude Oliva (see `http://tinyurl.com/y9yessmr`). The findings are in conflict with the standard view about memories. Of course, also the memory feats of so called idiot savants known for decades are in sharp conflict with the standard view about memory.

The discussion of these findings in TGD framework led to a decisive improvement in the understanding of the proposed mechanism of sensory memory recall. Also a connection with the model of topological quantum computation [K2, K114] realized axon-microtubule level emerged. Sensory memory would be realized as a topological quantum computer program running in reversed time direction in memory recall and generating the virtual sensory input from brain to sensory organs creating the original sensory experience.

13.5.1 The findings

The following gives a brief summary of the results of the [**?**] experiment discussed in the popular article.

1. A huge amount of storage capacity is required and it increases as more and more experiences are experienced. One can imagine an abstraction as a cure: store only essentials about the input. This is extremely powerful manner to store the relevant information. Picture about grandmother's house with all detail is replaced with world "grandmother's house". What is lost is detail. This storage mechanism is certainly used at higher levels of evolutionary hierarchy. Verbal memories are a good example.

   The experiment mentioned above however demonstrates that the memory storage is at least 1000 times more detailed than it could be, which suggest that a different very detailed storage mechanism usually unconscious to us is involved.

   Indeed, the memory feats of idiot savants show that sensory percepts can be stored in amazing detail. A possible TGD based explanation is that all of us have sensory memories - essentially re-experiences but at a lower level of personal self hierarchy, not as mental images represented as sub-selves but as sub-sub-..-selves not directly conscious to us. Temporal democracy would make it impossible to distinguish between recent and past and make it difficult to survive. Here would be the reason for why these persons are often called idiot savants.

   Sensory memories must be unconscious at our level of self hierarchy to allow the experience about living in definite moment of time and only cognitive (symbolic, verbal) memories involving a lot of abstraction satisfy this condition. If the percept is cognitive, it is about geometric past. If sensory, it is about "Now". Perceptive field effectively reduces from 4-D to 3-D (actually the duration of sensory chronon is about .1 seconds).

   Situation changes when temporal lobes are stimulated electrically as neuroscientists have known for decades but "forgotten". Perhaps animals do not conceptualize and have sensory memories.

2. Proteins used for the storage in terms of modified synaptic contacts is slow by a factor 1000 slower than required to understand the above experiment. Memorizing would require a repeated stimulation but now the pictures were seen only once or twice.

3. The lifetime of the proteins in synaptic contacts is only few weeks so that also long term memories would be unstable. Humans can remember for about 50 years, 1000 times longer than expected.

4. The technical realization of the 3-D storage is also a problem. One should remember also the place, where the memory is stored, not only the memory itself! Here the association mechanism seems the only possibility but would allow only conditionings. In computer language LISP this idea is very concretely realized. Conditionings are however only pseudo-memories.

13.5.2 Wrong views about time and the notion of memory as the basic problems

To sum up, the standard view about memories suffers from two fatal problems.

1. The first fatal problem of the standard model of memory is the wrong view about the relationship between experienced and geometric time. The identification of these times forces to the notion of memory storage analogous to that in computer. The information about what happened must be stored again and again. This view has many problems already discussed.

2. Second fatal problem is the conceptual flaw forced by behaviorism: memories are identified as conditiongs, habits, or behaviors - as you like. Genuine sensory memories are however re-experiences and would however correspond to re-experience to which is associated a synchronously firing neuron group: what neurons fire is not determined by synaptic contacts but by the sensory input mapped topographically to sensory area. This is very delicate and crucial difference.

13.5.3 TGD view about sensory memories

Could one realize memory as re-experience in TGD framework?

1. In zero energy ontology (ZEO) of TGD *no* 3-D memory storage to the "brain now" is required. Memories are ideally where (in 4-D sense) the event occurred but memory recall creates further - usually less detailed and more abstracted copies - of the memory [K84] [L66]. To remember (in the genuine sense of the word) is to re-experience. Memory in this sense would be in the geometric past. Memory recall would be seeing in time: sending a signal to geometric past, where it is time-reflected back. Each memory recall could generate at least a conceptual copy about the memory and in this manner the signal sent to the geometric past would have higher probability to generate the re-experience or at least secondary version of it. Learning, which is not mere conditioning, could rely on the generation of copies of the memory in 4-D perceptive field.

2. Memories as re-experiences would involve synchronously firing neuron groups associated with quantum coherent units defined by magnetic bodies (MBs) of neurons and representing mental images. To understand this concretely, one needs besides the notion of MB also the hierarchy $h_{eff} = n \times h_0$, $h = 6 \times h_0$ of Planck constants. The synchronously firing neuron group (involving quantum coherent part of MB) in the geometric past is woken up by the time reversed signal to the geometric past and reflecting from it by providing energy (now negative). ZEO makes this possible.

3. How the memory recall could realize this synchronous firing in the geometric past? This mechanism should be analogous to the reflection of negative energy signal in time direction from the brain of the geometric past. ZEO allows sending of a negative energy signal travelling to geometric past. It should somehow induce a transition generating the synchronous firing. The signal generating this transition should be very simple. It must induce the transition at correct location in the geometric past. Here the period of the carrier wave of the signal could be essential and large value of h_{eff} could make the signal energetic enough despite the period which could be measured in years so that energy for the ordinary value of Planck constant would be extremely small. Signal could also provide metabolic energy for the neurons, which should fire synchronously. Replicas of the memory help to achieve activation at the correct location.

4. There must be a coding of the sensory input to the physical state of neuronal pathways coded by nerve pulse patterns representing the original sensory input from the sensory organs. If genuine sensory re-experience is required a signal generating the original sensory experience and thus the nerve pulse pattern from sensory organs creating it should be re-generated.

   As if one had in the geometric past a magnetic tape representing somehow the original experience. When played it would generate a signal to the sensory organs in turn generating the signal to the brain (including nerve pulses) giving rise to the original sensory experience.

Note that ZEO indeed allows the sensory experience to be in geometric past. It is however communicate cognitive information about it to recent too.

TGD leads to a model for what could happen based on the idea that topological computation is realized in terms of the braiding of magnetic flux tubes connecting two subsystems [K2, K114](see `http://tinyurl.com/yawk2x4t` and `http://tinyurl.com/y9z499a6`). This model leads to a model of memory representations as a kind of topological quantum computer program giving the original experience as an output while running.

Let us assume that second system is axonal membrane along which the nerve pulse patterns (and whatever else is needed) representing the sensory input flow. Second system would be naturally microtubules inside it.

1. The flux tubes would connect the lipids of the axonal membrane to the tubulins (or units formed by them). Axonal membrane can be in liquid-crystal state meaning that the lipid are like liquid particles able to move. Nerve pulses would induce a 2-D liquid flow inducing the braiding of the flux tubes having second end fixed to (say) tubulin of the microtubule.

   There would be both time-like and space-like braiding. Dance metaphor is very helpful here. Consider dancers at the parquet with legs connected by threads (flux tubes) to a wall (microtubule). Time-like braiding would correspond to the dynamical dance pattern of lipids in time direction having a representation as a 2-D projection defined by the paths of dancers at the parquet. Time like braiding would be analogous to a running topological quantum computer program.

   Space-like braiding would be the outcome of the dance representing tangle of the flux tubes fixed to the wall and defining topological quantum computer program serving as a representation for the time like braiding and therefore also for the nerve pulse pattern (and whatever the signal involves) and the sensory input. Space-like braiding is analogous to the code representing the topological quantum computer program and should make possible to represent the program.

   If this space-like braiding can generate a signal serving as a virtual sensory input to the sensory organs, the sensory memory could be regenerated. The running of the topological quantum computer program would mean the opening/un-knotting of this braiding and would represent the time reversal of the sensory input, not yet sensory input, which could correspond to nerve pulse pattern from the sensory organs generating the sensory percept. It seems that the opening must generate a signal to sensory organs as virtual sensory input.

2. Virtual sensory input brain indeed is the basic element of TGD inspired model of sensory perception as construction of artwork [L42] (see `http://tinyurl.com/yczv2o5b`). The basic difference to the standard view is that the sensory qualia are at the level of sensory organs rather than in brain. Brain only gives names for the percepts and builds standard sensory mental images by using virtual sensory input from brain. The process is like pattern recognition by driving sensory input to a standard input near to the real input.

   In TGD framework however nerve pulse patterns would not carry the sensory information to the brain but would generate sensory input to MB as Josephson radiation from the cell membrane. The transmitters emitted at the synaptic contacts would generate bridges connecting axonal magnetic flux tubes to longer connected flux tubes and in this manner create the communication channels - kind of wave guides. Along thee dark photons (which can transform to bio-photons) could travel with light velocity.

   This communication mechanism is dramatically faster than the communication by nerve pulses and allows forth-and-back signalling involving virtual sensory input from brain to generate the standard percepts assignable to the synchronously firing neuron groups accompanied by magnetic bodies obtained by connecting neuronal magnetic bodies by flux tubes.

   The standard mental images would contain only the features relevant for survival or otherwise interesting. A still open question is whether the virtual sensory input corresponds to the time reversal of the ordinary sensory input [L66] (see `http://tinyurl.com/ybe4vf3j`). The following consideration suggests that time reversal is indeed in question.

3. If the virtual sensory input from brain to sensory organs is dark photon signal in time reversed time direction, one can think of very simple model for memory as re-experience. In ZEO based view about conscious entities "big" state function [L54] would occur meaning that the mental images associated with braiding generated by nerve pulse pattern and dark photon beam die and re-incarnate in opposite time direction. A time-reversed mental image would be generated. This mental images is not conscious at our level of hierarchy living in opposite time direction.

   This mental image is not quite exact time reversal of the original and there is non-determinism of state function reduction involved. One can have however statistical determinism possible if large enough number of neurons are involved. Therefore the differences need not be too big. Also standardization comes in rescue: it would take care that the sensory mental is very nearly the counterpart of the original.

   The time-reversed signal from brain to the sensory organ should generate a nerve pulse pattern just as in the case of ordinary perception and the dark photon signal generating the sensory mental image defining the original sensory memory in good approximation.

4. For the simplest alternative dark photons alone induce the flow of the lipids. Hitherto it has been assumed that the flow is induced by nerve pulse patterns. The most general option is that both are involved in the generation of the flow. One cannot exclude the possibility that the communication of data about nerve pulse pattern to MB generates a control signal which induces the liquid flow. There are many options to consider but the basic idea is clear and involves ZEO and MB in a crucial manner.

5. An important open question is whether the virtual sensory input using dark photons propagates

   (a) to the "sensory organs then" so that only cognitive memories would result as copies. In this case a person, who has lost eyesight during lifetime could have visual memories from time when she could see.

   (b) or via the MB to the "sensory organs now" and stimulates sensory experience in "brain now". Person lost eyes during lifetime could not have visual sensory memories in this case.

   For the latter option one can ask whether the sensory experience is

   (a) realized by the mere virtual sensory input to sensory organs. No copies of the sensory representation at the microtubule-axon level would be generated. If sensory organs are not intact, sensory memories would not be possible.

   (b) or whether also a signal from sensory organs to brain involving nerve pulse pattern is needed to generate the experience. Each memory recall would create an almost exact copy of topological computer program giving rise to a genuine sensory memory while running.

   Various options might be tested by electric stimulation of the temporal lobes known to generate sensory memories.

13.6 Are basic biochemical processes induced by topological quantum computer programs running in non-standard time direction?

The basic bio-chemical processes such as replication, transcription, translation have remained mysteries in standard biology. My conviction is that a lot of new physics is needed. Bio-chemistry is not enough, even QFT is not enough. Even standard views about space-time and classical fields, QM, and basic ontology are not enough.

   TGD approach indeed brings in several new physics elements.

1. The notion of magnetic body (MB). MB carrying dark matter identified as dark variants of charged particles having non-standard value $h_{eff} = n \times h_0$ of Planck constant is central in TGD inspired quantum biology. MB is the intentional agent receiving sensory input from biological body and controlling it. The interactions at the level of ordinary bio-matter would be governed by the MBs of molecules, and bio-chemistry would be a shadow of this much simpler dynamics.

   MB of water entrains to the cyclotron frequencies of the MBs of the basic biomolecules by varying flux tube thickness. This makes possible water memory [L59] (see `http://tinyurl.com/y9mr9s2w`) and implies homeopathy like mechanisms serving as basic quantal building bricks in the functioning of the immune system. Dark variants of DNA, etc.. realized as dark proton sequences would be one aspect of this representation.

2. The braiding of the magnetic flux tubes makes possible realization of topological quantum computer (TQC) programs. Biological functions should correspond to TQC programs and the challenge is to understand how they emerge naturally. A possible answer to this question will be proposed in the sequel.

3. There are also other central notions such as zero energy ontology (ZEO) predicting that the arrow of time is not fixed. The following arguments suggests that ZEO is absolutely essential for the understanding of the miracles of bio-chemistry. TQC programs running *backwards in time* would generate as output various biological functions such as DNA transcription and other basic processes.

13.6.1   What are the big problems?

It is best to start from the problems that one should solve. At bio-molecular level the basic problem is to understand how complex temporal sequences of bio-chemical reactions involving bio-catalysts are possible as highly deterministic sequences.

1. How the reacting molecules - including catalysts - are able to find each other in the molecular soup?

   TGD answer: Contraction of flux tubes connecting molecules very selectively as h_{eff} is reduced brings molecules together. Connections between molecules are generated by re-connection of U-shaped flux tubes scanning enviroment and producing pair of flux tubes connecting the two systems provided they have the same cyclotron frequency. Resonant em coupling by dark photons is in question.

2. How the attached molecules are able to attach to just the correct spot and orient just in the correct manner?

   TGD answer: the contraction mechanism for flux tubes automatically guarantees also this.

3. How the rate of reaction can exceed the expected rate by so huge factor?

   TGD answer: Reactants are connected by flux tubes so that the probability that they find each other is much higher and depends on the occurrence of h_{eff} reducing transition which occurs spontaneously. The energy liberated in the contraction of flux tube allows to overcome potential wall in the reaction and exponential increase in the rate is achieve.

4. How bio-catalysis can proceed in time ordered manner like deterministic computer program so that very many initial states can lead to the same outcome?

   Here the initial states would correspond to positions orientations, etc of input molecules. Huge number of initial states lead to the same outcome.

   I think that this is the really difficult question. I am highly skeptic about the possibility to understand this in QFT framework. In the following I propose TGD inspired solution of this problem requiring ZEO, which means a revolutionary modification of basic ontology and of views about time.

13.6.2   Basic biological processes as TQC programs

Apparently a breaking of second law is involved. Very many initial states lead to the same outcome rather than vice versa. As if the process would be controlled by the time reversal of the original process and entropy would increase but in opposite time direction as usually but at the control level! The notion of syntropy introduced by Fantappie comes in mind!

TGD answer would involve at least the following pieces.

1. Dark DNA and dark variant associated with enzyme should be part of the story. Large h_{eff} brings in conscious information realized as algebraic complexity and large scale quantum coherence.

2. ZEO allowing time reversed processes should be essential. ZEO predicts both directions of time and motor actions are postulated to correspond to sensory perception in opposite arrow of time. What this precisely means is not however clear.

3. Magnetic body (MB) should be the boss controlling dynamics. This dynamics should be very simple. Biochemistry should be shadow dynamics and apparently extremely complex.

4. Topological quantum computational (TQC) [K2, K114] is also a central aspect but I have not been able to articulate what TQC programs are and how they would emerge: the following ZEO arguments suggests an astonishingly simple solution to both problems.

   The complex reaction sequences like transcription should correspond to a running of topological quantum computer (TQC) program coded by the braiding. The proposed realization of sensory memories serves as a guideline. Memory recall would be like a quantum computer program running backwards in time and producing sensory experience as output.

   There is a strong temptation to believe that this is completely general aspect of all also motor actions. By fractality also DNA transcription, translation, etc... are analogs of motor actions. Somehow they should be coded to TQC programs realized as braidings of flux tubes of MB.

   The output of the TQC program running *backwards* with respect to the standard direction of time would be motor action as we observe it. All basic bio-processes involving several steps be coded to braidings. One can imagine a hierarchical structure: programs, subprograms, etc... for the TQC programs. Braidings of braidings of.... This conforms with the hierarchical many-sheeted structure of space-time.

How to realize motor actions as outputs of TQC programs running in non-standard direction of time?

1. Assume that when some process - such as DNA transcription or its time reversal occurs - it induces braiding of flux tubes - topological quantum computer (TQC) program at the level of MB. The braiding flux tubes connecting systems of ordinary matter as they move would automatically generate the TQC program representing the motion as a motor action.

   As this TQC program runs backwards in time, the *time reversal* of the original process is generated as output at the level of ordinary bio-matter - inverse braiding in the previous example. The running in reverse time direction would follow a "big" state function reduction for the quantum system defined by the flux tubes inducing time reversed motion (meaning death of this sub-self and reincarnation in opposite time direction). The interaction with ordinary matter system living in ordinary time direction and corresponding to different values of h_{eff} would serve as a template for the dynamics of ordinary matter forcing it to obey time reversed dynamics.

2. For instance, in the case of transcription, one should assume that the time reversal of transcription meaning the decay of mRNA back to its building bricks generates the TQC program as braiding of flux tubs. Running of this TQC problem in the reverse time direction should generate transcription and bio-chemical level.

3. The sub-..-self corresponding to the TQC program is lost only temporarily in the process. A death and re-incarnation of time-reversed self creates the program in the original time direction but the corresponding CD has increased in size. Are all sub-CDs/TQC programs conserved or can they disappear? Also disappearance is in principle possible if zero energy state associated with CD is not orthogonal to a tensor product of vacuum states associated with its opposite boundaries.

4. What looks strange that the time reversal of the assembly process - essentially a decay process occurring in very ways - would code for the highly deterministic TQC program for the assembly process. But this is actually just what one wants!!

   The decay process is highly unpredictable but its time-reversal is highly predictable! There are very many TQC programs, which give rise to the desired output! The ways from Rome lead to all possible directions but all ways lead to Rome! In ZEO butterfly effect transforms to extreme predictivity in opposite time direction!

5. Also the standardized sensory percepts discussed in the model of sensory memory could be seen as TQC programs generating as an output standardized sensory mental image nearest to the actual sensory input. The propagation of bio-photons forth-and-back between sensory organ and brain would generate this standardized mental image. Is sensory memory just a motor action at the level of ordinary matter generated by the time-reversed signal to geometric past identifiable as TQC program running backwards in time? As a matter of fact, there should be no difference between sensory memory and sensory percept in 4-D sense.

6. How MB and space-time sheets assignable to ordinary matter and having opposite arrows of time - or more generally two levels of h_{eff} hierarchy with different values of h_{eff} and different arrow of time - could interact? If the arrows of time are opposite, the intersection of space-time sheets should have dimension smaller than $D = 4$. Since the classical dynamics determined by twistor lift breaks T symmetry (the analog of Kähler action in M^4 degrees of freedom is the reason), 3-D intersection does not imply that the surfaces co-incide for the space-time surface and its time reversal.

   The interaction should be via common boundary conditions: the space-time sheets with different arrow of time should intersect along 3-D or even lower-dimensional surfaces at the boundaries of CD and perhaps also at the 3-D light-like orbits of partonic 2-surfaces at which the signature of the induced metric changes. Magnetic flux tubes induce braiding, which suggests that magnetic flux tubes of MB as 4-D surfaces should have at most 3-D intersection with the space-time surfaces representing ordinary bio-matter and defining the nodes of tensor network [L34]. These 3-D - possibly light-like - intersections would mediate the interaction. For the usual arrow of time for MB the interaction would be sensory input to MB and induce braiding. For the opposite arrow of time for MB it would be motor action in which MB would be the controller forcing bio-matter to follow in the un-braiding process.

   In the generic case the intersection of two 4-surfaces in $M^4 \times CP_2$ is discrete. Could the intersection of space-time surfaces with different arrow of time consist of a discrete set of points? Could this be enough for MB to control bio-matter? Note that cognitive representations identified as intersections of real space-time surfaces and their p-adic variants consist of a discrete set of points [L43].

7. The connection with Sheldrake's vision about morphogenetic fields, in particular the generation of "habits" even at the level of so called dead matter [I55, I56] is rather obvious. TQC programs would indeed code for habits and would be generated by Nature without a need of a programmer writing the code. I have discussed Sheldrake's vision from a slightly different viewpoint in [L30].

   There are interesting connections to ancient Indian philosophy and Christianity. ZEO has analog in ancient Indian philosophy as I learned from a discussion with Savyasanchi Ghose while writing this. As notions doer and un-doer are analogous to self and time reversed self. MB would be in the role of supreme observer although it would not be outsider to the Universe. The undoing

the time reversal of deed by MB would serve as a template for the dynamics of deed at the level of ordinary matter.

Building braids and opening them are indeed the basic operations in TQC according to ZEO. A visit to web using "undoer" reveals that it appears also in Christianity, Mary the undoer of knots! Knots are now a metaphor for sins and undoing them means mercy. In Christianity God would be the counterpart of MB and we would be 4-D dynamical images of God.

To sum up, this sounds like mystics and brings strongly in my mind a french movie about time that I saw decades ago. It was very poetic and somehow caught at the emotional level something very deep about the mysteries of time, life, and consciousness in a way not expressible using the vocabulary of scientist. It seems that TGD is providing the language that I did not have at that time and that ZEO is starting to demonstrate its magnificent explanatory power.

13.7 Three findings about memory recall and TGD based view about memory retrieval

I received within few weeks 3 highly interesting links telling about the work of neuro-scientists relating to memory recall. This inspired a construction of a detailed model for the memory recall which generalizes to a model of sensory perception and motor action based on the vision discussed in detail in [L66] (see http://tinyurl.com/ybe4vf3j). The original vision about motor action as time reversal of sensory percept is sharpened so that motor action corresponds to a "big" state function reduction (BSR) changing the arrow of time and sensory percept to "small" state function reduction (SRS) preserving it. What is also new, is the combination of this picture with the old TGD based vision [K15] about living system as a conscious hologram. The idea about brain as hologram is originally due to Karl Pribram [**?**].

A short summary of TGD inspired theory of consciousness is in order to help the reader to follow the arguments.

1. Zero energy ontology (ZEO) predicts that quantum states are superpositions of deterministic time evolutions (preferred extremals representing space-time surfaces as minimal surfaces). These space-time surfaces connect 3-surfaces the opposite boundaries of causal diamond (CD) forming a scale hierarchy. There are two kinds of state function reductions.

   Zero energy states can be regarded as pairs of ordinary quantum states located at opposite boundaries of CD and having interpretation as wave function in the space of 3-surfaces at the boundary of CD. The 3-surfaces at opposite boundaries of CD are connected by space-time surface - preferred extremal - which is minimal surface apart from 2 dimensional string world sheets and their 1-D light-like boundaries at light-like 3-D orbits of partonic 2-surfaces at which the signature of the induced metric of space-time surface changes its signature from Minkowskian to Euclidian [L81, L69].

   "Small" state function reductions (SRSs analogous to weak measurements in standard quantum measurement theory) leave the passive boundary of CD unaffected as also states at it but affect the states are active boundary, and also shift the active boundary farther away from the passive one (in statistical sense at least). Each small state function reduction is preceded by a unitary evolution of state at the active boundary meaning shift of the active boundary: actually a time-delocalization of the active boundary takes place in the moduli space of CDs. SRS involves a localization with respect to time defined by the temporal distance between the tips of CD. The correlation between experienced time and geometric time identifiable as the distance between the tips of CD follows since state function reductions identifiable as basic building bricks of conscious experience increase this distance in a statistical sense.

   "Big" state function reduction (BSR) changes the roles of the boundaries of CD and corresponds to state function reduction as it appears standard quantum measurement theory. In particular, the arrow of time as a property of zero energy state changes. The change of arrow of time is in a fundamental role in TGD inspired quantum biology and corresponds to the death of self followed by a re-incarnation with reversed arrow of time.

4. Since the superposition of preferred extremals is only replaced with a new one in state function reductions, they are consistent with the determinism of classical physics, which is an exact part of quantum TGD - space-time surfaces can be regarded as analogs of Bohr orbits. One also avoids the basic paradox of standard quantum measurement theory and there is no need for "interpretations".

5. The original somewhat fuzzy vision about motor action and sensory perception was as time reversals of each other so that the difference between them would be only relative. The recent view is more precise and implies absolute difference: Motor actions correspond to BSRs and sensory percepts to SRSs. Also memory recall can be seen as time reversal of sensory perception in a well-defined sense [L66].

The model for various findings described below relies on this picture combined with the vision about living system as conscious hologram [K15]. The TGD inspired model for for the memory recall generalizes to a model of sensory perception and motor action. The common mechanism of sensory perception, motor action, and memory recall would be surprisingly simple.

Magnetic body (MB) would send reference beams R interfering with incoming beams O representing sensory input to build a sensory representation as a hologram H on living matter serving as a substrate. Conjugate hologram $\overline{H}$ would correspond to a time reversal of H constructed using conjugate beams $\overline{R}$ and $\overline{O}$. The reading of sensory percepts/memories would take place by illuminating $H/\overline{H}$ with $R/\overline{R}$ coming from MB.

An important challengeable assumption is that the time reversals of our mental images are not conscious-to-us. It implies that the reading of the memory by $\overline{R}$ does not yet produce mental image conscious-to-us: only the next BSR would generate memory representation readable by applying R. This picture is consistent with the empirical findings inspiring the detailed model.

13.7.1 The findings

In the following brief summary about findings is given.

Ripples race in the brain as memories are recalled

The first link was to a popular article in *Science News* with title "*Ripples race in the brain as memories are recalled*" (see http://tinyurl.com/y5hohv2h) telling about the findings of neuroscientists Vaz *et al* about memory recall published in Science as article with title "*Coupled ripple oscillations between the medial temporal lobe and neocortex retrieve human memory*" [?] (see http://tinyurl.com/y48kdkrl).

1. Results

The results come from the study 14 patients suffering from epilepsy. They had electrodes placed on their brains as part of their treatment. The electrodes also allowed scientists to monitor neural activity while the people learned pairs of words.

One to three minutes after learning the pairs, people were given one word and asked to name its partner. As participants remembered the missing word, neuroscientist and neurosurgeon Kareem Zaghloul and his colleagues caught glimpses of fast brain waves rippling across parts of the brain at a rate of about 100 per second.

These ripples appeared nearly simultaneously in two brain regions — the medial temporal lobe known to be important for memory, and the temporal association cortex having a role in language. When a person got the answer wrong, or didn't answer at all, these coordinated ripples were less likely to be present, the researchers found.

The abstract of the article provides a more technical summary.

Episodic memory retrieval relies on the recovery of neural representations of waking experience. This process is thought to involve a communication dynamic between the medial temporal lobe memory system and the neocortex. How this occurs is largely unknown, however, especially as it pertains to awake human memory retrieval. Using intracranial electroencephalographic recordings, we found that ripple oscillations were

dynamically coupled between the human medial temporal lobe (MTL) and temporal association cortex. Coupled ripples were more pronounced during successful verbal memory retrieval and recover the cortical neural representations of remembered items. Together, these data provide direct evidence that coupled ripples between the MTL and association cortex may underlie successful memory retrieval in the human brain.

2. Ripples as hologram

The basic question concerns the interpretation of the ripples appearing both during the formation and the retrieval of the memory. The TGD based vision about living system as a conscious hologram [K15] suggests an answer (for the notion of hologram see `http://tinyurl.com/qgjsdzz`).

1. During the sensory perception the ripples are created by the interference of the reference beam coming from magnetic body (MB) with dark photon beam representing sensory input transformed to dark photons at sensory organs as TGD inspired model for the generation of percept as forth-and-back communication between MB/brain and sensory organs assumes [L61].

2. During memory recall MB sends the phase conjugate of the reference beam scattering from the time reversed conscious hologram and generates phase conjugate beam representing the time reversal of the sensory input. At quantum level this involves BSR and the phase conjugate mental image resides at boundary of CD opposite to that carrying the ordinary mental images.

   This sensory mental image need not be conscious-to-us and this has been the assumption. The "death" of the phase conjugate mental image in a further BSR gives rise to a mental image at the "normal" boundary of CD. This mental image need not be sensory mental image (sensory/episodal memory) and could correspond to imagination or verbal memory.

There are several questions to be answered. Can one keep the earlier hypothesis that the phase conjugate sensory mental image is not conscious to us? Does the "normal" mental image correspond to sensory mental image (episodal/sensory memory) or almost sensory mental image (declarative or verbal memory)?

The human brain works backwards to retrieve memories

The second interesting link was to an popular article "*The human brain works backwards to retrieve memories*" (see `http://tinyurl.com/y7hbqmug`). The article tells about the work of Linde-Domingo & Wimber *et al* published in Nature Communications as article titled "*Evidence that neural information flow is reversed between object perception and object reconstruction from memory*" [**?**] (see `http://tinyurl.com/y375ht5f`).

1. Results

During the study, participants saw images of specific objects, and then learned to associate each image with a unique reminder word, for example the word 'spin' or 'pull'. The participants were later presented with the reminder word and asked to reconstruct the associated image in as much detail as possible.

Brain activity was recorded throughout the task via 128 electrodes attached to the scalp, allowing the researchers to observe changes in brain patterns with millisecond precision. Finally the researchers trained a computer algorithm to decode what kind of image the participant was retrieving at different points in the task.

The abstract of the article summarizes the results.

Remembering is a reconstructive process, yet little is known about how the reconstruction of a memory unfolds in time in the human brain. Here, we used reaction times and EEG time-series decoding to test the hypothesis that the information flow is reversed when an event is reconstructed from memory, compared to when the same event is initially being perceived. Across three experiments, we found highly consistent evidence

supporting such a reversed stream. When seeing an object, low-level perceptual features were discriminated faster behaviourally, and could be decoded from brain activity earlier, than high-level conceptual features. This pattern reversed during associative memory recall, with reaction times and brain activity patterns now indicating that conceptual information was reconstructed more rapidly than perceptual details. Our findings support a neurobiologically plausible model of human memory, suggesting that memory retrieval is a hierarchical, multi-layered process that prioritises semantically meaningful information over perceptual details.

2. TGD vision

This picture is consistent with the general TGD vision predicting that memory recall and sensory perception differ by time reversal: it however turns that one must also assume that motor action corresponds to BRS and sensory perception to SRS. The picture is also consistent with an entire hierarchy of levels labelled by the values of effective Planck constant $h_{eff} = nh_0$ measuring roughly the level of evolutionary hierarchy [L52, L51] and by p-adic length scales. The larger the value of h_{eff}, the longer the relevant time and length scale is, and the more abstract the representation is. The "gist" would correspond to large values of h_{eff} to which one can assign largest maximum value of information content.

Neuroscientists read unconscious brain activity to predict decisions

The third link was to a popular article "*Neuroscientists read unconscious brain activity to predict decisions*" (see `http://tinyurl.com/yxgnr9x6`). The article tells about the work of Koenig-Robert and Person published in Scientific Reports as an article with title "*Decoding the contents and strength of imagery before volitional engagement*" [**?**] (see `http://tinyurl.com/yyp6hugz`).

1. In the experiment the situation was following. The subject person looked at most $T = 20$ seconds two different pictures, decided to imagine either of them, and pushed immediately the knob. Then she tried to imagine the chosen picture. Subject person reported also the subjectively experienced intensity of imagination.

   Neural activity was detected in brain and it was found that it emerged $t = 11$ second before the decision. From the pattern of activity it was possible to predict the picture. Also the subjectively experienced intensity of imagination could be predicted. One could say that the sensory experience was re-created by imagination in the brain of past.

2. The imagination involved could be also regarded as an active memory recall. This interpretation suggests that the time t at which the neural activity appears must be within the $T = 20$ second interval during which the decision was made.

3. The authors leave open whether their finding excludes free will. The first interpretation is that the choice really occurred at unconscious level and for some reason subject person experienced illusion of choise. A real choice combined with illusion about real choice looks rather weird idea, and only shifts the problem of free will to a level unconscious to us. If there is no free will then all experiments involving choice are pseudo experiments: this would throw a large portion of neuroscience to trash bin.

These findings will be used to build TGD based model for memory recall based on TGD based vision about living systems described in the introduction.

13.7.2 TGD based model for what happens in imagination as active memory recall

The experiments discussed above give good hopes about a detailed model for what happens in imagination as active memory recall.

Background ideas

To develop this model some background ideas about TGD are needed.

1. I have developed a model for motor action as time reversal of sensory perception based on ZEO in an earlier article [L66] (see http://tinyurl.com/ybe4vf3j). This leads also to a model for remory recall as sending a signal to geometric past giving rise to time reflected signal as memory recall.

   Could memories correspond to mental images in standard time direction generated by time reflected dark photon beam as has been assumed hitherto or do they correspond to time reversed mental image in the geometric past at the opposite boundary of CD. The earlier assumption has been that time reversed mental images are not conscious to us.

2. There are several words to which one must give meaning: what do "re-experience in geometric past", "time reflection", "imagination as active memory recall" mean? Who is the imagining intentional agent? The above experiment inspired an attempt to give a more precise meaning for these words.

   The idea is to combine the model of memory with a decades old model of living matter as conscious hologram [K15] (see http://tinyurl.com/y6lz3t3y) (one more imprecisely defined word!) .

3. MB is the basic notion. MB acts as intentional agent using biological body (BB) as motor instrument and sensory receptor. In the recent case MB imagines and performs active memory recall by selecting the picture and directing its attention to it (still more words to be explained!).

   Dark matter hierarchy as hierarchy of phases of ordinary matter (also photons) assignable to the MB and labelled by the value of effective Planck constant $h_{eff} = n \times h_0$ is a further central element of the general picture. In particular, EEG photons are dark photons with very large value of Planck constant guarantewing that their energies are above thermal threshold. Bio-photons would with energies in visible and UV range would result as dark EEG photons with very large value of h_{eff} transform to ordinary photons.

4. Brain as a hologram is an old idea originally to Karl Pribram. The formation of hologram involves two waves with the same freqeuency: reference wave and the wave representing the target - typically a wave of same frequency reflected from the target. The reference wave is a simple plane wave with some frequency. These waves must interfere so that coherence is required. The interference pattern is stored by the modification of the hologram substrate. The transmission coefficient of the substrate is proportional to $T = |vertU_0 + U_R|^2$, where U_0 and U_R are complex amplitudes.

   If one illuminates the resulting hologram by reference wave U_R the image of the target is formed. If one illuminates the target with the phase conjugate $\overline{U}_R$ of the reference wave - its time reversal $\overline{U}_0$ - the phase conjugate of the image is formed. In ZEO time reversal has precise quantal meaning as also the time reversal of self and of mental image.

   This requires coherence in the length scales of hot and wet brain. Without non-standard large enough value value of h_{eff} makes this is not possible. The coherence for ordinary photons need not be quantum coherence, but is induced by quantum coherence of dark photons transforming to ordinary photons. Quite generally, the coherence of living matter would be induced in this manner from quantum coherence of dark matter at magnetic flux tubes.

TGD inspired model for memory retrieval

With these ingredients one can build a rather simple model for memory retrieval.

1. Memory and sensory mental images is generated as MB creates a reference wave in the formation of hologram as interference pattern of incoming ordinary light beam and dark reference beam. This induces the pattern of neural activity. Coherence is not quantum coherence but inherited from quantum coherence of dark photon beam from MB. Also phase

conjugate in active memory recall comes from MB. The ripples associated with the formation of sensory percept would correspond to the formation of conscious hologram.

2. Phase conjugate wave corresponds to time reversal of wave and would be created in ZEO in BSR reversing the arrow of time for self involved. The phase conjugate of the reference wave generated by MB acting as intentional agent trying to imagine would propagate to geometric past and scatter from the brain substrate acting as a hologram and generate the memory mental image in geometric past at the opposite boundary - the "re-experience", which need not be conscious-to-us. The ripples reported in the first article [**?**] would correspond to the scattering of the phase conjugate wave from the hologram.

This phase conjugate mental image need not be conscious-to-us: the assumption has indeed been that time reversed mental images are not conscious to us. The assumption will be kept also now.

The next BSR would mean the "death" of the memory mental image and rebirth as a mental image in standard time direction. This would correspond to the "time reflection" generating a signal to the geometric future defining in the recent situation declarative, verbal memory of the mental image. This would be the outcome of imagination experienced by the subject person.

Why these "normal" mental images are not usually genuine sensory mental images at our level of self hierarchy? A good reason for this is that they would interfere with the ordinary sensory perceptions. We can indeed have this kind of mental images during dreaming and hallucinations. During dreaming it is not a threat for survival as it is during hallucinations. I have discussed a detailed model for imagination as almost sensory mental images [L61] (see `http://tinyurl.com/ydhxen4g`). They would be created by feedback signals from MB via cortex to a level above sensory organs in the hierarchy so that no actual sensory percepts is obtained. Also imagined motor actions would be similar.

An essential element of the model is that the sensory input is transformed to dark photons beams propagating along flux tubes parallel to axons and being responsible for the communications. The function of nerve pulses would be creation of communication channels by connecting flux tubes associated with axons to longer structures: neural transmitters and various information molecules would do this connecting. Situation would be very much analogous to that in mobile phone communications.

The notion of re-incarnation is certainly the most controversial aspect of the proposed vision. TGD predicts self hierarchy and sub-selves are identified as mental images so that one can look whether re-incarnation hypothesis makes sense for them. After images appearing periodically would be examples of this kind of mental images: they would be conscious to us and correspond to the level of self hierarchy immediately below us. Since they are typically of different color than the original image, we know that they do not represent a real object. The periods without after image would correspond to the phase conjugates of these mental images and would be un-conscious to us. Essentially a sequence of re-incarnations of mental image would be in question.

3. How can subject person (identifiable as MB!) actively choose the target of the memory recall? In the experiment considered the two pictures were seen by the subject person for a time not longer than $T = 20$ seconds. Both generate a hologram like structure in visual cortex which in good approximation are disjoint patterns of neural activity - presumably regions of coherence induced by quantum coherence of the dark reference beam.

A conscious choise associated with the memory recall requires that the two areas are labelled by some control parameter which MB can vary. Fixing this parameter directs the attention of MB to either picture. The frequency of the laser beam is the only parameter available. Incoming beam of light corresponds to the energies of visible light and for the ordinary value of Planck constant one cannot vary the frequency. There is however EEG frequency, which can be varied but its ratio to the frequency of visible light is of order 10^{-14} for 10 Hz! The energy $E = hf$ of EEG photons is extremely small and EEG photons should have absolutely no effects on brain or correlate with the contents of consciousness. We however know that it does!

In TGD framework this fact was the original motivation for the hierarchy of Planck constants for which adelic physics [L52, L51] provides a mathematical justification. The choice of the picture to be imagined/attended by MB would mean that the value of h_{eff} associated with it changes. The chosen picture naturally corresponds to a larger value of Planck constant since the maximal conscious information content of the system increases as h_{eff} increase. The increase of h_{eff} requires metabolic energy as directed attention certainly indeed does.

EEG also requires metabolic energy and it would be non-sensical to send information to outer space without any receiver: MB is the natural receiver of this information.

4. A more refined view about memory recall motivated by the second article described above [**?**] involves a hierarchical structure in which memory recall is built up so that first the "gist" of the pattern is recalled and then come the details. This is the opposite of what happens in sensory perception in which features are identified first and the holistic view emerges later.

   TGD predicts self hierarchies labelled by the values of h_{eff} and by p-adic length scales. The higher the level of self hierarchy, the longer the corresponding length scale. The "gist" corresponds to large values of h_{eff} and low EEG frequencies whereas details correspond to smaller values of h_{eff} and higher EEG frequencies and smaller wavelengths for ordinary photons. The construction of the memory mental images would correspond to a cascade of state function reductions proceeding from long to short length scales and beginning from largest value of h_{eff} involved. The model for what happens in state function reduction in TGD framework assumes this cascade [K59] [L54] (see `http://tinyurl.com/yyv3v9u8` and `http://tinyurl.com/ycxm2tpd`).

5. It is essential that sensory input is transformed to dark photons at sensory organs propagating to the brain: this also makes the processing of sensory information fast and sensory mental images can be built as standardized mental images - pattern recognition - by forth-and-back signalling between brain and sensory organ combining artificial sensory input from brain with genuine sensory input. It is hard to imagine anything simpler!

6. Neural activity associated with the neural percept preserves the topography of the visual percept so that the shape of the firing pattern in cortex is same as that of object. This cannot be however used as an objection against holography since it is the reading of the neural hologram which generates the image of the object. The topography of the hologram has nothing to do with the shape of the object.

This mechanism should generalize to the case of sensory perception and motor action as its time reversal. MB as an intentional agent would be sending reference beams and their phase conjugates at various frequencies f and values of h_{eff} serving as control knobs! The details are however far from clear. At least to me, it is very difficult to gain detailed understanding. This is to be expected, since our standard intuition of time relies on preferred arrow of time and on the identification of the experienced and geometric time. The following is one particular humble attempt.

1. Are motor action and sensory perception really mirror images as has been assumed hitherto so? The differences between them would be only relative and they would change their roles as the arrow of time is changed?

   Or could it be that the difference is absolute? Motor actions would correspond to BSRs and change the arrow of time. Sensory percepts would correspond to SRSs and preserve the arrow of time. The latter interpretation looks more natural and is consistent with the earlier intuitive but not precise enough view deduced from Libet's findings that sensory percept and motor action correspond to different arrows of time. Let us assume the latter option.

2. Sensory representation, hologram H is formed using reference beam R and object beam O entering to the active boundary of CD. Sensory experience, "reading" of H, is achieved by applying R to H. Subsequent SRSs correspond to R.

   It does not make sense to apply time reversal $\overline{R}$ to H: here the situation differs from that for the ordinary holograms. $\overline{R}$ can be applied only to $\overline{H}$ and would require BSR replacing H with its phase conjugate $\overline{H}$.

If this picture is correct, one would say that the basic activities are printing to make H and reading of H using R. The triplet $\{R, O, H\}$ would be characterize the situation.

The formation of H would be like printing and the application of R to it is like reading of the text. R must correspond to a SRS at the active boundary of CD.

3. Motor representation $\overline{H}$ formed using $\overline{R}$ and conjugate object beam $\overline{O}$ at opposite boundary of CD being now active would be sensory representation in our geometric past having opposite arrow of time. The hypothesis is that what is conscious $\overline{T}$ is unconscious-to-us.

   Our sensory percepts would reflect the motor actions of our temporal mirror image. This motor action has changed the arrow of time for sub-self to that for us and the signals coming from past are passively experienced by us.

4. Our (MB's) motor action - volitional act - involves BSR at some - presumably nearest - level of self hierarchy below us (MB) changing the roles of boundaries of sub-CD in question. At this level the receiver of sensory input is in the geometric past and memory is formed by $\overline{R}$ but as such is not conscious-to-us: this conforms with the findings of the articles. Only the next big state function reduction makes the memory conscious-to-us as sensory or possibly verbal memory and we can read it by making SRSs.

5. The application of $\overline{R}$ to time reversed mental image (conjugate sub-self) $\overline{H}$ would be unconscious memory for us. It would become conscious in BSR for it producing memory at our level: this conforms with the findings of the articles. The application of R to time mental image (sub-self) would be conscious-to-us precognition or sensory experience. Sensory experience are indeed known to be also predictions as is natural in ZEO in which quantum states are superpositions of entire deterministic classical time evolutions.

   Needless to add that this view is only a sketch. It is good to list the key assumptions.

1. BSRs correspond to motor actions and SRSs to sensory percepts including precognition.

2. Sub-selves with same time orientation are conscious to use but not their conjugates. I do not have a really good argument for why time reversed mental images should be unconscious-to-us.

3. Only R can be applied to hologram but not $\overline{R}$ as for ordinary holograms.

Could one demonstrate experimentally that the standard view about time is wrong?

The prevailing view in neuroscience and physics identifies experienced time with geometric time despite the fact that these two times have very different properties. In TGD framework these times are not identified but are closely correlated. TGD inspired theory of consciousness based on zero energy ontology (ZEO) [L54, L64] [K7] allows to understand the relationship between the two times and leads to rather dramatic predictions.

TGD interpretation says that in the act of free will MB sends phase conjugate signal to the brain of geometric past or stating it otherwise: replaces the deterministic time evolution of brain (and also its past) with a new one (strictly speaking, replaces their quantum superposition with a new one). This should happen also in the choice of which picture is to be imagined.

Could a modification of the experiment of [**?**] replacing imagination with an activity not requiring memory recall allow to demonstrate that the standard view about time is wrong?

1. Consider a thought experiment experiment in which the subject person receives a stimulus and makes a decision to do something - not imagine but something else - during some time interval T after it. Suppose that the decision is found to be preceded by neural activity before the stimulus appears.

   Standard view about time not does allow this since person could have decided about the reaction to the stimulus before it came (precognition would be the only explanation).

   TGD view about the relationship between subjective and geometric time allows this since the decision sends signal to the brain of the past and there is no reason why the moment in past could be before the stimulus.

2. The modification of the above experiment in this manner could mean the reduction of $T = 20$ seconds to - say - $T = 9$ seconds. If the neural activity would appear say $t = 11$ second earlier it would emerge before person has seen the pictures and one would have paradox for standard view about time. However, if the imagined picture relies on memory, this should not happen.

Chapter 14

About TGD based view of neuron

14.1   Introduction

The inspiration for looking again at the TGD view about nerve pulse conduction [K80] came from email discussions with Jouko Alanko. I learned about the conduction of action potentials in the myelinated portions of axons, where ion fluxes assignable to the action potential do not seem to be possible, remains a mystery although 71 years has passed since the proposal of the Hodkin-Huxley model of nerve pulse conduction (`https://cutt.ly/ATvjVHD`).

J. W. Jacak proposes a model of saltatory conduction [**?**] (`https://cutt.ly/cTvj0db`) according to which action potential could propagate in plasmon-polariton condensate and the myelinited portions of length about $L = 100$ μm could behave like electric dipoles. This requires coherence in scale L and one might ask whether quantum coherence of plasmon-polariton condensed might be involved.

What makes this idea interesting is that plasmon-polaritons are known to form BEC condensates in the presence of energy feed as laser light. In the TGD framework this particular BEC formed in the presence of an external energy feed would represent one example of a much more general phenomenon in which the metabolic energy feed increases the values of h_{eff} for the system and keeps their distribution stationary. This would not be a stationary BEC but a BEC analogous to flow equilibrium. For instance, metabolic energy feed would give rise to a forced bio-superconductivity. An exciton-polariton condensate could be also present. However, to me the answer to the question whether this can give rise to an action potential remained unclear to me.

This inspired a careful reanalysis of the earlier TGD inspired visions of nerve pulse conduction [K80], EEG [K35, K83, K51, L119] and of brain based on the new view about pace-time, the notion of the magnetic body carrying $h_{eff} > h$ phases behaving like dark matter, and the zero energy ontology (ZEO) based quantum measurement theory extending to a theory of consciousness.

The TGD view about nerve pulse assumes that nerve pulse is a secondary phenomenon induces by a voltage modulation wave assignable to a generalized Josephson junction formed by lipid layers of the cell membrane for which Josephson frequency f_c is replaced by the sum $f_c + \Delta E_c$, where ΔE_c is the difference between cyclotron frequencies from transversal flux tubes at the different sides of the axon.

What propagates is the deviation of membrane potential, possibly below the critical value for the generation of action potential. There is no action potential in the myelinated portions and it is generated only in the unmyelinated portions of length about 1 μm and gives rise to chemical effects and would also communicate a signal to the magnetic body (MB) if the notion of generalized Josephson junction is accepted.

The model survived the Occam's razor with small modifications and became much more precise and led to more explicit formulation of the speculative generalization of the genetic code [L120].

An interesting challenge for the model is the discovery that the density of the voltage gated ionic channels in the dendrites of neurons is considerably lower for humans than for mammals. The general model suggests that the spatiotemporal patterns of Josephson radiation emitted by segments between nearby ionic channels or pumps define analogs of sentences of language having

nerve pulse as a punctuation mark analogous to the stop codon for DNA, then these sentences would be longer for humans, which could relate to the emergence of the human language capacity.

14.2 Neuron and brain according to TGD

The TGD view of the brain has evolved during the last 30 years and differs from the neuroscience based view in several aspects. The notion of MB carrying $h_{eff} \geq h$ phases behaving like dark matter and zero energy ontology (ZEO) predicts time reversal in ordinary ("big") state function reductions (BSFRs). BSFRs would be counterparts for motor actions and "small" SFRs following unitary time evolutions would be counterparts for sensory perception.

Josephson radiation communicates information from the biological body (BB) to MB and gives rise to EEG and possibly also its scaled variants. BSFRs at MB produce cyclotron resonance peaks, which would generate a feedback signal to the central nervous system (CNS) via genome and/or microtubules. These signals in turn induce oscillatory perturbations of the soliton sequence leading to secondary nerve pulses. This gives rise to a closed control loop BB-MB-BB.

The generalization of Nottale hypothesis [E3] states that one can assign to gravitational flux tubes gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$, where G is Newton's constant, M is large mass - say Earth's mass or solar mass -, and m is mass of particle, and $v_0 \leq c$ is a velocity parameter [L57, L119, L130, L128] [K11]. The Nottale hypothesis, in particular the dependence of $\hbar_{gr}$ masses (more generally charges) is discussed from the point of view of Yangian symmetry implying polylocal conserved charges in [L124].

Nottale hypothesis conforms with the Equivalence Principle and implies universality in several senses. The cyclotron energies $E_c = \hbar_{gr}ZeB/m = ZeGMB/v_0$ for charged particles and gravitational Compton length $\Lambda_{gr} = GM/v_0$ are independent of the particle mass m. Cyclotron frequencies do not depend on h and Josephson frequency $f_J = ZeV/h_{gr} = ZeVv_0/(2\pi GMm)$ is inversely proportional to mass m just like f_c so that the ratio f_c/f_J is also universal in that it does not depend on the mass of the charged particle. Also the generalized Josephson frequency $F_J = \Delta f_c + f_J$ is universal.

Cell membrane as a (generalized) Josephson junction is an essential element and its ground state corresponds to a propagating soliton sequence. A perturbation reducing the membrane potential below the critical value for the generation of action potential replaces nerve pulse as a fundamental phenomenon and the soliton sequence would be present in all cell bodies but would not propagate as it does in the axons and dendrites. Neither would it generate a nerve pulse. The modulation is universal and the same for all charged particles. Frequency scale is however inversely proportional to the particle mass m and highest for electrons.

If the modulation is small, the cyclotron frequencies define the frequency scale and corresponding natural time scale for events at the MB. In the "endogenous" magnetic field $B_{end} \simeq 2B_E/5$, where $B_E \simeq .5$ Gauss is the nominal value of the Earth's magnetic field, tentatively interpreted as monopole flux part of the Earth's magnetic field the cyclotron frequencies of proton and electron are $f_c(e) = 6 \times 10^5$ Hz and $f_c(p) = 300$ Hz (assignable to the rotating shaft of ATPAse). Ions have cyclotron frequencies in the EEG range. For protons, a modulation by a nerve pulse of duration of few milliseconds would represent rather slow frequency modulation in the scale of $f_c(e)$. For protons and ions, the modulation would be a short ripple and presumably of no significance. Hence the nerve pulse could be significant only for the representation of the system provided by dark electrons.

This suggests that generalized Josephson radiation for B_{end} appears in various frequency scales characterized by cyclotron frequencies of electron, proton, and biologically important ions and that one can assign flux tubes of the gravitational part of magnetic body with various kinds of ions with characteristic frequency and time scales but universal cyclotron energies. Besides B_{end} also other values of B can be considereed and the model of bioharmony suggested that approximately correspond to frequencies of 12-note scale [L12, L73, L100, L120].

One can assign to elementary particles also a p-adic secondary time scale and for electrons this scale corresponds to .1 second assignable to the alpha band of EEG. Intriguingly, for u and d quarks this time scales if of the order of the millisecond time scale assignable to nerve pulse.

14.2.1 TGD based view about nerve pulse conduction

In the TGD framework, nerve pulses would be induced by more fundamental dynamics of the neuronal membrane acting as a possibly generallized Josephson junction between superconductors associated with the lipid layers of the membrane. Also the ordinary cell membrane would give rise to this kind of Josephson junction. The sequence of Sine-Gordon solitons propagating along the axons would represent the resting state of the axon and its perturbations would define the fundamental dynamics. An interesting question is, how this sequence relates to the time crystals now in fashion.

At the microscopic level, this Josepson junction would decompose to Josephson junctions associated with the membrane proteins acting as ion channels.

1. In the microscopic picture, the axon is analogous to a sequence of penduli associated with the membrane proteins acting as Josephson junctions and during nerve pulse as ion channels.

   The Sine-Gordon soliton sequence is mathematically analogous to a sequence of rotating penduli such that the phase difference between subsequent penduli is constant. This gives rise to a constant phase velocity v. Perturbation corresponds to the local transformation of the rotation to oscillation so thay frequency parameter is reduced. The perturbation propagates with the same velocity as the solitons of the soliton sequence.

   If the perturbation takes the membrane potential below critical value, action potential is generated and in myelin free regions the optimum velocity v is identifiable as the conduction velocity v_c of the nerve pulse. For $v \geq v_c$, the physiology is too slow to react to the perturbation.

2. There is no need for action potentials in the myelinated regions. This would lead to considerable energy savings reducing the energy feed by factor $1/100$ as the ratio of the lengths of Ranvier nodes and myelinated portions.

   The perturbation of the soliton sequence could propagate freely since it would not be forced to move at the same velocity as the action potential restricted by physiological constraints. This would increase the propagation velocity and apparent conduction velocity by a factor of order 100 and give rise to the dramatic difference between vertebrates having myelinated axons and invertebrates without them.

3. Action potentials would be generated only in the unmyelinated Ranvier nodes of length about 1 mm between myelinated portions of length about 100 μm. This allows considerable savings in metabolic energy. Overcritical modulation would generate an action potential at positions of voltage gated ion channels inside the Ranvier node.

4. The TGD based model would solve the still-unsolved problem about how action potentials are conducted in the myelinated portions of axon. Saltation is the proposed mechanism but is plagued by many blatant conflicts with empirical facts [**?**] (`https://cutt.ly/GTvjEJo`). For instance, the thickness of myelinated axons is not enough to guarantee high enough conduction velocity.

   The fact that the splitting of the axons does not prevent the transfer of the action potential between myelinated portions, which suggests that there is a deeper propagation type phenomenon involved. In the article it is proposed that the saltation could be understood as a wave packet in plasmon-polariton condensate and that the entire myelinated portion effectively acts as a dipole.

   In the TGD framework there would be no conduction of nerve pulses inside myelinated regions but propagating waves in plasmon polariton type condensates (Ca waves?) could induce perturbations of propagating soliton sequence assignable to cell membrane as a generalized Josephson junction allowing communication of chemical "sensory" data to magnetic body (MB) of the system.

What is the function of neurotransmitters?

In the standard picture, the neurotransmitters would make possible propagation of a membrane voltage modulation through synaptic gap by building a bridge. This picture looks rather reasonable

in the context of standard neuroscience.

What the function of neurotransmitters could be in the TGD framework? TGD allows several guesses for what happens at synaptic contact.

1. Flux tubes, or rather, the massless extremals (MEs) [K68, K8]) associated with them act as wave guides for classical gauge fields. Neurotransmitters at the synaptic contacts would connect pre- ja postsynaptic flux tubes to longer flux tubes. This would make classical communications possible inside the brain and generate classical coherence. There would be no quantum coherence at the level of ordinary matter but the classical coherence would be induced by the quantum coherence at the level of MB.

   At the level of MB the neurotransmitters would induce the increase of the scale of quantum coherence and h_{eff} could increase. h_{eff} and therefore the scale of quantum coherence tend to be reduced spontaneously so that it can last for some average time τ. Therefore $L = v \times \tau$ gives an upper limit for the average coherence scale at the level of CNS. The higher the conduction velocity v, the larger the size of the coherence regions. For $v = 100$ m/s and $\tau \simeq 1$ ms, one would have $L = .1$ m, the size scale of the human brain hemisphere. In the TGD view, the high conduction velocity would not be a prerequisite for high rate of communications in the brain but for the formation of large enough coherence regions.

   TGD also suggests that the bridges at junctions serve as relays making possible communications to the MB of a system consisting of pre- and postsynaptic neurons.

2. In this framework, the difference between vertebrates and invertebrates would not reflect the different rates of information processing but the different sizes of coherence regions and of the associated quantum coherence regions at the level of MB, which should be for vertebrates roughly by a factor 100 larger than for invertebrates.

   Note however that octopus (see `https://cutt.ly/cTvh3yD` and `https://cutt.ly/zTvh5Ir`) is is a highly intelligent invertebrate. In particular, it also has EEG. Octopus CNS has several centers analogous to the brain but there are no somatotopic mappings of sensory data providing a representation of the entire organism or even part of it. These features could be understood as reflecting the smaller size of the coherence regions at the level of the CNS.

3. The (possibly generalized) Josephson radiation communicated to MB from both unmyelinated and myelinated portions of the axon would create a sequence of cyclotron resonance peaks at flux tubes of MB. Resonance is obtained when the frequency modulated (generalized) Josephson frequency coincides with the cyclotron frequency at the flux tube of MB which can vary along the flux tube.

   The sequence of resonance peaks transforms the Josephson radiation to an analog of nerve pulse sequence and yields a feedback communicated via genomes and/or microtubuli to the postsynaptic neuronal membrane by transversal flux tubes. The outcome would be oscillations of the membrane potential perturbing the soliton sequence and possibly generating nerve pulses so that a closed control loop would be obtained. This communication to MB would correspond to EEG and possibly existing fractally scaled analogs of EEG.

   The communication of Josephson radiation followed by SSFR or BSFR is analogous to Fourier transform. The continuous temporal pattern of Josephson oscillations is transformed to a sequence of resonance peaks analogous to a sequence of nerve pulses defining a sequence of time differences.

4. This picture suggests that the information processing occurs at the level MB. How the response of MB to this sensory input is generated? The simplest option is that it is realized as a BSFR inducing time reversed time evolution just like raising the finger in the experiments of Libet. No specific mechanism would be needed.

5. For the ordinary Josephson junctions, the quantum coherence would be lost during action potential and the idea about small modulation of Josephson frequency does not make sense. This need not be the case for generalized Josephson junctions. The generalized Josephson frequency F_J is the sum $F_J = \Delta f_c + f_J$ of terms consisting of the difference Δf_c of cyclotron

frequencies for transversal flux tubes at both sides of the membrane and of Josephson frequency f_J, which would be small correction giving rise to modulation which is larger than in absence of nerve pulse.

If only ordinary Josephson junctions are present, the role of nerve pulse would be passive and purely chemical. Nerve pulse activity would affect the chemistry and would be essential in motor actions and in the long term modulation of brain structure and of function and behavior, say by inducing long term potentiation.

If MB is there, it would look natural for it to participate also in the long term modulation of brain function and behavior so that the communication of nerve pulse patterns to MB requiring generalized Josephson junctions looks a more attractive option.

14.2.2 Brain as a factory of standardized mental images

According to an earlier view, the brain would be a factory of standardized mental images. They would be produced by a quantum counterpart of pattern recognition involving virtual sensory input to sensory organs. How does the new view relate to this picture?

Earlier view

TGD leads to the proposal that nerve pulses do not transfer information inside the brain. The information about nerve pulse pattern could be communicated to MB if the notion of generalized Josephson junction makes sense as a modulation of the frequency F_J of generalized Josephson radiation containing a contribution proportional to membrane potential. This does however not seem absolutely necessary.

1. The starting point of the TGD based model of the brain is the idea that biophotons are ordinary photons produced from dark photons. There are indeed indications for the role of biophotons in brain functioning. This leads to the idea that dark photons and classical em fields propagating along massless extremals (MEs) parallel to magnetic flux tubes in the scale of brain are essential for the communications inside brain and that nerve pulses serve as relays connecting pre- and postsynaptic flux tubes to larger structures.

2. Also connections to much larger MBs are possible and could even give rise to communications allowing to exceed the limitations due to finite speed of light since signals could be time reflected by BSFR from very distant objects. The occurrence of BSFR is assumed quite generally in the new view.

3. Even BSFRs, the fact that light velocity dramatically exceeds the velocity of nerve pulse conduction would make possible virtual sensory input from the brain (or from MB via brain) to sensory organs as ordinary dark photon signals. This would make possible iteration producing standardized mental images. REM dreams serve as a support since they could be regarded as reflecting virtual sensory input from MB.

The open problem of this picture is that detailed mechanisms for the information processing at cortex or MB and for the generation of virtual sensory input are missing. Zero energy ontology (ZEO) [L86] [K123] could automatically provide these mechanisms.

The modified view

In the new view the signalling between parts A and B of brain (and body) would always occur in scales via an appropriate layer of MB as A→ MB → B rather than directly as A→B and involve BSFR at MB.

The BSFR at the level of MB would be followed by the step S→ MB (S denotes sensory organ) inducing a virtual sensory input MB→S via a signal via genomes of neurons of axon or microtubuli.

1. Genomes and/or microtubuli would receive the cyclotron radiation induced by a sequence of resonance peaks at MB and by stochastic resonance would transform this sequence to

oscillations affecting the membrane potential. The step MB→S would be a time reversal for the transformations of the Josephson photon signal to resonance peaks in the step $S \to MB$.

Remark: This picture explains why we can remember our dreams although we remember nothing about the sleep state. The natural assumption is that the sleep state corresponds to a change of the arrow of time by BSFR and that we cannot remember anything about this period. We remember dreams and this can be understood as a partial wake-up of the brain by another BSFR giving rise to the standard arrow of time. The change of the arrow of time at MB for a part of the brain would give rise to a virtual sensory input at some sensory organs and to REM dream.

2. MB has a layered onion-like structure involving several scales and the communications in shorter scales as communications $BB \to MB \to MB$ occurring via BSFR would be fast and have the same effect as classical communications. In longer scales involving layers of MB of size of order Earth, light velocity would become a problem, and the time reversal of BSFR could overcome this problem. One can even consider sizes of MB so large that the barrier due to finite light-velocity is overcome.

3. Brain can be seen as a factor of standardized mental images also in this picture. Communication steps between brain (and possibly MB of brain) and sensory organs are only replaced with the steps S→ MB → S.

   One can also consider the possibility $S_1 \to$ MB→ S_2 making possible quantal associations and synesthesia. Also sensory motor associations as an analog of synesthesia becomes possible.

Is the new picture consistent with the earlier view?

Is the new view about the brain as a factor of mental images consistent with the earlier view? Zero energy ontology (ZEO) implies that classical physics is an exact part of quantum physics so that also BSFR must have classical correlates.

In ZEO, zero energy state is a superposition of classical deterministic time evolutions - space-time surfaces which are preferred extremals - having 3-D ends at the boundaries of a causal diamond (CD).

1. The passive boundary of CD is not affected during the sequences of "small" SFRs (SSFRs) and also the 3-D states at it are unaffected (analog of Zeno effect). The active boundary of CD is shifted and the size of CD increases at least in statistical sense during the sequence of SSFRs. Also the states at the active boundary are affected in SSFRs.

2. In BSFR, the roles of boundaries of CD are changed and the new zero energy zero energy state as pair 3-D states (or perhaps their superposition) is a superposition of time reversed time evolutions beginning from the final state in 3-D sense (note that holography is almost exact). The strange looking experimental findings of Minev *et al* [L75] and Libet [**?**] support this picture [L75]. This implies that BSFRs look like deterministic classical time evolutions for times assignable to the final state in 3-D sense.

3. Quantum classical correspondence is an essential element of TGD and implied by ZEO. Classical signals defined by what I call topological light rays (massless extremals, MEs) propagating with light velocity define a subset of classical correlates for what happens in BSFRs. The MEs would be parallel to flux tubes and signals would propagate along them to sensory organs and effectively give rise to the virtual sensory input.

   The next BSFR would re-establish the original arrow of time and give rise to the modified sensory input from sensory organ (S) to the brain as nerve pulse patterns and oscillations of membrane voltage. The iteration of the loop S→ MB → S would give rise to standardized mental images in analogy with the pattern recognition.

   Therefore one can say that the earlier picture is consistent with the new view if it is interpreted in terms of classical correlates.

There are several views about what memories are and one can invent an endless variety of representations of memories. As a matter, in the TGD framework one cannot separate representations of realities from the realities and conscious representations are everywhere.

14.2.3 How information is represented at the level of MB?

The basic question is how information is represented at MB. Computationalists assume analog of computer memory but in the TGD framework the representation as conscious repetitive processes looks more appropriate.

Memories as behaviors

Neuroscientists understand memories as behavioral patterns realized statistically as connections between neurons. Conditioning and associations as behaviors are realized in terms of strengthening of the synaptic contacts between post- and presynaptic neurons. This gives rise to neural networks.

In the TGD framework MB would realize these networks as flux tube networks at higher level and induce the counterparts of these networks at the level of BB (CNS). The connections A-B between nodes would be via MB as connections A-MB-B. If the generalization of Josephson junction is accepted, MB would actively control long term potentiations and development of behaviours.

The communication of the perturbations of propagating Sine-Gordon sequence associated with the axonal membranes and stationary Sine-Cordon lattice associated with the cell membrane would define one particular representation.

Memories as conscious mental images

Conscious information can be represented as conscious mental images defining temporal and spatial patterns.

1. Episodic and sensory memories are this kind of memories, kind of re-experiences. This kind of patterns would correspond in the TGD inspired theory of consciousness mental images as sub-selves, living entities having analogs of wake-up and sleep periods. After images provide a good example. They would be born in BSFR and die in the next BSFR and disappear from consciousness of self. They would however live with an opposite arrow of time during their sleep period.

2. Short term memories and perhaps also long term memories could be analogous to repeating after images. The loop BB-MB-BB from axon to magnetic flux tube and back could create a repeating nerve pulse pattern accompanying a similar repeating pattern of membrane potential oscillators modulating the frequency of the Josephson current. One can wonder whether this kind of representation applies for all time scales as memory spans.

Criticism of the computationalistic view about data representation and data storage

Computationalistic view about memory interprets memory as a sequence of symbolsm carved in stone. One can argue that the mathematical complexity of the sequence serves as a measure for the information carried by the sequence. This however does not tell anything about the information itself and a more approprite interpretation is as complexity.

As such the symbol sequence carries no conscious information. One can invent an endless number of various physical representations. How the physical realization is "read" to conscious experience remains however unsolved. Reading ordinary text induces a conscious experience in the reader and one could say that the experience tells what the information coded by the text is. The text has different meaning for different readers or no meaning at all.

Conscious information must be assigned to temporal dynamic patterns but they are not dynamical in the classical sense of the word. State function reduction (SFR) as a moment of consciousness would be the basic building brick for these patterns and since SFR replaces the quantum universe with a new one, one must give up the idea that deterministic dynamical patterns with respect to geometric time could carry any information as such. One can assign to them a measure of complexity, say as the dimension and structure of extension of rationals associated with the space-time region, but no information.

TGD based model of the genetic code

The TGD inspired model of genetic code based on the notion of bioharmony allows quite a dramatic generalization of the genetic code and suggests a radically different view about representation of information and its communication and even about how living matter functions.

1. DNA is often regarded as a sequence of letters and the 64 codons represent 6 bits of information. In this view, genes would correspond to bit sequences and be analogous to computer programs. Transcription to mRNA translated to proteins would be reading and printing of this information.

2. In the TGD framework, the notion of genetic code generalizes. These entities have magnetic bodies carrying dark matter which provides the fundamental realization of the genetic code. Chemical code would be a secondary realization.

   The flux tubes parallel to DNA strands are assumed to realize genetic codons as states of dark proton triplets [L12, L100]. The communications between DNA, RNA, tRNA, and amino-acids are realized in terms of dark photon triplets also realizing genetic code as 3-chord music of light one might say. The three dark protons/photons form a single quantum coherent unit.

   Bioharmony would correspond to what might be identified as the holistic emotional aspect of intelligence not taken into account in computationalism whereas codons as 6-bits would correspond to a reductionistic local aspect of intelligence.

   This idea generalizes further. Also genes can be realized as quantum coherent units both in terms of dark N-protons and N-photons analogous to Bose-Einstein condensates.

3. The formation of dark N-protons and N-photons relies on a universal number theoretic mechanism for the formation of bound states by what I call Galois confinement. At the M^8 level the mechanism has a simple description. The momenta of quarks at the fundamental level are algebraic integers in the extension of rationals defined by 4-surface of M^8 mapped to H by $M^8 - H$ duality.

   This makes possible number theoretic universality, meaning that the momenta of quarks defining the quantum state and corresponding to a subset of points in $X^4 \subset M^8$ make sense also for the extensions of p-adic numbers defined by the extension of rationals. The subset of points of X^4 carrying quarks defines the physical set as a cognitive representation.

   Bound states of quarks would have by periodic boundary conditions momentum components, which are ordinary integers for a suitable momentum unit defined by the size scale of CD. This means Galois confinement. Fermi ball with each point with momenta having integer components is a maximal cognitive representation.

4. This gives rise to a hierarchy of Galois confinements in which the Galois non-singlets of a given level can form singlets at the next level. This generalizes also to wave functions in the space of momenta with algebraic integer valued components which would be Galois singlets for physical states.

   This would define a universal mechanism for the formation of bound states. Stability however requires that the energy of the bound state is smaller than the sum of the energies of composites. Dark N-codons and dark 3N-photons would represent special cases of these entities.

   This picture also leads to a vision about communication and control and information processing in living matter.

1. 3N-(cyclotron)-resonance between dark proton N-triplet representing DNA, RNA, tRNA or amino-acids by dark photon N-triplet makes possible communications in which only identical codon sequences get in contact. Frequency- and energy resonance are possible if the values of h_{eff} are the same and only energy resonance if they are different.

   Resonant communication by dark photons, possibly transforming to dark photons with a different value of h_{eff} or to ordinary photons, gives rise to association sequences analogous to those appearing in computer language LISP.

2. Even this is not enough. In the TGD framework the spectrum of possible genetic code expands dramatically and DNA and basic biomolecules could be only a special case.

   The hyperbolic space realized as a mass shell at the level of M^8 would define an infinite number of tessellations [L120]. Perhaps the simplest tessellation, known as icosa-tetrahedral tessellation also involving octahedrons, realizes genetic code in the model of bioharmony. The projection of this tessellation induces a tessellation at 4-surface of H mapped to $M^4 \times CP_2$ by $M^8 - H$ duality. The induced tessellation is. analogous to the quasicrystal, which is also obtained as a projection of a higher dimensional lattice.

   This tessellation could assign variants of genetic code which can be, not only 1-, but also 2- and 3-dimensional. For instance, the cell membrane could provide a 2-D realization of genetic code. Genetic code could be present everywhere, even outside biology.

3. Could the generalized Josephson radiation consisting of dark 3N-photons have an interpretation as N-codons analogous to 2-D variants of genes so that the propagation of the perturbation of the soliton sequence would be like reading a "sentence" for MB serving as a listener? Could the myelinated portions of axons define this kind of generalized genes? Could the nerve pulse at Ranvier nodes define the analog of punctuation mark ending a "sentence"?

   This proposal is actually inspired by the TGD inspired model for the emergence of human language [L161, L162].

14.2.4 Model for how information is communicated to MB

Since MB represents a higher level in the self hierarchy, the above considerations suggest that the communication of information from BB to MB is analogous to speech or written language.

Could Josephson radiation patterms assignable to the myelinated portions of axon define "sentences"?

The intuitive feeling is that the decomposition of axon to myelineated portions and the Ranvier modes generating action potential should have some meaning from the point of view of communications from BB to MB. Since MB should provide a higher level cognitive representation of the sensory data, the natural idea is that Josephson radiation patterns assignable to the myelinated portions of axon define analogs of sentences and that the Ranvier nodes and the associated action potential defines an analog of punctuation mark. BB would be talking to MB and MB would be bresponding.

For generalized Josephson junctions also nerve pulse patterns are communicated to MB and an interesting question is whether they could be analogs of punctuation marks or of stopping codons for DNA and divide the signal to MB to what might be regarded as "sentences".

1. If one assumes generalized Nottale's hypothesis, the nerve pulse durations of about ms would be longer than the cyclotron frequency $f_c = 6 \times 10^5$ Hz of electron in B_{end} by a factor of order 10^3 and the propagation along myelinated portion would last about $T = 1$ μs, which is of the same order of magnitude as $T_c = 1/f_c(e)$ so that the interpretation is not plausible. Rather, slow modulation of generalized Josephson radiation for electrons looks a more plausible interpretation.

2. For ions, T is too short as compared with the cyclotron time scale T_c for B_{end}. Ions could correspond to slow oscillations of the membrane potential above $f_{J,c}$. Fast Calcium waves have velocities 10-30 μm/s. Slow Calcium waves propagate with velocity about $v \sim 1$ μ/s (`https://cutt.ly/tTWrTrA`). In these cases, one would have $T \in 3.3 - 10$ s and $T = 100$ s.

3. The propagation velocity assignable to the perturbation of the soliton sequence need not be the same as that for the soliton sequence and it could depend on the ion to which the perturbation is associated. In this case, the interpretation of the Josephson radiation pattern as a "sentence" of text and of the action potential at the ion channel as an analog of punctuation mark can be considered.

4. More generally, various ions could induce propagating oscillations of the membrane potential parameterized by frequency and velocity, each in their own frequency scale, and these oscillations would correspond to a modulation of F_J giving rise to cyclotron resonance peaks at the gravitational MBs of dark ions. This would define a sensory representation of the chemical dynamics at various layers of MB.

The ion waves could correspond to waves assignable to plasmon-polariton BEC condensates proposed in the article of Jacak [?] but with $h_{eff} \leq\leq h_{gr}$. Plasmon corresponds to an oscillation of the density of plasma particles. In units with $c = 1$, the plasma frequency for free charges is given by $f_P = Ze\sqrt{n/m}/2\pi$, where n is number density of the ions, Ze is ion charge, and m is ion mass. Usually only electrons are considered because they are the most important charged plasma particles.

Surface-plasmon-polariton appears at the surface of metal in contact with dielectric (such as air) and can be seen as a quantum superposition of electromagnetic field propagating in dielectric and a surface plasmon at the plasma surface. Plasmon-polariton BEC condensates as analogs of flow equilibria could be driven by metabolic energy feed. It has been proposed that plasmon-polariton BECs appear also in cell membranes [I29] (`https://cutt.ly/LTWbH13`). These BECs might form a bridge between BB and MB.

Model for the flux tubes receiving the Josephson radiation

It is interesting to consider models for the perception of the Josephson radiation at the flux tube or of a bundle of flux tubes having interpretation as many-sheeted space-time but regarding CP_2 instead of M^4 as fixed space-time.

Consider first a model based on single flux tube with a varying thickness.

1. The magnetic field strength at the flux tube scales like the inverse of the area S of the flux tube proportional to the radius squared. The variation of the flux tube radius R therefore defines a range of resonance frequencies and different momentary Josephson frequencies correspond to special points of the flux tube and single point if the flux radius is monotonically increasing.

2. This would translate the temporal variation of frequency modulated generalized Josephson radiation to a motion of the resonance point along the flux tube and could give rise to a conscious experience as a sensation analogous to a moving point of touch. If BSFR accompanies the resonance, the arrow of time would change at the point considered and give rise to wake-up at the resonance point.

3. For the myelinated regions the motion is smooth in the entire frequency interval. For the unmyelinated portions, one can divide the frequency range to two intervals corresponding to the frequencies above the critical frequency $f_{c,c}$ for the generation of the action potential and those below $f_{c,c}$. One would have a smooth motion for over-critical frequencies $\Delta f_c + f_{J,crit}$, where $f_{J,c}$ is the critical value of Josephson frequency below, which action potential is generated. For sub-critical frequencies a rapid motion from $\Delta f_c + f_J$ to $\Delta f_c - f_J$ and back scanning over the entire flux tube portion and back occur in unmyelinated regions.

A possible interpretation is that this defines the analog of punctuation mark for the signal as analog of written "sentence" defined by the input from the unmyelinated region.

4. For $v = 10^2$ m/s and $L = 100~\mu$ m, the duration $T = L/v$ of the "sentence" associated with the myelinated portion of axon would be about 1 microsecond. Interestingly, the cyclotron frequency of electron in the "endogenous" magnetic field B_{end}, proposed to correspond to the typical value of the field strength at the monopole flux tube contributing to the Earth' magnetic field, is 6×10^5 Hz. For an unmyelinated portion of axon of length about 1 μm the velocity is roughly 1 m/s and the duration would be roughly 1 microsecond and roughly the same. The duration of nerve pulse is measured in milliseconds and is considerably longer so that the natural interpretation is as a modulation of Josephson frequency assignable to electron.

5. As already explained, if the perturbations of the membrane potential propagate slowly as Ca waves do, then the Josephson radiation pattern for ions could define "sentences" for the myelinated portions of axon and Ranvier node could play the role of a punctuation mark.

One can also consider a model based on a bundle of flux tubes such that each flux tube has a constant thickness and single cyclotron frequency. The flux tubes would be like pipes of an organ and the incoming Josephson radiation would serve as an organist. The bass register of the organ would be activated during the nerve pulse and nerve pulse would give rise to forth-and-back arpeggio between $F_{J,max} = \Delta f_c + f_{J,c}$ and $F_{J,min} = \Delta f_c - f_{J,c}$.

14.3 Humans are different

The popular article in Medicalxpress (`https://cutt.ly/2TvhXVE`) tells about highly interesting observation described in the Nature article "Allometric rules for mammalian cortical layer 5 neuron biophysics" by Mark Harnett [**?**] (`https://cutt.ly/8TvhMej`).

14.3.1 The volume density of voltage gated channels in human brain is much lower than for other mammals

The finding is that the density of voltage gated channels in the human brain is dramatically lower than in other mammalian brains. The neuronal system studied was layer 5 pyramidal neurons. Dendrites of these neurons were considered. Densities of voltage gated channels per neuron volume and per brain volume were studied. The ion channels studied were Na and K channels. The channels considered are ion pumps and need metabolic energy.

10 mammalian species were studied so that cortical thickness and neuron size were the varying parameters. As the neuron size increases, the density of neurons decreases. The first finding was that the density of ion channels for the neuron increases as the neuron size increases. The density of ion channels per brain volume was however found to be constant.

Humans were found to be an exception. The density of the channels per brain volume is dramatically reduced. The proposed interpretation is that this reduces the amount of metabolic energy needed to generate action potentials and the metabolic energy is used for other purposes.

Before continuing, it is good to recall some basic facts about neurons. Synapses (`https://cutt.ly/GTvjyFp`), dendrites (`https://cutt.ly/KTvjo7J`), and myelination (`https://cutt.ly/ZTvjdm1`) are the basic notions needed if one tries to understand these findings. It is enough to notice that most synaptic contacts are between axons to dendrites but that almost any other combinations are possible. Myelination occurs mostly for axons and only rarely for dendrites. The dendrites of the excitatory pyramidal cells studied in the article are profusely decorated with dendritic spines.

Could the TGD view about the brain allow us to interpret these findings? Why would the density of the voltage gated ionic channels be smaller for (at least) pyramidal dendrites? How could this relate to the evolutionary leap leading to the emergence of humans?

14.3.2 Possible interpretations for the reduction of the density of the voltage gated channels in humans

What could the reduction of the density of voltage gated channels mean? Why would the distances between voltage gated channels be longer for humans and what does this imply?

Recall first the basic ideas of the TGD based model of the nerve pulse.

1. The TGD inspired proposal is that humans differ from other mammals in that the value of h_{eff} involved is considerably larger for some neurons. The MBs of neurons would form an evolutionary hierarchy as also genes. In fact, the TGD inspired model for the generation of language [L161, L162] assumes that the value of h_{eff} for the MBs of language genes is considerably larger than for other genes.

2. The average distance between voltage gated ionic channels defines a spatial resolution scale and is a good candidate for the minimum wavelength λ assignable to a signal propagating along the dendrite. For an ordinary photon, λ defines energy, which must be above the thermal energy at physiological temperatures. This minimum energy is rather near to the minimal energy of the ordinary Josephson photons associated with membrane potential (about .05 eV) and the corresponding wavelength is 14.8 μm.

3. Nerve pulses [K80] are induce by perturbations of oscillating Josephson current, which in the rest state corresponds to a propagating sequence of Sine-Gordon solitons mathematically analogous to a sequence of rotating gravitational penduli. Nerve pulse corresponds to a perturbation, which kicks some penduli from rotational to an oscillating motion and this perturbation propagates along the axon with the same velocity as nerve pulse.

4. For generalized Josephson junctions, the Josephson radiation is frequency modulated by nerve pulse patterns. Also the spatial pattern of Josephson radiation characterized by the density of voltage gated ionic pumps along the flux tube contains information. The density of voltage gates, whose transversal flux tubes act as Josephson junctions characterizes the length scale resolution of the spatial variation at the receiving part of MB, say magnetic flux tube. MB receives a collection of Josephson radiation signals from the points of axons containing a voltage gated channel.

This allows us to consider two different but not mutually exclusive explanations for the finding.

1. The spatial resolution of the percept produced at MB by Josephson radiation would be reduced for humans. This need not be a drawback since it could be also understood as an abstraction. High spatial resolution would be needed only for local percepts in the scale of neuron soma. On longer scales it would mean generation of useless information and metabolic energy waste.

   The natural guess is that the resolution scale is proportional to $\hbar_{eff,B}$ at intra-brain flux tubes in turn proportional to $\hbar_{eff,MB}$ for the flux tubes at the MB of brain having quantal length scales much longer than brain size. The range of variation of the spatial resolution could correspond to the variation of ordinary photon wavelengths between visible wavelengths (of order μm) and IR wavelengths of order 14.8 μm. Note however that the lengths of myelinated portions are about 100 μm.

2. Suppose that Josephson radiation patterns associated with the myelinated portions of axon define "sentences" and the unmyelinated portions define punctuation marks ending these "sentences" by a nerve pulse. Does the notion of "sentence" make sense also for dendrites?

   At least in the case of humans, having a reduced volume density of ion channels, this picture might generalize also to dendrites, which are usually un-myelinated since the myelination is not needed since the dendrites are typically short as compared to axons. If so, the average distance between two ion channels would define length and duration for a "sentence".

   For other mammals than humans, the "sentences" would be very short or the notion of "sentence" would not make sense at all (the spatial extent of the perturbation of the membrane potential would be of the order wavelength of the soliton). Could this reflect the emergence of language in humans? MB would not only receive long "sentences" but also send them back as control commands inducing motor actions and virtual sensory input.

3. If the communication between pre-and postsynaptic neuron occurs via MB, dendrites would receive "sentences" from the MB of the presynaptic neuron as a feedback. If generalized motor action is in question, BSFR and time reversal would be involved. The action potentials propagate along axons in a single direction, which would reflect a fixed arrow of time. Does the reversed arrow of time imply that the action potentials along dendrites propagate outwards from the cell body?

   According to Wikipedia (`https://cutt.ly/9TnRDo4`), dendrites indeed have the ability to send action potentials back into the dendritic arbor. Known as back-propagating action potentials, these signals depolarize the dendritic arbor and provide a crucial component toward synapse modulation and long-term potentiation. Furthermore, a train of back-propagating action potentials artificially generated at the soma can induce a calcium action potential (a dendritic spike) at the dendritic initiation zone in certain types of neurons.

4. Dendrites are usually unmyelinated. This conforms with the fact that dendrites are much shorter than axons so that myelination is not needed. Myelination would also restrict the

number of synaptic contacts. Myelinated dendrites have been however found in the moto-chords of frog (`https://cutt.ly/HTnmqOi`) and in the olfactory bulb (OB) of some mammals, for instance mouse (`https://cutt.ly/ITnmC1d`). Their fraction is small.

Olfactory system (OS) is very interesting in this respect since it represents the oldest parts of CNS. The axons from the nasal cavity to the olfactory bulb (OB), where odours are thought to be processed are unmyelinated as are the axons of invertebrates in general. The axons from the olfactory bulb (OB) to the olfactory cortex (OC) are myelinated. This conforms with the idea that OB corresponds to the oldest part of OS. The TGD interpretation would be OB sends the results of analysis to OC via MB as "sentences".

OB also can have a small fraction of myelinated dendrites implying a reduction in the number of synaptic contacts. The rule "A→B" → "A→ MB→ B" suggests that there is an MB between olfactory epithelium and OB and that some analysis is performed at MB. If so, the myelinated dendrites would correspond to input from MB as long "sentences".

Chapter 15

Quantum Statistical Brain

15.1 Introduction

The considerations of this chapter were inspired by two popular articles. The first popular article (`https://cutt.ly/1IM14xa`) told about findings [**?**] (`https://cutt.ly/aIMOajF`) of Li *et al* supporting the view that neural noise carries information in the sense that it represents the uncertainty of visual short term memories so that both the content of memory and its uncertainty are represesented.

Second inspiring popular article published in Science Times (`https://cutt.ly/iONjRI2`) had a long title "*Are We Living In the Past? New Study Shows Brain Acts Like A Time Machine That Brings Us 15 Seconds Back*". It caught my attention because the basic prediction of TGD inspired theory of consciousness is that the perceptive field is 4-dimensional rather than 3-D time=constant snapshot as in standard neuroscience.

The original article by Mauro Manassi and David Whitney, published in Science Advances [**?**] (`https://cutt.ly/lONjIQn`), has a less provocative title "*Illusion of visual stability through active perceptual serial dependence*". The findings suggest that visual perception is a kind of temporal average over a time interval, which can be even longer than 15 seconds.

15.1.1 The findings of Li *et al*

Does neural noise carry information about the uncertainty of visual short term memories?

The highlights of Li *et al* are following:

- Humans know the uncertainty of their working memory and use it to make decisions.

- The content and the uncertainty of working memory can be decoded from so called BOLD signals.

- Decoding errors predict memory errors at the single-trial level.

- Decoded uncertainty correlates with behavioral reports of working memory uncertainty.

The abstract of the article provides an overall view about what has been done and found.

Neural representations of visual working memory (VWM) are noisy, and thus, decisions based on VWM are inevitably subject to uncertainty. However, the mechanisms by which the brain simultaneously represents the content and uncertainty of memory remain largely unknown. Here, inspired by the theory of probabilistic population codes, we test the hypothesis that the human brain represents an item maintained in VWM as a probability distribution over stimulus feature space, thereby capturing both its content and uncertainty.

We used a neural generative model to decode probability distributions over memorized locations from fMRI activation patterns. We found that the mean of the probability distribution decoded from retinotopic cortical areas predicted memory reports on a trial-by-trial basis. Moreover, in several of the same mid-dorsal stream areas, the spread of the distribution predicted subjective trial-by-trial uncertainty judgements. These results provide evidence that VWM content and uncertainty are jointly represented by probabilistic neural codes.

It is not surprising that the states of feature detector neurons should obey a statistical distribution. It is however not obvious that the reliability of the memory should correlate with the width of this distribution and that even the subjective estimate for the reliability should reflect this width.

Does the distribution in the feature space reflect quantum non-determinism?

Could the distribution in the feature space reflect quantum non-determinism rather than uncertainty of sensory perceptions and somehow also the uncertainty of memories.

1. If features as states of feature detector neurons or groups of them correspond to the outcomes of quantum measurements, they have a probability distribution. The real input to these neutron would have produced this distribution and could be estimated from the probability distribution.

   The outcomes are eigenstates of density matrix determined by the entanglement and determined apart from phase factors. For instance, in the measurement of spin of spin 1/2 particle the probabilities of spin 1/2 and spin -1/2 states can be deduced for an ensemble of identical particles but the relative phase of the spin 1/2 and spin -1/2 state cannot be deduced.

2. The interpretation of quantum measurement would differ from the classical one. Classically, and according to recent neuroscience, sensory perception means that brain, system A, detects the state of system B in the external world. Quantum mechanically, the entanglement between A and B is reduced in the measurement and entangled state becomes a tensor product of are eigenstates of the density matrix. The relationship between A and B is what is "measured". For an ensemble of outcomes, the probabilities of outcomes allow to deduce information about the entanglement before measurement.

3. If the reduction of the entanglement between sensory organ and external world can be measured repeatedly, it gives rise to a distribution of outcomes coding also the uncertainty caused by the quantum measurement. This however requires that the entanglement is regenerated between these measurements. Is this possible?

   The distribution of features would not reflect uncertainty of memories but the non-determinism of the outcome in the reduction of entanglement. Interestingly, in quantum computation this kind of ensemble is produced and from the distribution of outcomes of the measurement halting the quantum computation, the outcome of the quantum computation is deduced. The method is essentially statistical.

   In TGD framework the notion of magnetic body (MB) using biological body as sensory receptor and motor instrument emerges as a new notion. The entanglement between magnetic body and sensory organs could be reduced in sensory perception. There is a hierarchy of levels and entanglements at them and SFR is replaed with a cascade of SFRs proceeding from long to short scales.

Is the feature distribution realized as a temporal ensemble?

In sensory perception, the distribution of features should correspond to a distribution of states of feature detector neurons or their groups. How is this distribution realized? How does this distribution relate to the distribution of memories?

Let us consider the questions about sensory perceptions.

1. The neuroscience based answer to question in the case of sensory perceptions would be "As a spatial ensemble consisting of feature neurons". But how does this distribution relate to the distribution of memories?

2. In TGD framework, the answer would be "As a temporal ensemble". Zero energy ontology (ZEO) leads to a new view about quantum states as superpositions of deterministic time evolutions and modifies the view about quantum measurements allowing to circumvent the basic paradox of quantum measurement theory leading to various interpretations.

   The outcome is the notion of 4-D brain, which suggests a temporal ansemble formed by memory mental images of the feature. In ZEO, the sequences of "small" state function reductions (SSFRs) as counterparts of so called weak measurements would form temporal ensembles of memory mental images so that the connection with short term memory would be direct. The spatial ensemble would be replaed by temporal ensemble experienced consciously as memories.

15.1.2   The findings of Manassi and Whitney

"Why do the objects in the world appear to be so stable despite constant changes in their retinal images?" was the question that motivated the work of Manassi and Whitney [**?**] (`https://cutt.ly/lONjIQn`). Retinal images continuously fluctuate because of sources of internal and external noise. Retinal image motion, occlusions and discontinuities, lighting changes, and perspective changes and many other sources of noise are present. However, the objects do not appear to jitter, fluctuate, or change identity from moment to moment. Why does the perceived world change smoothly over time although the real world does not?

This problem is also encountered in quantum consciousness theories. If conscious experience consists of a sequence of non-deterministic quantum jumps as moments of consciousness, it is not at all clear how a smooth stream of consciousness is possible.

One modern explanation for the smoothness of conscious experience is some kind of change blindness or inattentional blindness. The finite capacity of visual short-term memory is certainly a fact and forces a finite perceptive resolution and effectively eliminates too fast temporal gradients. This finite resolution poses limits in perceptual, decisional and memory processing. This would naturally apply also to other sensory memories.

In the standard view sensory percept corresponds to a time=constant snapshot of the physical world. The basic prediction is that the object at a given moment of time is the real object but in a finite perceptive resolution.

The alternative hypothesis studied in the article is that the visual system, and presumably also other sensory systems, use an active stabilization mechanism, which manifests as a serial dependence in perceptual judgments. Serial dependence causes objects at any moment to be misperceived as being more similar to those in the recent past. The serial dependence has been reported in the appearance of objects, perceptual decisions about objects, and the memories about objects. In all of these examples, serial dependence is found for random or unpredictable sequential images.

This raises the question whether one can understand the serial dependence by identifying the conscious perception at a given time as a weighted temporal average of preceding time= constant perceptions over some time interval T and what additional assumptions are needed to understand the other findings related to the phenomenon. This is what the model explaining the findings of Li *et al* indeed suggests.

15.1.3 TGD based view about sensations and short term memories

To develop a more detailed model based on the proposed ideas, one must answer several questions in the TGD framework. What sensory experiences, perceptions, and features are in TGD Universe? What could the phrase "statistical ensemble of features" mean? What does sensory perception as a quantum measurement and quantum measurement itself correspond to?

The notions of sensation, perception, and feature

Sensation as the core of sensory experience must be distinguished from perception. Sensation is just the sensory awareness with nothing added. Perception involves a cognitive representation providing an interpretation of perception and consists of objects and the associations and memories associated with them.

Brain is believed to analyze the sensory input from the sensory organs to features. Features are just those aspects of the input that are relevant to survival or target of attention. Neutrons serve as feature detectors (`https://cutt.ly/vIMObqB`).

This deconstruction process is followed by reconstruction which proceeds upwards from features to objects of the perceptive field so that the perceptive field decomposes to standardized mental images representing objects with various attributes, orientation and motion are such attributes. This is basically pattern recognition. Features are basic building bricks of the sensory mental images and not necessarily conscious to us.

The reconstruction process is analogous to first drawing a simple drawing consisting of lines and then gradually filling the picture by adding colors with varying intensities. Something analogous happens also when the sound-scape of a movie is constructed. One starts from the actual sound-scape but the outcome is quite different and very far from the original. One could say that sensory perception is essentially an artwork.

In the mathematical modeling, one can speak of a feature space. Features have attributes and the claim of the article discussed is that one can assign to features a probability distribution. Brain would not only build features but also represent this probability distribution making it possible to estimate the reliability of the visual short memory. It is however not clear how the distribution gives rise to a conscious experience about reliability and how the short term memory relates to the sensory perception.

Ensemble of features as temporal ensemble of memory mental images?

The probability distribution for features should be realized somehow as a statistical ensemble. One can consider two alternative options.

1. In the standard physics framework spatial ensemble seems to be the only possible realization. The perception would be represented as a large number of copies. The fact that the inputs in the retina are mapped in a topographic way to various parts of the visual cortex poses strong constraints on the number and location of the copies. If there is a spatial ensemble its neurons should form groups of neary neurons. The problem is how the distribution of features in this ensemble can code for the reliability of sensory or memory mental images and this requires a theory of consciousness.

2. In the TGD framework, the brain is 4-D and it makes sense to speak of a temporal ensemble of memory mental images. These temporal ensembles would correspond to temporal sequences of memory mental images and the distribution aspect would be automatically realized. The variance of this distribution would provide conscious experience about the reliability of the mental images. The natural interpretation would be in terms of short term memory.

For the TGD option, the sensory input to the sensory organ, say retina, would generate a temporal ensemble of visual mental images making possible short term memory. This ensemble would be characterized by a probability distribution. The probability distribution for the states of feature neurons would be a neuronal level example of this kind of distribution. Variance would be one characteristic of this distribution and characterize the reliability of short term memory. Sensory perceptions would give rise to short term memories.

Many questions remain to be answered. How are these memory mental images generated in quantum measurements? How does the memory recall of long term memory generate a short term memory represented as a temporal ensemble of visual mental images?

1. For instance, in the memory recall of a phone number, long term memory is involved. Somehow the memory recall creates "almost" sensory, that is virtual, perception, which suggests that a virtual sensory input from MB is involved and creates a virtual sensory perception giving rise to a visual short term memory.

2. In the TGD framework, these virtual sensory perceptions would also make possible imagination. The virtual sensory input would come from MB to cortex and proceed to the lower levels of the brain but would not reach sensory organs except during dreams, hallucinatory states, and sensory memories (memory feats of idiot savants).

3. The sensation associated with the sensory experience would correspond to a state function reduction (SFR) occurring in quantum measurement. But what does SFR correspond to in TGD?

   In the zero energy ontology (ZEO), the notion of SFR generalizes. The are two kinds of SFRs: "big" SFRS (BSFRs) as analogs of ordinary quantum measurements in which a large change is possible and "small" SFRs (SSFRs) as analogs of so called weak measurements, which are assumed in quantum optics but are not very-well defined in the standard quantum theory and do not appear in the text books.

   SSFRs relate closely to the Zeno effect which states that the state of the physical system remains unaffected if the same measurement is repeated. In reality this is not quite true, and the sequence of SSFRs represents a generalization of a repeated quantum measurement allowing us to understand what really happens.

   Sensory perception would be repetition of SSFRs following analogs of unitary time evolutions and would produce an temporal ensemble of sensory mental images giving rise to short term memory. The system would be measured, it would return back to almost its original state and would be measured again. SSFR is almost a classical measurement.

In the sequel the above summarized view is discussed in more detail. Three sections are devoted to TGD inspired theory of consciousness, quantum biology and quantum brain. A more extensive discussion can be found in [L118]. In the next section a model for the generation of sensory perception and short term memory explaining the findings of Li *et al* [**?**] is considered. The last section discusses the model explaining the findings of Manassi and Whitney [**?**].

15.2   TGD inspired theory of consciousness briefly

TGD inspired theory of consciousness can be regarded as an extension of quantum measurement theory to a theory of consciousness that relies on Zero Energy Ontology (ZEO) [L114].

15.2.1   Conditions satisfied by the theory of consciousness

Any quantum theory of consciousness must be consistent with existing physics. Since existing physics cannot explain biological phenomena and consciousness, a theory explaining them is bound to predict some new physics.

The new theory must solve the basic problems intractable to current theoretical physics. Many of these problems are philosophical. This theory should also be applicable to quantum biology and neuroscience and answer at least the following questions.

1. In everyday life everyone, even a strict physicalist, will in their subjective experience, regard free will as real, but in the role of natural scientist, deny it since it is inconsistent with the determinism of classical physics. Could the underlying view of time be wrong? Could free will be consistent with deterministic field equations after all?

   It seems that behavior is built from deterministic time evolutions connecting initial and final states. Biological functions, behaviors, and computer programs represent good examples

of this. Could free will be in the selection between deterministic time evolutions. These questions suggest a new ontology in which a deterministic classical time evolution becomes the basic entity instead of the time=constant snapshot of time evolution central to the standard ontology.

2. A similar problem plagues quantum measurement theory. The state function reduction (SFR) is non-deterministic whereas the Schrödinger equation is deterministic. This has led to myriads of "interpretations". This problem is analogous to the conflict between free will and classical deterministic physics.

   It is easy to trace the origin of the problem. In standard quantum theory the observer can affect the measured system but still remains an outsider. A quantum theory of consciousness would generalize quantum measurement theory. The notion of "self" as part of a system would replace that of "observer".

   Quantum coherence is assumed to be possible only at very short scales. Coherence of biological systems, however, suggests this assumption is wrong. There is also the question whether there is some scale at which quantum behavior transforms to classical behavior. This question has not been answered. Could the quantum world actually prevail at all scales and only appear as classical? Could discontinuous quantum jumps somehow look like deterministic and smooth classical time evolutions?

3. Experienced time and the geometric time of the physicist are very different. Subjective time however correlates with geometric time: contents of sensory experience correspond to a moment of geometric time within an accuracy of .1 second: one can speak of a sensory chronon. How should one distinguish between these two times?

4. Are there physical correlates for cognition and imagination? Could they be realized at the level of space-time?

5. What do life, death, and aging mean? Could they be universal notions applicable at all scales? Does consciousness survive after the cessation of bodily function in some sense? If this were the case, universality might make it possible to provide indirect, and yet convincing, evidence for life after death.

15.2.2 ZEO based quantum measurement theory extends to a theory of consciousness

ZEO based quantum measurement theory [L114] leads to a quantum theory of consciousness. In particular, the theory predicts that the arrow of time (AT) changes in "big" (ordinary) SFRs (BSFRs) as opposed to "small" SFRs (SSFRs) as the counterparts of "weak" measurements (`http://tinyurl.com/zt36hpb`).

BSFR suggests that self-organization (SO) at all scales partially reduces to dissipation with a reversed AT implied by the generalization of the second law of thermo-dynamics (SL).

1. SO always involves an energy feed. The energies of quantum states increase with $h_{eff} = nh_0$ and h_{eff} tends to be reduced spontaneously. The energy feed prevents this and hence the reduction of the universal "Intelligence Quotient" (IQ) as the dimension n of EQ characterizing the algebraic complexity of EQ and of a space-time surface [L108, L109]. This prevents also the reduction of the scale of quantum coherence. In biology this corresponds to the metabolic energy feed.

2. In ZEO, the energy feed necessary for SO could be partially replaced with an extraction of energy from the environment by dissipation in a reversed direction of time. The self-organizing system could effectively send negative energy to the environment.

   The basic signature is a generation of gradients in conflict with SL in its standard form. This conforms with what happens in SO but does not of course prove that SO is based solely on time reversed dissipation. Both the energy feed and the extraction of energy from the environment are involved.

For time reversed dissipation no specific mechanisms are required and only metabolic energy storages - systems able to receive the negative energy dissipated in a reversed time direction - are enough. Even thermal energy could be used and there is evidence for this [L160]. This inspires a totally new vision, not only of living matter, but also in regards to possible energy technologies.

3. Time reversals occur at very short time scales at the elementary particle level and for ordinary matter with $h_{eff} = h$). For MBs controlling ordinary matter, time reversals would have long lasting effects on ordinary matter as well.

   MB has an onion-like layered structure implied by the p-adic length scale hypothesis [K64] and h_{eff} hierarchy [L83]. Layers have sizes even larger than the size of the Earth. The slaving hierarchy formed by the layers of MB carrying dark matter could control the dynamics by inducing time reversals at the lower levels as BSFRs interpreted as generalized motor actions (master and slave are standard notions in the theory of SO). A given layer of MB is characterized by its size determined by a p-adic length scale characterizing flux tube thickness and by the value of h_{eff}.

ZEO

The TGD based view of consciousness relies on ZEO solving the basic paradox of quantum measurement theory. First, a brief summary of ZEO [L114] is required.

1. The notion of a causal diamond (CD) 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 [L52])via the $M^8 - H$ duality [L94, L108, L109].

2. In the ZEO, quantum states are not 3-dimensional, but superpositions of 4-dimensional deterministic time evolutions connecting ordinary 3-dimensional states. By holography 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 AT that give rise to an analog of the Zeno effect (`https://cutt.ly/yl7oIUy`) [L114].

    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 [L121] 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.

BSFR as death and reincarnation in universal sense

In BSFRs, AT is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. The BSFRs can occur at all scales since TGD predicts a hierarchy of effective Planck constants h_{eff} with arbitrarily large values. There is empirical support for BSFRs.

1. The findings of Minev *et al* [L75] for atomic systems can be explained by the same mechanism [L89]. BSFR replaces the zero energy state with a new one and changes the roles of the 3-D states (active and passive state) at the boundaries of CD.

   For an observer with a standard AT, the final zero energy state is a superposition of deterministic, smooth time evolutions leading to a fixed 3-D state at the formerly active boundary of CD. Interestingly, once this evolution has started, it cannot be stopped unless one changes the stimulus signal inducing the evolution. The ZEO based interpretation is that a second BSFR as a return back to the initial state occurs.

2. Libet's experiments on the active aspects of consciousness [**?**] can be understood from this perspective. For instance, a test subject raises his index finger and neural activity starts *before* the conscious decision to do so. In a physicalistic framework, neural activity leads to the experience of making the decision so that free will would not be real.

   Libet himself proposed what he called a veto option: free will is in the decision to stop the action already initiated. The problem with the veto option [**?**] is that the activity beginning .5 seconds earlier looks like dissipation with a reversed AT. In the standard direction of time this looks like self-organization which leads from a chaotic state to an ordered state at around .15 seconds before the raising of the finger. The ZEO explanation is that a macroscopic BSFR occurred and generated a signal proceeding backwards in time which generated neural activity and dissipated to randomness.

3. An example from a different scale comes from earthquakes and supports universality. Earthquakes involve a strange anomaly: they are *preceded* by ELF radiation. One would expect that ELF radiation would follow the earthquake. In the TGD framework, the identification as BSFR can explain the anomaly [L90, L72].

   In biology, the reversals of AT may occur routinely [**?**] and indeed are a central element of biological SO in the TGD framework. Time reversal also explains self-organized quantum criticality (SOQC) identifiable as the basic mechanism of homeostasis [L93, L160]. Homeostasis would occur spontaneously rather than being a result of programming.

Sequence of SSFRs as life cycle

SSFRs are counterparts of "weak" measurements, which are much like classical measurements and do not involve any dramatic changes. The sequence of SSFRs gives rise to a conscious entity - self - as a sequence of moments of consciousness. Subjective time as a sequence of SSFRs correlates with the geometric time for which one identification is as the distance T between the tips of CD, whose size increases statistically.

1. In SSFRs [L112] members of states at the "passive" boundary (PB) of the CD are not changed and PB itself is not shifted although it increases in size. The active boundary (AB) recedes from PB and increases in size in a statistical sense. Also, the states at AB change by unitary time evolutions followed by SSFRs that do not affect the states at PB.

   SSFRs correspond to a measurement of observables whose action does not affect the states at PB. Cognitive measurements are excellent candidates for these kind of measurements [L112]. The time T identified as the temporal distance between the tips increases in a statistical sense and correlates with the subjective time identified as a sequence of SSFRs.

2. The identification of a "geometric now" as a correlate of "subjective now" is not unique. The most natural identification of the geometric time is as the linear M^4 time coordinate assignable with the line connecting the tips of CD. The "geometric now" would correspond to the $T_{now} = T/2$ which corresponds to a 3-D ball (not a 2-D sphere, which is its boundary)

at which the expansion of 3-ball with light-velocity changes to contraction - the analogy with
the Big Bang followed by the Big Crunch is obvious. T_{now} increases in a statistical sense.

3. $M^8 - H$ duality predicts that the roots r_n of the real polynomial P define special moments
$t = r_n$ of M^4 linear time: I have called them "very special moments in the life of self"
[L44, L45, L46, L80, L108, L109]. If these moments correspond to the values of T_{now} for
SSFRs, the size of CD increases in a step-wise manner.

4. The Lorentz invariant light-cone proper time "a" labeling the hyperboloids inside the lower
and upper half-cones of the $CD \subset H = M^4 \times CP_2$ is the second natural candidate for the
geometric time coordinate and is completely analogous to cosmic time. It reduces in a good
approximation to "t"   near the time axis connecting the tips of CD.

This picture applies at the level of H. $M^8 - H$ duality [L108, L109] forces also consider the
M^8 level. M^8 is analogous to momentum space: there is no time and space in the usual
sense. Could the claims of timeless and spaceless states of consciousness correspond to the
M^8 mode? In momentum space, time and spatial coordinates are replaced with energy and
momenta.

$M^8 - H$ duality leads to a more detailed picture of the evolution of self. One may consider
first what the evolution of self looks like geometrically.

1. A given space-time surface in M^8 is determined in terms of an octonionic polynomial $P(o)$
obtained by algebraically continuing a real polynomial $P(x)$ with rational coefficients (so that
p-adic variants of the space-time surface exist). $P(o)$ is decomposed to quaternion valued
"real" and "imaginary" parts and the space-time surface corresponds to a root for the real
part of $P(o)$ [L80, L108, L109].

The associativity of the normal space of the space-time surface is the number theoretical
dynamic principle. It implies that space-time surfaces are minimal surfaces. Also their
counterparts in $H = M^4 \times CP_2$ - obtained by $M^8 - H$ duality - are minimal surfaces
geometrizing the massless wave equation.

2. One can assign to the half-cones of the CD distinct polynomials which must be identical at
$t = T/2$. The condition is satisfied if the polynomials are $P(o)$ for the "lower" half-cone and
$P(T - o)$ for the "upper" half-cone. The space-time surfaces associated with the half-cones
are in well-defined sense mirror images glued together at $T_{geom} = T/2$. This is not however
the case for the space-time surfaces assignable to sub-CDs of CD interpreted as correlates of
the mental images of the self assignable to CD.

This proposal has strong implications.

1. The evolution by steps consisting of unitary time evolution+SSFR increases the size of CD in
a statistical sense (the number of CDs larger than the given CD is infinitely larger than those
smaller than it). PB remains unaffected apart from scaling. Hence the size of the region of
space-time surface identified as a "root" of the real part of P, increases: more of the surface
determined by P becomes visible in each SSFR. This is like opening a packet containing a
gift. Each "very special moment" $t = r_n$ brings something new in light.

2. At $T_{now} = T/2$ the sensory input from the geometric past induces sensory mental images
drifting to the geometric future and gives rise to memory mental images assignable to sub-
CDs. Contrary to a naive expectation, memory mental images indeed drift to the
geometric future of T_{now} as the size of CD increases rather than remaining in the geometric
past. The emergence of these sub-CDs in shorter scales breaks the mirror symmetry between
half-cones.

This makes it possible to learn from experiences during a given life cycle and utilize that
learning during the next life cycle with an opposite AT. In the BSFR, AB becomes passive
and these memory mental images become the "silent wisdom" for the time reversed self
representing what was learned during the previous life cycle.

ZEO and planned actions

ZEO also provides a model for planned actions. To understand the basic idea, it is good to first describe a strange finding by Armor and Sackett [**?**] and its TGD based explanation.

1. Armor and Sackett made a surprising discovery: the prediction of what happens in a future event is more reliable if the person knows that the event will actually occur. The future event was a scavenger hunt and the participant had to predict her performance defined as the number of items to be found. The participants who knew that the event would actually take place, made better predictions.

   Did the participants precognize their performance as passive spectators of themselves in the geometric future so that free will would be an illusion? This need not be the case: the information was about the number of items found and rather abstract. This did not fix the detailed behavior of the participant in the hunt.

2. Reference [L164] shows that the finding actually fits with the vision in which BSFRs occur as cascades which proceed from long to short scales. MBs represent a hierarchy of abstractions about the lowest level. The higher the level, the less detailed the information [L107]. Only this abstract information can be pre-determined.

   The BSFR for MB_2 above MB_1 in the hierarchy - the "boss" - corresponds to a time scale $T_2 > T_1$ and determines the fate of MB_1 in the time scale T_2. MB_1 can apply its free will in the time scale T_1 in the limits posed by its fate. This paradoxical finding makes the distinction between subjective and geometric time very concrete. The fate of the subject person MB_1 is to some degree determined by BSFR of MB_2. With respect subjective (geometric) time, this BSFR occurred *before (after)* MB_1 made the prediction.

   This a supports the idea of the organizer of the experiment to perform the experiment was actually communicated by MB_2 to the experimenter. Thus she only actualized her fate.

   Could most, if not all, planned actions be like this - induced by BSFR of MB_2 in the geometric future, but in the subjective past (of MB_1)? This would allow for more detailed planning at the level of MB_1. There would be the experience of planning and a realization induced by the signals from the geometric future sent by a higher level in the hierarchy of conscious entities! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than as agents with completely free will.

1. Ordinary matter is at the bottom of the master slave hierarchy and its coherence is forced by the quantum coherence at higher levels MB layers.

2. The BSFR for a higher level MB gives rise to what is experienced as a planned action at the lower levels of the hierarchy. Planned action at a given level induces a cascade of planned actions in shorter time scales which eventually proceed to the atomic level.

3. Sensory perceptions and motor actions would be universal. Sensory perceptions naturally correspond to SSFRs "weak" measurements (`http://tinyurl.com/zt36hpb`), and both BSFRs and SSFRs can occur with both arrows of time. Motor action is identifiable as a cascade of BSFRs, with each BSFR inducing sensory perceptions as SSFRs at lower levels. These would, in turn, induce motor actions as BSFRs in shorter time and length scales.

15.2.3 Negentropy Maximization Principle (NMP) as variational principle of consciousness

Negentropy Maximization Principle (NMP) defines the variational principle of consciousness in TGD [K59] [L123].

1. NMP replaces the second law (SL) and implies it for ordinary matter. SFR means a reduction of the entanglement for a pair $S_a - S_b$ of sub-system S_a and S_b, its complement in S. Instead of a single measurement, there is a measurement cascade, proceeding from long to short scales. At each step a system decomposes to a pair of unentangled subsystems. NMP states that the negentropy gain in each step is maximized and selects the pair $S_a - S_b$ at each step. This process can be visualized by a tree diagram.

2. In adelic physics [L51, L55] the entropy $N = -S_1 - S_2$ is the sum of real and various p-adic negentropies. p-Adic negentropies can be positive so that for non-trivial EQs one can have $N > 0$. Negentropic entanglement (NE) is stable against NMP so that the process stops. It is natural to assign positively colored emotions to NE. One can also say that NE distinguishes between living and inanimate matter and between dark and ordinary matter.

NMP as a generalization of the second law of thermo-dynamics

On the basis of empirical facts, Jeremy England [I52] has proposed that SL implies evolution. This statement seems to be in conflict with the standard thermodynamic view of biology [L27].

England's view that SL implies evolution, is clearly in error. NMP [L123] explains why England's paradoxical view is apparently true. A generalization of quantum measurement theory to a ZEO based theory of consciousness, and a number theory based view of cognition leading to adelic physics, is required to understand this misinterpretation.

1. SFR decomposes a given system (unentangled from the environment) to 2 subsystems in such a way that the negentropy gain is maximal for the "winning" decomposition. This corresponds to the quantum measurement of a universal observable, identified as the density matrix for the subsystem-complement pair.

2. TGD allows a genuine notion of negentropy assignable to entanglement and thus to the density matrix. The negative of the ordinary entanglement entropy $N = -S$ defines negentropy which at best is $N = 0$ since N is always non-positive.

   A genuine measure of information is needed. Since information is associated with cognition, one must expand the realm of physics to include cognition. One can also assign to the extensions of p-adic number fields an entanglement negentropy by the analog of a Shannon formula replacing logarithms of probabilities with the logarithms of their p-adic norms [K59] [L123].

   Remarkably, p-adic entropy can be negative and NMP mandates this. Furthermore, its magnitude is not smaller than that of real entropy. Therefore negentropy identified as the sum $N = -S_1 - S_2$ of real and p-adic entanglement negentropies can be positive for non-trivial EQs. N defines a genuine measure of information and, by NMP, increases during the life span of the conscious entity. This however implies the increase of real entanglement entropy [L27].

   p-Adic number fields, combining with real numbers to form an adele, are needed [L51, L55]. The algebraic extensions of p-adic number fields induced by EQs form an infinite hierarchy with increasing complexity which is identifiable as an evolutionary hierarchy. EQs emerge from $M^8 - H$ duality [L108, L109]. Space-time regions are determined by polynomials defining the EQs via their roots. Evolution as an increase of the dimension of EQ is unavoidable.

3. Consider now the connection with thermo-dynamics. When SFR occurs, entanglement entropy becomes zero, but ensemble entropy increases. That is, the outcome of measurement is not deterministic and reduction probabilities correspond to the eigenvalues of the density matrix. This means an increased thermo-dynamic entropy and generation of disorder.

   However, if the SFR cannot occur, entanglement is stable. For the negentropic states for which negentropy cannot decrease, NMP prevents SFR! The negentropic states approach cognitive fixed points and replace thermodynamic equilibria for which entanglement negentropy is maximum. The conscious entity maximizes its knowledge during its life-span quite universally: this applies to all systems at all scales, not only humans.

   For $h_{eff} = h_0$, NMP implies standard quantum measurement theory. Entanglement can be also non-negentropic for non-trivial EQs. In this case, NMP does not prevent complete de-entanglement from occurring and SL holds true. For dark matter with $h_{eff} > h$ NMP can, however, stabilize entanglement. This gives rise to a generation of conscious information. In summary, a pessimistic SL transforms to an optimistic NMP and implies SL for ordinary matter.

15.3 Some aspects of TGD inspired quantum biology

15.3.1 MB carrying dark matter as controller of ordinary biomatter

The TGD based quantum model for living matter relies heavily on the notions of MB carrying $h_{eff} > h$ phases behaving like dark matter and ZEO.

MB contains dark matter identified, as phases of ordinary matter characterized by EQ with a dimension $n = h_{eff}/h_0$ serving as a measure of the algebraic complexity of a given space-time region [L108, L109], and interpreted as a universal IQ. The scales of quantum coherence increase with h_{eff}. The layers of MB characterized by the value of n naturally form a master-slave hierarchy in which ordinary matter with the smallest Planck constant is at the bottom, and controlled by higher levels. The energies of systems increase with h_{eff} and since h_{eff} tends to be spontaneously reduced, an energy feed is needed to preserve the distribution of h_{eff}: the interpretation is as an analog of a metabolic energy feed.

MB acts as a "boss" controlling ordinary matter and induces self-organization [L93].

Anatomy of MB

MB has, as its body parts, magnetic flux quanta: flux tubes and flux sheets. There are two kinds of flux quanta. Flux can be vanishing, which corresponds to a Maxwellian regime. Flux can also be non-vanishing and quantized corresponding to a monopole flux. In the monopole case, the magnetic field requires no current for its creation. This option is not possible in the Maxwellian world. By fractality of the TGD Universe, these flux tubes play a key role at all scales [L91].

Also the Earth's magnetic field with nominal value of $B_E = .5$ Gauss has two parts.

1. The monopole flux part corresponds to the "endogenous" magnetic field $B_{end} = .2$ Gauss and explains the strange effects of ELF EM radiation on the physiology and behavior of vertebrates [**?**].

   The presence of this part explains the stability of the Earth's magnetic field. This field should have decayed long ago in a Maxwellian world since it is generated by currents which disappear.The contribution of the molten iron in the Earth's core to B_E decays but the changes of the orientation of B_{end} regenerate it [L105]. Also, magnetic fields that penetrate super-conductors as quantized fluxes and even those of permanent magnets (as opposed to electromagnets) may have a monopole part consisting of flux quanta.

2. The interaction of MB with the gravitational field of Earth is discussed in [L131]. Intriguingly, the metabolic energy currency with the nominal value of .5 eV is rather close to the energy for the escape velocity of a proton. Could the transfer of ions from the surface of the Earth to MB be a standard process?

Communications to and control by MB

Communication from the biological body (BB) to MB and its control by MB would rely on dark photons, which can transform to ordinary photons with a large h_{eff} and vice versa. Molecular transitions would represent one form of control.

1. Cell membranes could act as generalized Josephson junctions generating dark Josephson radiation with energies given by the sum $E_J + \Delta E_c$ of ordinary Josephson energy E_J and the difference ΔE_c of cyclotron energies for flux tubes at the two sides of the membrane. The variation of the membrane potential modulates the Josephson frequency and codes the sensory information at the cell membrane to a dark photon signal sent to MB.

2. The large effects of radiation at ELF frequencies observed by Blackman and others [**?**] could be understood in terms of the cyclotron transitions in $B_{end} = .2$ Gauss if "h" in $E = hf$ is replaced with h_{eff}. h_{eff} should be rather large and possibly assignable to the gravitational flux tubes with $\hbar_{eff} = \hbar_{gr} = GMm/v_0$. For the simplest model, M represents the Earth's mass coupling to the small mass m, and v_0 is a parameter with dimensions of velocity expected to have discrete spectrum. The energies $E = h_{eff}f$ of dark photons should be in the biophoton energy range (visible and UV) characterizing molecular transitions [K12, K22].

3. For the value $v_0/c \simeq 2^{-11}$, suggested by the Nottale's model for planetary orbits [E3], the predicted cyclotron energy scale is 3 orders of magnitude higher than the energy scale of visible photons. Several solutions of this problem were considered [L130, L119] . The most plausible solution is $\beta_0 = v_0/c = 1/2$ for living matter so that gravitational Compton length $\Lambda_{gr} = GM/\beta_0$ equals to Schwartschild radius at the surface of Earth. and brings nothing new to the original Nottale hypothesis.

By its higher level of "IQ", MB would naturally be the master controlling BB by cyclotron radiation - possibly via a genome accompanied by dark genome at flux tubes parallel to the DNA strands.

1. Cyclotron Bose-Einstein condensates (BECs) of bosonic ions, Cooper pairs of fermionic ions, and Cooper pairs of protons and electrons would appear as dark matter in living systems and the $h_{eff} = h_{gr}$ hypothesis predicts a universal cyclotron energy spectrum in the range of bio-photon energies.

2. Dark photons may transform to bio-photons [L10, L9] with energies covering the visible and UV energies associated with the transitions of bio-molecules. This control of biomolecules implies that remote mental interactions are routine in living matter. EEG signals would represent a particular instance of these communications: without the presence of MB it is difficult to understand why the brain would use such large amounts of energy to send signals to outer space.

3. In ZEO, the field body (FB) and MB correspond to 4-D rather than 3-D field patterns and quantum states correspond to quantum counterparts of behaviors and biological functions. Conscious holograms could be generated as a result of interference of a dark photon reference beam from MB and a dark photon beam carrying the sensory information. This hologram would be read by MB using the conjugate of the reference beam.

   In ZEO time reversals of these processes also take place. This makes it possible to understand memory as a result of communications with memory mental images (see section 15.2.2).

15.3.2 Adelic physics, cognition, and biology

$M^8 - H$ duality [L94, L108, L109] concretizes the number theoretic vision.

1. $M^8 - H$ duality states that space- times are representable as 4-D surfaces in either complexified M^8 (complexified octonions O_c) or $H = M^4 \times CP_2$. $n = h_{eff}/h_0$ has an interpretation as a dimension of EQ identifiable as the degree n of the polynomial determining the space-time surface in M^8. Roots correspond to different sheets of n-sheeted space-time surface, and the Galois group G of EQ permutes the sheets with each other and act as a number theoretic symmetry group. Dark matter states at the flux tubes define representations of G.

2. The wave functions in the set of space-time surfaces obtained by the action of G may be interpreted as functions in G defining the group algebra $L(G)$ of G. They define quantal cognitive representations. Also their fermionic counterparts make sense. Galois group G would thus act as the symmetry group of cognition. The notion of cognitive measurement in $L(G)$ makes sense and leads to a model of cognitive process as a cascade of cognitive SSFRs [L112, L123].

3. Galois confinement [L106] would force n-particle states to behave as coherent units like hadrons do as color-confined states.

4. The model makes rather far-reaching predictions. The decomposition of EQ to an extension of an extension of an extension ... of rationals defines a *finite* hierarchy of normal subgroups which in turn makes it possible to express the element of $L(G)$ as entangled products of states in the group algebras associated with the normal subgroups. Simple groups, whose classification is known, are groups which have no normal subgroups [L123, L121] so that this decomposition is trivial. Cognitive processes such as SSFR cascades are impossible for simple Galois groups - thus thinking as analysis is impossible. Could simple groups classify meditative states (or irreducible ideas as analogs of axioms)?

15.3.3 Genetic code (GC)

The model of bio-harmony [L17, L18, L92, L104, L120] is essential for the TGD based understanding of what might be called emotional intelligence (whose reality is accepted) and its relations with ordinary intelligence. The surprising outcomes are the connection with GC and the key role of bioharmony in quantum information processing in living matter.

1. The notion of bioharmony relies on icosahedral and tetrahedral geometries. The representation of the 12-note scale as a sequence of quints, reduced by an octave equivalence (notes differing by octave are experienced as equvalent) to the basic octave, defines the harmony for a given Hamiltonian cycle: the 20 allowed 3-chords of the icosahedral harmony correspond to the 20 triangular faces. The symmetries of the harmony are defined by some subgroup (Z_6,Z_4, or Z_2) of the icosahedral group.

2. Genetic codons correspond to dark photon triplets (3-chords of light) defined by the triangular faces of an icosahedron and tetrahedron. The counterparts of amino-acids are identified as orbits of 3-chords under the symmetries of a given harmony.

   Any combination of 3 icosahedral harmonies with 20 chords with symmetries Z_6, Z_4 and Z_2 and of the tetrahedral harmony with 4 chords gives a particular bioharmony with 20+20+20+4=64 chords assignable to DNA codons. DNA codons coding for a given amino acid correspond to the chords at the orbit of the symmetry group. Rather remarkably, the numbers of DNA codons coding for a given amino acid come out correctly.

3. Music expresses and creates emotions. Musical harmony codes for moods and emotions as holistic aspects of music. Bio-harmony with 64 3-chords, would assign the binary, local, aspects of information to the 6 bits of the codon and its holistic, emotional aspects to the bio-harmony. A chemical representation of the genetic code can thus correspond to several moods represented by bioharmony. In contrast with physicalism, emotions would appear already at the molecular level, and would have physical effects that are not reducible to bio-chemistry. This understanding is not possible without using the notion of MB.

   The model of bio-harmony requires that the values of B_{end} correspond to those associated with the Pythagorean scale definable by the quint cycle. These frequencies correspond to energies that a molecule must have in order to serve as a basic biomolecule. This criterion could select DNA, RNA, tRNA, and amino-acids.

In the second model of GC [L70], codons are represented as dark proton triplets.

1. The numbers of dark proton triplets turn out to correspond to numbers of DNA, RNA, tRNA codons, and amino acids. The numbers of DNA and RNA codons assignable to a given amino-acid in the vertebrate GC are correctly predicted. Genes would correspond to sequences of dark proton triplets [L92].

2. Dark proton triplet - dark codon - would be analogous to baryon and Galois confinement [L106] behaving like a single quantum unit. The N dark codons of a dark gene would, in turn, bind to Galois confined states of the Galois group of an EQ associated with the sequence of codons. An entire hierarchy of confinements is possible.

3. Galois confinement can be realized also for dark photon triplets and the sequences of N dark-photon triplets representing genes as dark $3N$-photon states. Genes could serve as addresses for communications based on dark $3N$-photon resonances.

   For communications between levels with the same value of h_{eff} there would be both energy and frequency resonance and for levels with different values of h_{eff} only the energy resonance. It is an open question whether dark $3N$-photons transforms to single ordinary photon or $3N$ ordinary photons (biophotons) in dark-ordinary communications.

4. The basic hypothesis is that both DNA, RNA, tRNA, and amino acids are paired with their dark analogs, and that energy resonance mediates the interaction between the members of pairs.

How could the icosahedra and tetrahedra be realized? Why must one glue them together? This looks aesthetically unappealing. However, surprisingly, both icosahedrons and tetrahedrons appear in, perhaps the simplest honeycomb of the hyperbolic 3-space H^3 (cosmic time = constant hyperboloid). H^3 is also central to special relativity and cosmology [L120]. Dark GC can be realized in terms of both dark protons and photons using this particular tessellation and would be universal. This master tessellation would induce sub-tessellations at the space-time surface, in particular representations of GC at magnetic flux tubes. Also 2-D and even 3-D representations of GC can be considered (i.e. cell membrane and microtubules) [L122].

15.4 TGD based view of brain

The TGD based view of the brain differs in several ways from the standard neuro-scientific model relying on materialism and reductionism [K52, K51]. The notion of MB as a controller of BB (biological body) forces us to abandon the idea of the brain as the sole seat of consciousness. Also the view of the role of nerve pulses is radically different.

15.4.1 MB and brain

In the TGD framework, the onion-like hierarchical structures of the MB of the brain would correspond to brain regions and provide an abstract map of the brain. The structure of MB with levels labelled by EQs partially characterized by $n = h_{eff}/h_0$ measuring the scale of quantum coherence, would also reflect the geometric and topological structure of the brain.

MB as a hierarchy of abstractions

There is evidence that functionally similar neurons can be modelled using statistically determined hyperbolic geometry [**?**]. Functionally similar neurons not necessarily physically near to each other would be near to each other in the effective hyperbolic geometry.

MB could realize this hyperbolic geometry quite concretely as an abstract representation of the hierarchical functional structure of the brain [L107]. That is, functionally similar neurons and also higher level brain structures not near to each other in the brain would be connected to nearby points at MB by flux tubes. Classification, visualizable as putting similar things in the same box, is a basic cognitive function and the hierarchy of MBs could realize classification geometrically.

An astonishing finding supports this view. In the lab, the neurons of the brain of a salamander were shuffled like a pack of cards. The salamander however recovered and preserved its memories (identified as learned behaviors) [**?**]. In [K76, K78] this finding was considered as a support for the view that the brain is analogous to a hologram (The TGD Universe can be seen as a conscious hologram [K14]). It seems, however, clear that a single neuron cannot represent the information content of the entire brain. However, if memories are represented by the images of neurons at the level of the MB, the shuffling of neurons has no effect on memories as the experiment indeed demonstrated. Neurons would be analogous to RAM in computer science.

Dark photons and communications and control

Communications both inside the central nervous system (CNS) and also from ordinary cells, could occur by dark cyclotron photon signals with $h_{eff}/h = n$ and light velocity. The value of h_{eff} could be considerably smaller than for the EEG communications from CNS to the large part of the MB. The value of h_{eff} could be estimated from the scaling up of cell length scale to a typical scale found in CNS. This iteration of back-and-forth communications makes pattern completion and recognition possible.

Dark photons could transform in an energy conserving manner to biophotons with energies in the visible and UV range (at least) and thus above thermal energy and therefore have effects that are not masked by thermal radiation. The brain is known to emit biophotons and they are also associated with axons [K22, K12].

Dark Josephson radiation would make information transfer to MB possible whereas the control signals from the MB would be as dark cyclotron photons.

1. Nerve pulse patterns modulate generalized Josephson frequencies for the flux tubes associated with the membrane proteins (such as ion channels and pumps) which act as generalized Josephson junctions. The sensory input is encoded by the Josephson radiation sent to the "big" part of MB [K35].

2. The frequency modulated Josephson radiation generated by nerve pulses would give rise to EEG (and perhaps also to its scaled variants) as a communication of information from the brain to MB via Josephson frequency modulation. In sharp contrast with the brain-centered neuroscience orthodoxy, the size scale of this layer of the MB would be rather large (i.e. of the order of c/f_c and given by the circumference of the Earth for the Schumann frequency $f_c \sim 7.8$ Hz). The structure of the Earth's magnetosphere suggests that both EEG bands and regions of BB correspond to regions of the magnetosphere [L119].

3. Nerve pulse patterns would code for information communicated to various layers of MB assignable to the EEG bands as a frequency modulated generalized Josephson radiation. Generalized Josephson frequency would be the sum of the ordinary Josephson frequency $f_J = ZeV/h_{eff}$ and the difference Δf_J of the cyclotron frequencies $f_c = ZeB/2\pi m$ for flux tubes at different sides of the neuronal membrane and transverse to it. The modulation of f_J by the nerve pulse patterns [K80, K35, K83] would code for sensory and cognitive information.

4. The frequency modulated dark photon radiation absorbed in cyclotron transitions at MB would generate a sequence of cyclotron resonances at MB, which code for sensory input.

   Already the modulation of the membrane potential at the basal ganglia of sensory receptors could communicate sensory information in this manner. If so, nerve pulse patterns could be a secondary representation of sensory information induced by the sequence of resonance peaks from MB back to the brain. This picture also applies to other forms of information (there are also basal ganglia inside the brain).

5. The dual representations of sensory information as resonance peaks and continuous Josephson radiation would be analogous to the local representation of a function provided by its values for a discrete sequence of time values, and to the holistic representation provided by its Fourier transform for a discrete set of frequencies.

MB controls BB and the motor output generated by the control signals from MB would act as "negative energy" signals with a reversed AT: two BSFRs are required to re-establish the original AT. The motor output of MB could take place via genes and induce gene expression as proteins.

Also other forms of gene expression such as as dark photon signals to the cell-/neuronal membranes could induce nerve pulse patterns.

The number theoretic vision suggests a considerable generalization of the idea of resonant communications [L163]. The model of Galois confinement (GC) based on the notion of bio-harmony [L17, L18, L104, L120] and the notion of GC [L112] suggests that dark $3N$-photon states, analogous to BECs, function as coherent dynamic units.

This inspires the notion of $3N$-resonance. Genes could be represented as sequences of N dark photon "3-chords" serving as addresses in dark $3N$-photon communications [L104, L120]. This picture leads to a model of human language [L161, L162].

15.4.2   General TGD view of sensory perception

The identification of sensory organs as seats of sensory qualia and a new view of the role of nerve pulses distinguish between the standard view of neuroscience and the TGD view.

Sensory organs as seats of sensory qualia

According to the TGD view, sensory perception generates sensory mental images at sensory organs rather than in the brain [L71]. This could solve some of the basic problems in neuroscience due to the similarity of neural tissue in various sensory areas. The basic objection is phantom limb

syndrome. The new view of time and memory implied by ZEO would solve this problem: the pain in the phantom limb would be a sensory memory of pain.

This view could solve several mysteries in neuroscience. The stimulation of temporal lobes indeed generates sensory memories, and people with cognitive impairment are known for memory feats such as being able to draw a building, seen in the past, in fine detail, or to learn entire works of music from a single listening.

1. These feats can be understood if the sensory memories and memories in general correspond to "seeing" in time direction.

2. The "obvious" interpretation would be that a beam of dark photons travels to the geometric *past*, is reflected back and produce memories as an analog of ordinary vision. Memories would be in the geometric past. However, on further consideration, the process seems to be more complex.

3. It is possible to build a rather detailed model for sensory memories [L110, L111] based on three ZEO and the notion of CD as a perceptive field of self at the level of embedding space. A crucial element is the identification of the geometric correlate of the "subjective now" (T_{now}) as the 3-D ball along which the half-cones of CD are glued together.

   Memories as mental images would correspond to sub-selves assigned to sub-CDs residing in the *geometric future* of T_{now} and shifting to the geometric *future* (!) during the sequence of SSFRs defining self and increasing the size of the CD and value of T_{now}. In the BSFR, identified as the death of self in a universal sense, these memories would become "silent wisdom" for the next life cycle with an opposite AT. Computer scientists would refer to this function as construction of log files.

New view of the role of nerve pulse transmission

Since perception is not mere passive reception of sensory input, but involves pattern recognition building standardized mental images, the TGD based view of sensory organs requires back and forth signaling between the brain and sensory organs. There should be a virtual sensory input from the sensory areas of the brain, or from MB via the brain, to sensory organs.

A sensory perception would be an actively constructed work of art, a standardized mental image, which is as near as possible to the sensory input. Pattern recognition would occur when the constructed pattern is sufficiently close to a standardized mental image.

The velocity of nerve pulse conduction is too slow to build a standardized sensory mental image by back and forth signalling. Nerve pulse duration of order of 1 ms defines the lower bound for the duration of the synaptic "bridge" making possible the propagation of dark photon signals. For a 10 cm long neural pathway this duration allows about 10^6 forth and back paths of light for a signal between the sensory cortex and retina.

The TGD view of sensory perception and the function of the nerve pulse transmission differs from the standard view. Nerve pulse conduction would not be communication between parts of the CNS but construction of "waveguides" for dark photons as connected flux tubes from axonal units [L71] [K80]. Nerve pulse patterns at the level of the brain would build standardized cognitive representations by decomposing the sensory input into "named" objects of a perceptive field from which associations could be built.

Sensory organs are seats of sensory qualia and sensory perception. This model explains REM dreams, hallucinations, and psychedelic experiences as experiences involving only the virtual input. Imagination can be understood as an "almost sensory" experience.

More concretely:

1. Sensory mental images at the level of sensory organs are generated by an iteration involving the virtual sensory input from the brain to the sensory organs [L71]. Pattern recognition is realized as a carving of a 4-D work of art representing a standardized mental image as near as possible to the original sensory input.

2. Nerve pulses would connect existing flux tubes parallel to axons to form longer flux tubes: neurotransmitters at synaptic contacts would act as relays. There is an obvious analogy with

an old fashioned telephone network. It would requiree too energy to keep all connections on all the time.

The meridians assigned with acupuncture network could correspond to a permanent flux tube network and would not require nerve pulses, transmitters, nor information molecules as relays. For CNS, this flux tube network would be dynamic. Plants would only have the meridian system.

3. The standard view of learning as a strengthening of synaptic connections translates into a gradual build-up of long-lived flux tube connections, which make possible dark photon communications. The sender and receiver neuron groups can also fuse to a single, quantum entangled, system.

4. Actually all information molecules (neural transmitters, hormones, and messenger molecules) could be connection builders. An alternative view is that information molecule such as hormone is attached to the end of a flux tube, which stretches as the molecule travels to the target.

The same theory applies to water memory [K42], which remains a dismissed concept in mainstream science although the research performed outside the confines of institutional support has revealed much about the involved mechanisms.

Dreams, hallucinations, and imagination

TGD makes it possible to understand sensory imagination as virtual sensory inputs from MB via the brain, which do not reach sensory organs. Imagined motor actions as virtual motor actions would not reach muscles.

Virtual sensory inputs would be received by virtual sensory organs inside the brain. A good candidate is the basal ganglia. Ganglions are also associated with sensory receptors. The input from MB or brain would be represented as dark photons.

The notions of virtual sensory and motor input are central to the understanding of speech comprehension and also inner speech. Hallucinations, psychedelic experiences and REM dreams (motor activities during sleep) could be understood as virtual sensory (motor) inputs reaching the sensory organs (muscles). Memory recall could involve virtual (real in the case of sensory memories) sensory input from MB at which memory mental images are realized [L114, L80].

15.4.3 Memories

To understand what memories and memory recall could be in ZEO one must specify what the geometrical correlate of "subjective now" is.

"Geometric now" corresponds to the $T_{now} = T/2$ slice of CD with maximal size located in the middle of the CD. If one accepts $M^8 - H$ duality [L94] "geometric now" corresponds to a "special moment in the life of self" [L94, L113] identifiable as intersection of the space-time surface and a 6-sphere which is a brane-like entity (in the sense of branes encountered in M-theory) appearing as a universal special solution to algebraic equations determining the space-time surfaces in M_c^8. The special values of T_{now} would correspond to the roots of the real polynomial defining the space-time surface.

2. During the sequence of SFRs, AB shifts towards the geometric future and the size of CD increases (in the statistical sense). The sub-CDs accompanying sensory and other mental images shift in the direction of the geometric future as CD increases during the SFR sequence and become potential memory mental images experiencing BSFRs in a shorter time scale.

The time=constant snap-shots at the upper half of CD assignable to the memory mental images are ordered with respect to Minkowski time t but the order is opposite to the order of subjective experiences. This makes possible for the time-reversed re-incarnate to have these memories as "silent wisdom". Snapshots correspond to subselves to which memory recall builds a connection by entanglement or by sending a signal, reflected back in a BSFR of the memory mental image.

How are episodic memories recalled in ZEO?

1. Spontaneous memory recall could correspond to the death of a memory mental image (sub-self/sub-CD) having the same AT as self (CD) followed by re-incarnation with an opposite AT. This would be accompanied by an emission of a past directed "negative energy" signal received by the self associated with the "geometric now". The interpretation is as an extraction of metabolic energy: memory recall indeed requires metabolic energy.

   Active memory recall could correspond to the receipt of a future directed "positive energy" signal by memory mental image arriving from the "geometric now", and allow interpretation as a metabolic energy feed. Reflection of the signal in opposite time direction requires BSFR. Why should BSFR happen? Could the metabolic energy feed induce (by NMP) rapid evolution and aging of the memory mental images leading to its death by BSFR.

2. The prediction is that in an active memory recall by a "positive energy" signals received by the memory sub-CDs, the order of recalled memories is opposite to that of the original experience. There is evidence for this kind of change [**?**] (see also the popular article at http://tinyurl.com/y7hbqmug).

15.5   TGD inspired model for sensory perception and short term memory

The findings of [**?**] suggesting a statistical representation of short memories allowing a conscious estimate of the reliability of the memories allow to develop a more detailed form about sensory perceptions based on the interpretation of short term memories as sequence of "small" state function reductions (SSFRs) following analogs of unitary time evolutions.

The identification of SSFRs as cognitive measurements is discussed in [L102] in the number theoretic vision about TGD. In [L116] the possibility that all SFRs, including also "big" SFRs (BSFRs) and even particle scattering events, could be interpreted as cognitive SFRs, is considered. This involves the notion of $M^8 - H$ duality meaning that space-time surfaces in H are images of 4-surfaces in M^8 analogous to momentum space under $M^8 - H$ duality. At the level of M^4 the physics is purely number theoretic.

1. The first implication is cognitive representation defined by points of 4-surface in M^8 for which coordinates representing components of momentum are algebraic integers for the extension of rationals defined by the polynomial defining the 4-surface in M^4. As a matter of fact, the points of cognitie representation belong to a mass shell of M^4 and active points of cognitive representation contain quark.

2. Second key implications is Galois confinement prividing a purely number theoretic mechanism for the formation of bound states [L129, L127]. In this article these aspects will not be discussed.

   This picture leads to a highly detailed identification of scattering amplitudes [L116].

1. The interaction region of particle reaction can be interpreted as a cognitive process in which quarks of Galois singlets move freely and only re-organize to new Galois singlets. One might say that Nature is performing recombinatorics [L116].

2. Scattering interaction corresponds theoretically to a formation of a quantum superposition of functional composites of the polynomials associated with the external particles and a natural proposal is that the outgoing state corresponds to a product of the polynomials. Allowed functional compositions can differ only by a cyclic permutations of composite, which in dual string models and twistor Grassmann approach corresponds to allowance of only planar diagrams.

3. The cognitive measurement is identified as a cascade of measurements for a representation of a Galois group decomposing to a product of representations of its subgroups defined by its decomposition to an inclusion hierarchy of normal subgroups. Due to the inclusion hierarchy,

the quantum entanglements involved are directed and the natural interpretation is in terms of directed attention.

In [L126] a model of spin glasses is discussed and the proposal is made that the time evolution of spin glass corresponds to a sequence of analogs of unitary time evolutions followed by SSFRs.

1. The analog of unitary time evolution would correspond to a scaling rather than time translation as in standard quantum theory. This effectively replaces Minkowski time with its logarithm and predicts that decay rates obey power law rather than being exponential. The relaxation processes in spin glasses, which have a lot in common with living matter, indeed obey power law.

2. BSFRs would naturally correspond to time evolution as time translation and would give rise to exponential decay rates. If short term memory and sensory perception involves SSFRs, the prediction is that the decay of memories is not exponential but obeys power law.

15.5.1   How the sensory perception is formed?

The following represents a simple model for what might happen in sensory perception.

1. Sensory perception means a reduction of entanglement. This reduction is usually interpreted as quantum measurement but one could also say that it gives information about the relationship between A and B rather than state of A, or equivalently B. In a sequence of SSFRs, this measurement is carried out repeatedly for the regenerated entanglement. What this regeneration could mean in the TGD framework is discussed in the general number theoretical model for interactions based on $M^8 - H$ duality [L116]. The original entanglement need not be generated faithfully but could do so in a good approximation.

   What is essential is that Nature would replace single SFR with a sequence of cognitive SSFRs, which would be measurement cascades proceeding from long to short p-adic scales: the p-adic length scale is determined by largest ramified prime of the extension and decreases in the cascade defining SSFR [L116]. This sequence of SSFRs would produce a sequence of sensory mental images giving rise to a temporal statistical ensemble of mental images characterizing the unentangled state, which in the ideal case would be the same after all SFR cascades.

   The situation is analogous to that in quantum computation in which unitary time evolution determined by Hamiltonian produces a state of observables measured as the program halts. In quantum computation, one must produce a spatial ensemble of final states. One can also run the programs several times to build this kind of ensemble. The statistical distribution for the outcomes codes for the solution of the problem that the quantum computer program is supposed to solve, say factorization of an integer. I have considered two decades ago the possibility that living systems, for instance DNA-nuclear membrane system, could act like topological quantum computers: the braiding of magnetic flux tubes would code the quantum computer program [K2, K3, K114].

2. Quantum entanglement would be naturally between magnetic bodies (MBs) of the systems involved [L163, L101, L118]. The sensory input comes from the external world but it is unclear in what scales it can be quantum entangled with sensory receptors. The hierarchy of Planck constants predicts quantum coherence in all scales for MBS so that the entanglement could be macroscopic.

   What seems clear is that the MB of the sensory organ entangles with the MB of the conscious perceiver. The MB of the sensory organ would quantum entangle with the MBs of the receptor neurons and perhaps these in turn quantum entangle in the same scale with the MBs of the external world.

3. Sensory organs and their receptor neurons should entangle with the nearby neurons able to generate nerve pulses in order to communicate the information to brain. The sensory input could be communicated to MB from the neuronal membrane of sensory receptor neuron (which does not generate nerve pulses) to MB as frequency - and amplitude modulated (generalized) Josephson radiation generating a sequence of resonance peaks, which defined

feedback from MB to the neurons, which in turn give rise to nerve pulses from the sensory organ to the brain [K35, K83, L119, K80] [L115].

4. The SFR generating the sensation at our level of self hierarchy should occur in the scale of the sensory organ at least. The pair MB-sensory organ would be a natural pair to consider if generalized Josephson radiation communicates the sensory information to MB.

15.5.2   Models for the sensory input from the sensory organ to MB and vice versa

The basic objection against communications from the sensory organ to MB and vice versa is that the input from the sensory neurons to MB is expected to decompose to non-correlated inputs from separate neurons. If they are non-correlated, it is very difficult to understand how a macroscopic SFR giving rise to unitary conscious experience can take place. This problem is actually the key problem of all theories of consciousness and standard QM does not seem to be enough to overcome this problem.

Sensory input from the sensory organ to MB

What is required would be a large number of simultaneous dark cyclotron transitions as a quantum analog of a phase transition. The (generalized) Josephson radiation from the sensory neurons with the same receptive field should be in synchrony and somehow fuse to a kind of Bose-Einstein condensate. Here the number theoretic vision comes into rescue.

1. The hierarchy of Planck constants is the first prediction of the number theoretic vision. The second prediction is Galois confinement, which provides a universal number theoretic mechanism for the formation of bound states of quarks. All elementary particles and also their bound states would be formed by Galois confinement. Even particle reactions would be at the fundamental number theoretic level recombinations of Galois singlets formed from free quarks to new Galois singlets [L116].

2. For the 4-surface of M^8 determined by a polynomial P, quarks have momenta, which are algebraic integers in an extension of rationals determined by P. For instance, periodic boundary conditions require that the total momentum has integer valued components in units defined by the p-adic mass scale assignable to the Galois singlet is therefore formed.

   Galois confinement would bind Galois-non-singlets to singlets in all scales. In particular, dark N-photons are predicted as also dark N-protons and ions. Dark N-photons would be analogous to Bose-Einstein condensates and could induce N-cyclotron resonances at MB for N-ion Galois singlets. Dark genetic codons would be Galois singlets formed by dark proton triplets and dark genes would be Galois singlets formed from these triples but with momentum which does not have integer components.

   Consider now a more detailed model for the secondary sensory input from sensory organ to MB.

1. Generalized Josephson radiation [K35, K83] from neural membranes produces the sensory input to MB. The Josephson radiations from different sensory receptors form a Galois confined state as dark N-photon.

2. Frequency modulation of the generalized Josephson radiation is possible and transforms the information coded by the membrane potential modulation to a sequence of cyclotron resonances at MB. This sequence is communicated back to the sensory organ to neurons able to generate nerve pulses, most naturally neighbors of the sensory receptor neurons. Therefore the communication of sensory input to the brain occurs via the loop sensory receptor $\rightarrow$ MB $\rightarrow$ neuron able to fire.

3. The intensity of the generalized Josephson radiation radiation can be modulated by varying the density of the dark Cooper pairs of electrons, protons and fermionic ions and of bosonic ions at the cell membrane acting as a collection of Josephson junctions formed magnetic flux

tubes associated with ion channels and pumps. If the intensity is too low, the signal from MB is weak and no nerve pulses are generated. This would be the case during sleep and unconscious states in general.

As the intensity of the sensory input increases, also the intensity of Josephson radiation and therefore also nerve pulse response increases. The period for the amplitude modulation determines the rate of nerve pulses bursts.

4. Biological high temperature superconductors are open systems. The increase of h_{eff} for electrons giving rise to Cooper pairs requires energy and since the Cooper pairs have tendency to decay by the reduction of h_{eff}, the maintenance of the Cooper pair condensate requires a continual energy feed. Either sensory input or metabolic energy feed can provide the needed energy. The latter case the sensory input would mean amplification of the sensory input.

Model for the virtual sensory input from MB to brain

A virtual sensory input from MB to the brain is needed to generate memory mental images associated with short term memory. This input would also make possible imagination and dreams and hallucinations.

It is difficult to imagine a detailed mechanism for the generation of the virtual sensory input to the brain at the level of MB. ZEO however allows us to consider an option requiring no new mechanisms at the level of MB . This option would be based on a time reversal occurring BSFR at the level of MB. From the point of view of an observer with the standard arrow of time, time reversed communications from the sensory organ to MB would look like communications from MB to sensory organ!

The counterpart of the time reverse period following BSFR is analogous to death and is followed by a time-reversed period analogous to reincarnation. Sleep and hibernation would be examples of this time reversed period [L160]. Also at the level of fundamental biomolecules, periods analogous to sleep are a rule. In the case of a neuronal membrane, nerve pulse is followed by a dead time, which would be also analogous to a sleep period as a time reversed period.

15.6   Are we living in the past?

The original article by Mauro Manassi and David Whitney [**?**] (`https://cutt.ly/lONjIQn`) with title "*Illusion of visual stability through active perceptual serial dependence*" suggests that visual perception is a kind of temporal average over a time interval, which can be even longer than 15 seconds.

15.6.1   The findings of Manassi and Whitney

"Why do the objects in the world appear to be so stable despite constant changes in their retinal images?" was the question that motivated the work of Manassi and Whitney. Retinal images continuously fluctuate because of sources of internal and external noise. Retinal image motion, occlusions and discontinuities, lighting changes, and perspective changes and many other sources of noise are present. However, the objects do not appear to jitter, fluctuate, or change identity from moment to moment. Why does the perceived world change smoothly over time although the real world does not?

This problem is also encountered in quantum consciousness theories. If conscious experience consists of a sequence of non-deterministic quantum jumps as moments of consciousness, it is not at all clear how a smooth stream of consciousness is possible.

One modern explanation for the smoothness of conscious experience is some kind of change blindness or inattentional blindness. The finite capacity of visual short-term memory is certainly a fact and forces a finite perceptive resolution and effectively eliminates too fast temporal gradients. This finite resolution poses limits in perceptual, decisional and memory processing. This would naturally apply also to other sensory memories.

In the standard view sensory percept corresponds to a time=constant snapshot of the physical world. The basic prediction is that the object at a given moment of time is the real object but in a finite perceptive resolution.

The alternative hypothesis studied in the article is that the visual system, and presumably also other sensory systems, use an active stabilization mechanism, which manifests as a serial dependence in perceptual judgments. Serial dependence causes objects at any moment to be misperceived as being more similar to those in the recent past. The serial dependence has been reported in the appearance of objects, perceptual decisions about objects, and the memories about objects. In all of these examples, serial dependence is found for random or unpredictable sequential images.

This raises the question whether one can understand the serial dependence by identifying the conscious perception at a given time as a weighted temporal average of preceding time= constant perceptions over some time interval T and what additional assumptions are needed to understand the other findings related to the phenomenon.

15.6.2   The experiments demonstrating the serial illusion

Article describes 5 experiments related to serial illusion. The experiments are described in detail in [?] with illustrations (`https://cutt.ly/lONjIQn`) and in the sequel I summarize them only very briefly. The reader is strongly encouraged to read the original article providing illustrations and references to literature related to serial illusion.

Experiment 1: shift of the perception to past

In Experiment 1 the shift of the perception to the past was demonstrated.

1. 2 separate groups of 44 and 45 participants rated the age of a young or old static face embedded in a blue frame (13 and 25.5 years, respectively). This gave a distribution of ratings around some mean identified as the real age of the face. The rating of the static face alone is referred to as the reference face .

2. A third group of 47 independent participants were presented with a movie of a face that morphed gradually, aging from young to old. These observers then rated the age of the old face. The rating of the static face preceded by the movie is referred to as the test face . The last frame of the video was identical to the reference face.

3. The age ratings between physically identical static faces, either alone (reference face) or with a preceding video (test face) were compared. Although the test and reference faces were identical, the old test face, seen after the video, was rated as 5 years younger than the old reference face, seen without the video (20.2 versus 25.5 years).

4. One can argue that the stability illusion is due to a simple unidirectional bias in age ratings. Therefore a fourth group of 45 new participants watched a movie of a face that gradually morphed from old to young. Following the movie, observers rated the age of a young static test face embedded in a blue frame. The young face was rated as 5 years older than its actual age (18.4 versus 13 years). Therefore the stability illusion can cause faces to appear younger or older depending on the previously seen faces.

These findings are consistent with the temporal averaging hypothesis.

Experiment 2: the effect of noise

The noise is known to increase the serial dependence. Whether this is the case also in the case of illusion stability was tested. Stimuli with and without noise were represented to separate groups of observers. As a measure of the stability illusion strength, *attraction index* as the bias in age ratings toward the beginning of the movie was introduced.

1. A measure of the stability illusion strength, *attraction index* was introduced. *Attraction index* is defined as $\Delta T/T$, $\Delta T = |T_r - T_p|$, where T_r is the real and T_p the perceived age of the test face, and T is the total age range T. Real age refers to the average perceived age in the Experiment without preceding video.

2. When the movie and test face were presented alone or with superimposed dynamic noise, the static test face ratings were attracted by 28 and 42 % of the movie.

3. When the movie was presented with increasing dynamic noise and a test face with high noise, the attraction was around 48 %.

   The results conform with the earlier finding that serial dependence in perception increases with noise and uncertainty. As the increasing dynamical noise yielded the strongest illusory effect, it was used across subsequent experiments.

Why should the increase of the noise increase the strength of the illusion stability? Suppose that the perception is average over time=constant perceptions from a time interval T. For instance, one could think of a Gaussian distribution for the weights of the contributions over the interval T. It would seem that T gets longer in the presence of noise in order to achieve reliability.

Experiment 3: Central tendency bias not involved

It might be argued that the results are due to a central tendency bias, i.e., the tendency to rate test faces as being close to middle age, independent of movie content.

To test this, Experiment 3 replicated the same conditions Experiment 1 but linear increase/decrease in the age of the face was replaced with a more complex increase/decrease using staircase functions leaving intact the starting and ending points of the movies (young and old).

1. Attraction index gradually decreased with decreasing the number of age steps in the movie, thus showing that our illusion is not only due to a simple response or central tendency bias but also strongly depends on the whole content of the face morphing movie

2. The attraction index was computed with the last 6, 18, and 30 seconds of the video preceding the test face. Attraction linearly increased with increasing video duration, thus showing that the attraction effect involves all parts of the preceding video.

These results seem to be consistent with the averaging hypothesis. If Gaussian distribution can be used to model the averaging, the parameter T characterizing the locus of the distribution was at least of order $T = 30$ seconds and that the distribution was rather flat in this range.

Experiment 4: Temporal strength/range of illusion

If our illusion is due to the proposed active mechanism of perceptual serial dependence, it should occur on a broad temporal range in accordance with previous findings.

In experiment 4 the temporal strength of the stability illusion with an interstimulus interval (I.S.I.) of 0, 1, 5, 10, and 15 seconds between the movie and test face was measured.

Test face age ratings were attracted toward the movie at all intervals, thus showing that stability illusion extends across a large period of time . These results also show that, without intervening trials, serial dependence magnitude extends over a larger period of time than previously shown.

Experiment 5: Face feature similarity

The previous serial dependence literature on face stimuli suggests that stability illusion should be determined by face feature similarity and should occur only when the face morphing movie and test face are similar (belong to the same person, and even more, have very nearly the same age).

Unlike previous passive change blindness based explanations, any modulation of the illusion respecting feature similarity should be consistent with serial dependence and would make it possible to make predictions about the perceived age T_p of the test face.

In experiment 5, a movie of a face that morphed from young to old was represented, and after an interval of 1 second, the age of the static test face was varied by making it younger or older than the original test old face. On the basis of the known tuning of serial dependence for face similarity, three predictions were formulated.

1. Stability illusion should occur only with faces similar in age to the test face and not between dissimilar faces. It was found that the old test face was rated as younger (attraction effect) only for a few similar identities that were most similar to the old face; the attraction disappeared for more dissimilar identities.

2. As the old test face was perceived as being $\sim$ 20 years old after watching the movie, it was predicted that, when a reference face that is 20 years old is used as a test face after the movie, the degree of attraction for that face should be zero. No attraction for a test face of 20 years of age was found.

3. Test faces younger than $\sim$ 20 years old should be perceived as older, because the movie content contains older identities across the duration of the morph movie and, hence, should bias test face perception toward older ages. When the test face was younger, it was rated as older than it actually was.

The results and predictions were very well captured by a two-parameter derivative of a Gaussian model, in accordance with previous results, and ideal observer models proposed in the serial dependence literature.

15.6.3   TGD based explanation for the findings

TGD inspired quantum theory of consciousness as a generalization of quantum measurement theory allowing to overcome its basic problem caused by the conflict between determinism of unitary time evolution and non-determinism of state function reduction (see for instance [K106, K104, K105]). Zero energy ontology (ZEO) as an ontology of quantum theory [L86] [K123] plays a crucial role and leads to the proposal that the perceptive field is 4-dimensional so that one can speak of 4-D brain. This leads to a general vision about sensory perception and memory.

In the TGD framework, the question why the perceived world looks smooth is encountered already at quantum level. ZEO predicts two kinds of state function reductions (SFRs).

1. In "Big" SFRs (BSFRs) the arrow of time changes. In ZEO this explains in all scales why the world looks classical for the observer having arrow of time opposite to that for a system produced in BSFR [L75].

2. Sensory perceptions correspond naturally to "small" SFRs (SSFRs) and since SSFRs are the TGD counterparts of weak measurements of quantum optics and their sequences define what in the wave mechanics would correspond to a repetition of the same measurement (Zeno effect). Therefore one can hope that the problem disappears at quantum level.

   One must however understand why the perceived world seems to evolve smoothly although it does not.

The TGD based explanation for stability illusion and serial dependence relies on the general assumptions of TGD inspired theory of consciousness.

1. TGD inspired theory of consciousness predicts the notion of self hierarchy [K106]. Self has subselves, which in turn have subselves which correspond to particular sub-subselves of self. Self experiences its subselves as separate mental images determined as averages of their subselves. There are therefore three levels involved: self, subself, and sub-sub-self. Self hierarchy is universal and appears in all scales and one can ask whether the super-ego–ego–Id triple of Freud could be interpreted in terms of this hierarchy.

   The correspondences are therefore "We" $\leftrightarrow$ self; mental image $\leftrightarrow$ subself; subself as mental images of self $\leftrightarrow$ average over sub-subselves.

2. In accordance with the vision of the 4-D brain, ZEO makes possible the temporal ensemble of mental images as a basic element of quantum consciousness. No separate neural mechanism for forming the temporal ensemble is needed: its generation is a basic aspect of the quantum world.

3. The perception (subself) as a mental image is identified as a kind of temporal average over time=constant perceptions (sub-subselves), which basically correspond to quantum measurements and can in ZEO be identified as "small" state function reductions (SSFRs) in ZEO. Continuous stream of consciousness would replace the Zeno effect.

   The averaging smooths out various fluctuations (to which also SSFRs contribute at quantum level) and subselves as temporal averages over sub-subselves give rise to an experience of a smoothly changing world. The conscious sensory perception at "our" level is not about time=constant snapshot but an average over this kind of snapshots.

   Consider now a model for the stability illusion and various aspects of serial dependence. In the following T_r resp. T_p denotes the real *resp.* perceived age (after seeing the video) of the face. T denotes the total age range. t_k denotes the time associated with k^{th} video picture and t the total duration of the video.

1. Sub-subselves in the experiments of [?] correspond to $t = t_k < t$ video snapshots. Subself at $t = t_k$ corresponds to a statistical average M_k of $0 \leq r \leq k$ video snapshots at t_r. At $t = t_k$, "we" experiences M_k . The averaging over time gives rise to experience, which is biased towards earlier perceptions. The averaging creates the smoothing of the perception and generates the illusion that the perceived mental image is shifted to the past.

   If the perceived ages $T_{p,k}$, to be distinguished from t_k corresponding to real ages $T_{r,k} = T_0 + k\Delta T_r$ contribute with the same weight in the age interval T, the average corresponds to the central value of $T = T_0 + T/2$. In the general case, the average depends on the details of the distribution for $T_{r,k}$ and on the distribution of weights for t_k in accordance with the results of Experiment 3.

2. The higher the noise level, the longer the maximal time interval t_M over which the averaging takes place in order to gain reliability. This requires active response by changing t_M for M_k. t_M must increase with the noise level. For instance, if the weights in the average are Gaussian, the width of the Gaussian distribution must increase with the noise level. This explains the findings of Experiment 2 relating to the effects of noise.

   Experiment 5 provides the information needed to formulate a model for what could happen in the addition of a new face at $t = t_N$.

1. The test face F_{N+1} is first experienced as a different person. After that it is checked whether F_{N+1} corresponds to any memory mental image M_k in the ensemble $\{M_k | k = 1, ..., N\}$. This involves memory recall besides time=constant snapshot perception.

   If F_{N+1} is similar to some M_k in $\{M_k | k = 1, ..., N\}$, it is added to M_N and defines a new memory mental image M_{N+1} and there is a stability illusion.

   If it does not correspond to any M_k, it is not recognized as an already perceived face, and is not added to M_N as a new memory M_{N+1} so that there is no stability illusion.

2. This model explains the results of 3 sub-experiments of Experiment 5 relating to the face feature similarity. The second experiment however deserves a detailed comment since it involves criticality in the sense that a small variation of the real age of $F(N + 1)$ should lead to a disappearance of the stability illusion.

   Let $T_{p,A}$ be the perceived age of the test face in experiment A and $T_{r,B}$ the real age in the next experiment. For $T_{B,r} = T_{A,p}$ the stability illusion is absent whereas for $T_{B,r} \leq T_{A,p}$ it is present. The situation is therefore critical.

   The proposed model explains the presence of the illusion. One can however argue that $T_{B,r} \geq T_{A,p}$ rather than $T_{B,r} = T_{A,p}$ should actually hold true, or more precisely, there was no memory mental image M_k with $T_p \leq T_r$. A small variation of $T_{B,r}$ makes it possible to test whether the situation is really critical.

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 [L51, L52]. In the recent view of quantum TGD [L143], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L95, L96] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L86] [K123] 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) [L86, L125] [K123] 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 [A18] 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

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \ . \tag{A-2.1}$$

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 [A13] will be used and their relation to the complex coordinates is given by

$$\begin{aligned}
\xi^1 &= z + it \ , \\
\xi^2 &= x + iy \ .
\end{aligned} \tag{A-2.2}$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned}
\xi^1 &= r\exp(i\frac{(\Psi + \Phi)}{2})cos(\frac{\Theta}{2}) \ , \\
\xi^2 &= r\exp(i\frac{(\Psi - \Phi)}{2})sin(\frac{\Theta}{2}) \ .
\end{aligned} \tag{A-2.3}$$

The ranges of the variables r, Θ, Φ, Ψ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold CP_2 is compact and simply connected, with Euler number Euler number 3, Pontryagin number 3 and second $b = 1$.

Fig. 4. CP_2 as manifold. `http://tgdtheory.fi/appfigures/cp2.jpg`

Metric and Kähler structure of CP_2

In order to obtain a natural metric for CP_2, observe that CP_2 can be thought of as a set of the orbits of the isometries $z^i \rightarrow exp(i\alpha)z^i$ on the sphere S^5: $\sum z^i \bar{z}^i = R^2$. The metric of CP_2 is obtained by projecting the metric of S^5 orthogonally to the orbits of the isometries. Therefore the distance between the points of CP_2 is that between the representative orbits on S^5.

The line element has the following form in the complex coordinates

$$ds^2 \quad = \quad g_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \tag{A-2.4}$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} \quad = \quad R^2 \partial_a \partial_{\bar{b}} K \ , \tag{A-2.5}$$

where the function K, Kähler function, is defined as

$$\begin{aligned} K &= log(F) \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-2.6}$$

The Kähler function for S^2 has the same form. It gives the S^2 metric $dzd\bar{z}/(1+r^2)^2$ related to its standard form in spherical coordinates by the coordinate transformation $(r, \phi) = (tan(\theta/2), \phi)$.

The representation of the CP_2 metric is deducible from S^5 metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} \quad = \quad \frac{(dr^2 + r^2\sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \ , \tag{A-2.7}$$

where the quantities σ_i are defined as

$$\begin{aligned} r^2\sigma_1 &= Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_2 &= -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_3 &= -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \ . \end{aligned} \tag{A-2.8}$$

R denotes the radius of the geodesic circle of CP_2. The vierbein forms, which satisfy the defining relation

$$s_{kl} \quad = \quad R^2 \sum_A e_k^A e_l^A \ , \tag{A-2.9}$$

are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} \ , & e^1 &= \frac{r\sigma_1}{\sqrt{F}} \ , \\ e^2 &= \frac{r\sigma_2}{\sqrt{F}} \ , & e^3 &= \frac{r\sigma_3}{F} \ . \end{aligned} \tag{A-2.10}$$

The explicit representations of vierbein vectors are given by

$$
\begin{array}{llll}
e^0 & = & \frac{dr}{F} \ , & e^1 & = & \frac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \ , \\
e^2 & = & \frac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \ , & e^3 & = & \frac{r(d\Psi + cos\Theta d\Phi)}{2F} \ .
\end{array}
$$

$$
\text{(A-2.11)}
$$

The explicit representation of the line element is given by the expression

$$
ds^2/R^2 \quad = \quad \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2) \ .
$$

$$
\text{(A-2.12)}
$$

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

$$
de^A \quad = \quad -V^A_B \wedge e^B \ ,
$$

$$
\text{(A-2.13)}
$$

is given by

$$
\begin{array}{llllll}
V_{01} & = & -\frac{e^1}{r} \ , & V_{23} & = & \frac{e^1}{r} \ , \\
V_{02} & = & -\frac{e^2}{r} \ , & V_{31} & = & \frac{e^2}{r} \ , \\
V_{03} & = & (r - \frac{1}{r})e^3 \ , & V_{12} & = & (2r + \frac{1}{r})e^3 \ .
\end{array}
$$

$$
\text{(A-2.14)}
$$

The representation of the covariantly constant curvature tensor is given by

$$
\begin{array}{llllll}
R_{01} & = & e^0 \wedge e^1 - e^2 \wedge e^3 \ , & R_{23} & = & e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\
R_{02} & = & e^0 \wedge e^2 - e^3 \wedge e^1 \ , & R_{31} & = & -e^0 \wedge e^2 + e^3 \wedge e^1 \ , \\
R_{03} & = & 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , & R_{12} & = & 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ .
\end{array}
$$

$$
\text{(A-2.15)}
$$

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$
J \quad = \quad -is_{a\bar{b}}d\xi^a d\bar{\xi}^b \ ,
$$

$$
\text{(A-2.16)}
$$

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$
J^k_{\ r}J^{rl} \quad = \quad -s^{kl} \ .
$$

$$
\text{(A-2.17)}
$$

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

$$
J \quad = \quad dB \ ,
$$

$$
\text{(A-2.18)}
$$

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

$$
\begin{aligned}
B &= 2re^3 \ , \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = \frac{r}{F^2} dr \wedge (d\Psi + cos\Theta d\Phi) + \frac{r^2}{2F} sin\Theta d\Theta \wedge d\Phi \ .
\end{aligned}
$$
(A-2.19)

The vierbein curvature form and Kähler form are covariantly constant and have in the complex coordinates only components of type $(1, 1)$.

Useful coordinates for CP_2 are the so called canonical (or symplectic or Darboux) coordinates in which the Kähler potential and Kähler form have very simple expressions

$$
\begin{aligned}
B &= \sum_{k=1,2} P_k dQ_k \ , \\
J &= \sum_{k=1,2} dP_k \wedge dQ_k \ .
\end{aligned}
$$
(A-2.20)

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$
\begin{aligned}
P_1 &= -\frac{1}{1+r^2} \ , \\
P_2 &= -\frac{r^2 cos\Theta}{2(1+r^2)} \ , \\
Q_1 &= \Psi \ , \\
Q_2 &= \Phi \ .
\end{aligned}
$$
(A-2.21)

Spinors In CP_2

CP_2 doesn't allow spinor structure in the conventional sense [A10]. 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: $e^A = R^A_B e^B$ 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 $R^A_B(v)$ 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 [A22] 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

$$S_I^2 \ : \ \xi^1 = \bar{\xi}^2 \text{ or equivalently } (\Theta = \pi/2, \Psi = 0) \ ,$$

$$S_{II}^2 \ : \ \xi^1 = \xi^2 \text{ or equivalently } (\Theta = \pi/2, \Phi = 0) \ .$$

The non-equivalence of these sub-manifolds is clear from the fact that isometries act as holomorphic transformations in CP_2. The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for S_I^2. S_{II}^2 is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

A-2.2 CP_2 geometry and Standard Model symmetries

Identification of the electro-weak couplings

The delicacies of the spinor structure of CP_2 make it a unique candidate for space S. First, the coupling of the spinors to the $U(1)$ gauge potential defined by the Kähler structure provides the missing $U(1)$ factor in the gauge group. Secondly, it is possible to couple different H-chiralities independently to a half odd multiple of the Kähler potential. Thus the hopes of obtaining a correct spectrum for the electromagnetic charge are considerable. In the following it will be demonstrated that the couplings of the induced spinor connection are indeed those of the GWS model [B16] and in particular that the right handed neutrinos decouple completely from the electro-weak interactions.

To begin with, recall that the space H allows to define three different chiralities for spinors. Spinors with fixed H-chirality $e = \pm 1$, CP_2-chirality l, r and M^4-chirality L, R are defined by the condition

$$\begin{aligned} \Gamma \Psi &= e\Psi \ , \\ e &= \pm 1 \ , \end{aligned} \tag{A-2.23}$$

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

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) \ . \tag{A-2.24}$$

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

$$
\begin{array}{llll}
V_{01} &=& -\frac{e^1}{r} \ , & V_{23} &=& \frac{e^1}{r} \ , \\
V_{02} &=& -\frac{e^2}{r} \ , & V_{31} &=& \frac{e^2}{r} \ , \\
V_{03} &=& (r - \frac{1}{r})e^3 \ , & V_{12} &=& (2r + \frac{1}{r})e^3 \ ,
\end{array}
\tag{A-2.25}
$$

and

$$B = 2re^3 \ , \tag{A-2.26}$$

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

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2 \ , \tag{A-2.27}$$

where one have defined

$$
\begin{aligned}
I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\
I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ .
\end{aligned}
\tag{A-2.28}
$$

A_{ch} is clearly left handed so that one can perform the identification of the gauge potential as

$$W^\pm = \frac{2(e^1 \pm ie^2)}{r} \ , \tag{A-2.29}$$

where $W^\pm$ denotes the charged intermediate vector boson.

The covariantly constant curvature tensor is given by

$$
\begin{aligned}
R_{01} &= -R_{23} = e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\
R_{02} &= -R_{31} = e^0 \wedge e^2 - e^3 \wedge e^1 \ , \\
R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , \\
R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ .
\end{aligned}
\tag{A-2.30}
$$

The charged part of the curvature tensor is left handed.

This is to be compared with the Weyl tensor, which defines a representation of quaternionic imaginary units.

$$
\begin{aligned}
W_{03} &= W_{12} \equiv 2I_3 = 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\
W_{01} &= W_{23} \equiv I_1 = -e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\
W_{02} &= W_{31} \equiv I_2 = -e^0 \wedge e^2 - e^3 \wedge e^1 \ .
\end{aligned} \tag{A-2.31}
$$

The charged part of the Weyl tensor is right-handed and that the relative sign of the two terms in the curvature tensor and Weyl tensor are opposite.

Consider next the identification of the neutral gauge bosons γ and Z^0 as appropriate linear combinations of the two functionally independent quantities

$$
\begin{aligned}
X &= re^3 \ , \\
Y &= \frac{e^3}{r} \ ,
\end{aligned} \tag{A-2.32}
$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$
\begin{aligned}
\bar{\gamma} &= aX + bY \ , \\
\bar{Z}^0 &= cX + dY \ ,
\end{aligned} \tag{A-2.33}
$$

where the normalization condition

$$
ad - bc = 1 \ ,
$$

is satisfied. The physical fields γ and Z^0 are related to $\bar{\gamma}$ and $\bar{Z}^0$ by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$
\begin{aligned}
A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\
&+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 \ .
\end{aligned} \tag{A-2.34}
$$

Identifying Σ_{12} and $\Sigma_{03} = 1 \times \gamma_5\Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that γ couples vectorially leads to the condition

$$
c = -d \ . \tag{A-2.35}
$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$
A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.36}
$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$
\begin{aligned}
Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} \ , \\
I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} \ .
\end{aligned} \tag{A-2.37}
$$

The fields γ and Z^0 are defined via the relations

$$
\begin{aligned}
\gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) \ , \\
Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) \ .
\end{aligned} \tag{A-2.38}
$$

The value of the Weinberg angle is given by

$$sin^2\theta_W \quad = \quad \frac{3b}{2(a+b)} \quad ,$$

(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

$$F_{nc} \quad = \quad 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) \quad ,$$

(A-2.40)

where one has

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) \quad , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) \quad , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \quad , \end{aligned}$$

(A-2.41)

in terms of the fields γ and Z^0 (photon and Z- boson)

$$F_{nc} \quad = \quad \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \quad .$$

(A-2.42)

Evaluating the expressions above, one obtains for γ and Z^0 the expressions

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{12} \quad , \\ Z^0 &= 2R_{03} \quad . \end{aligned}$$

(A-2.43)

For the Kähler field one obtains

$$J \quad = \quad \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \quad .$$

(A-2.44)

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + fJ^{\alpha\beta}J_{\alpha\beta} \quad , \\ L_{sym} &= \frac{1}{4g^2}Tr(F^{\alpha\beta}F_{\alpha\beta}) \quad , \end{aligned}$$

(A-2.45)

where the trace is taken in spinor representation, in terms of γ and Z^0 one obtains for the coefficient X of the γZ^0 cross term (this coefficient must vanish) the expression

$$
\begin{aligned}
X &= -\frac{K}{2g^2} + \frac{fp}{18} \ , \\
K &= Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ ,
\end{aligned}
\tag{A-2.46}
$$

This parameter can be calculated by substituting the values of quark and lepton charges and weak isospins.

In the general case the value of the coefficient K is given by

$$
K = \sum_i \left[-\frac{(18 + 2n_i^2)sin^2\theta_W}{9} \right] \ ,
\tag{A-2.47}
$$

where the sum is over the spinor chiralities, which appear as elementary fermions and n_i is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$
sin^2\theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i(18 + n_i^2))} \ .
\tag{A-2.48}
$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$
sin^2\theta_W = \frac{9}{\left(\frac{fg^2}{2} + 28\right)} \ .
\tag{A-2.49}
$$

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 [L155] contains, besides the induced Kähler form, also the induced curvature form R_{12}, which couples vectorially. Conserved vector current hypothesis suggests that the average of R_{12} is non-vanishing. One can express the neutral part of the induced gauge field in terms of induced spinor curvature and Kähler form J as

$$
\begin{aligned}
R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) = J + 2e^0 \wedge e^3 \ , \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ , \\
R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) = 3J - 2e^0 \wedge e^3 \quad ,
\end{aligned} \tag{A-2.50}
$$

2. The induced fields γ and Z^0 (photon and Z- boson) can be expressed as

$$
\begin{aligned}
\gamma &= 3J - sin^2\theta_W R_{12} \ , \\
Z^0 &= 2R_{03} = 2(J + 2e^0 \wedge e^3)
\end{aligned} \tag{A-2.51}
$$
$$
per. \tag{A-2.52}
$$

The condition $\langle Z^0 \rangle = 0$ gives $2\langle e^0 \wedge e^3 \rangle = -2J$ and this in turn gives $\langle R_{12} \rangle = 4J$. The average over γ would be

$$
\langle \gamma \rangle = (3 - 4sin^2\theta_W)J \ .
$$

For $sin^2\theta_W = 3/4$ $langle\gamma\rangle$ would vanish.

The quantum averages of classical weak fields quite generally vanish. What about correlation functions?

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 [B6] .

   The action of the reflection P on spinors of is given by

$$\Psi \quad \to \quad P\Psi = \gamma^0 \otimes \gamma^0 \Psi \ . \tag{A-2.53}$$

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

$$\begin{aligned}
m^k &\to T(M^k) \ , \\
\xi^k &\to \bar{\xi}^k \ , \\
\Psi &\to \gamma^1 \gamma^3 \otimes 1 \Psi \ .
\end{aligned} \tag{A-2.54}$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2:

$$\begin{aligned}
\xi^k &\to \bar{\xi}^k \ , \\
\Psi &\to \Psi^\dagger \gamma^2 \gamma^0 \otimes 1 \ .
\end{aligned} \tag{A-2.55}$$

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 CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0. This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \quad .$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

$Im(\xi^1) = Im(\xi^2) = 0$ corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case e^1 and e^3 vanish so that the induced em, Z^0, and Kähler fields vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

A-3.3   Many-sheeted space-time

TGD space-time is many-sheeted: in other words, there are in general several space-sheets which have projection to the same M^4 region. Second manner to say this is that CP_2 coordinates are many-valued functions of M^4 coordinates. The original physical interpretation of many-sheeted space-time 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

$$
\begin{aligned}
J &= \frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta)d\Phi) + \frac{r^2}{2F} sin(\Theta)d\Theta \wedge d\Phi \ , \\
F &= 1 + r^2 \ .
\end{aligned}
\tag{A-3.1}
$$

The general expression of electromagnetic field reads as

$$
\begin{aligned}
F_{em} &= (3 + 2p)\frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta)d\Phi) + (3 + p)\frac{r^2}{2F} sin(\Theta)d\Theta \wedge d\Phi \ , \\
p &= sin^2(\Theta_W) \ ,
\end{aligned}
\tag{A-3.2}
$$

where Θ_W denotes Weinberg angle.

1. The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$
\Psi = k\Phi \ ,
$$
$$
(3 + 2p)\frac{1}{r^2 F}(d(r^2)/d\Theta)(k + cos(\Theta)) \quad + \quad (3 + p)sin(\Theta) = 0 \ ,
\tag{A-3.3}
$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$r = \sqrt{\frac{X}{1-X}} \ ,$$

$$X = D\left[|\frac{k+u}{C}|\right]^{\epsilon} \ ,$$

$$u \equiv cos(\Theta) \ , \ C = k + cos(\Theta_0) \ , \ D = \frac{r_0^2}{1+r_0^2} \ , \ \epsilon = \frac{3+p}{3+2p} \ , \tag{A-3.4}$$

where C and D are integration constants. $0 \leq X \leq 1$ is required by the reality of r. $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u + k| = [(1 + r_0^2)/r_0^2]^{(3+2p)/(3+p)}$ achieved only for

$$sign(u+k) \times [\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}} \leq k+1 \ ,$$

where $sign(x)$ denotes the sign of x.

The expressions for Kähler form and Z^0 field are given by

$$J = -\frac{p}{3+2p} X du \wedge d\Phi \ ,$$

$$Z^0 = -\frac{6}{p} J \ . \tag{A-3.5}$$

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 space-times. In this case classical em and Z^0 fields are proportional to each other:

$$Z^0 = 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u)\frac{\partial r}{\partial u} du \wedge d\Phi = (k+u)du \wedge d\Phi \ ,$$

$$r = \sqrt{\frac{X}{1-X}} \ , \ X = D|k+u| \ ,$$

$$\gamma = -\frac{p}{2} Z^0 \ . \tag{A-3.6}$$

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

$$
\begin{aligned}
ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta}d\Theta^2 + s^{eff}_{\Phi\Phi}d\Phi^2] \ , \\
s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \ , \\
s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \ ,
\end{aligned}
\tag{A-3.7}
$$

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

$$
\begin{aligned}
\Psi &= \omega_2 m^0 + k_2 m^3 + n_2\phi + \text{Fourier expansion} \ , \\
\Phi &= \omega_1 m^0 + k_1 m^3 + n_1\phi + \text{Fourier expansion} \ .
\end{aligned}
\tag{A-3.8}
$$

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

$$
\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \ ,
\tag{A-3.9}
$$

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 4-surfaces and this leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K45, K27, K87] [L129, 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 4-dimensional Minkowski space and 4-dimensional space-time surfaces are in a completely unique position as far as symmetries are considered.

In fact, this leads to a generalization of the Kac-Moody type symmetries of string models. $\delta M_+^4 \times CP_2$ allows huge supersymplectic symmetries for which the radial light-like coordinate of δM_+^4 plays the role of complex string coordinate in string models. These symmetries are assumed to act as isometries of WCW.

A-4.3   String-like objects and strings

String like objects obtained as deformations of cosmic strings $X^2 \times Y^2$, where X^2 is minimal surface in M^4 and Y^2 a holomorphic surface of CP_2 are fundamental extremals of Kähler action having string world sheet as M^4 projections. Cosmic strings dominate the primordial cosmology of the TGD Universe and the inflationary period corresponds to the transition to radiation dominated cosmology for which space-time sheets with 4-D M^4 projection dominate.

Also genuine string-like objects emerge from TGD. The conditions that the em charge of modes of 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 super-conformal invariance behave like "short" strings with length scale given by CP_2 size, which is 10^4 times longer than Planck scale characterizing strings in string models.

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 space-time topology. b) The 4-D analogs of both string diagrams and QFT diagrams appear but the interpretation of the analogs stringy diagrams is different. `http://tgdtheory.fi/appfigures/tgdgraphs.jpg`

A-5   About the selection of the action defining the Kähler function of the "world of classical worlds" (WCW)

The proposal is that space-time surfaces correspond to preferred extremals of some action principle, being analogous to Bohr orbits, so that they are almost deterministic. The action for the preferred extremal would define the Kähler function of WCW [K45, K87].

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 [L53] [L129, L133, L134] 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 [A18] 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 II$_1$ (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 II$_1$.

   A given inclusion hierarchy corresponds to a sequence $n(SS)_i$ such that $n(SS)_i$ divides $n(SS)_{i+1}$. Therefore the degree of the composite polynomials increases very rapidly. The values of $n(SS)_i$ can be chosen to be primes and these primes correspond to the degrees of so called prime polynomials [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 [K60, K61]). 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 $\delta M_+^4 \times CP_2$ [K45, K27]. 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 [L140].
    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 [K64, K55, K24]. The fusion of the various p-adic physics leads to what I call adelic physics [L51, L52]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K29, K30, K31, K31].

    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 [L95, L96] 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, L140]. Also the ordinary $3 \to 4$ 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 [L53] 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 [A9]. p-Adic numbers are representable as power expansion of the prime number p of form

$$x = \sum_{k \geq k_0} x(k)p^k, \; x(k) = 0, ..., p-1 \; . \tag{A-6.1}$$

The norm of a p-adic number is given by

$$|x| = p^{-k_0(x)} \ . \tag{A-6.2}$$

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

$$x = p^{k_0}\varepsilon(x) \ , \tag{A-6.3}$$

where $\varepsilon(x) = k + ...$ 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:

$$d(x,z) \leq max\{d(x,y), d(y,z)\} \ . \tag{A-6.4}$$

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 [B14]. The emergence of p-adic topology as the topology of the effective space-time would make ultra-metricity property basic feature of physics.

Canonical correspondence between p-adic and real numbers

The basic challenge encountered by p-adic physicist is how to map the predictions of the p-adic physics to real numbers. p-Adic probabilities provide a basic example in this respect. Identification via common rationals and canonical identification and its variants have turned out to play a key role in this respect.

1. Basic form of the canonical identification

There exists a natural continuous map $I : R_p \to R_+$ 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

$$y = \sum_{k>N} y_k p^k \to x = \sum_{k<N} y_k p^{-k} \ ,$$
$$y_k \in \{0, 1, .., p-1\} \ . \tag{A-6.6}$$

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

$$
\begin{aligned}
x &= \sum_{k=N_0}^{N} x_k p^{-k} \;, \\
x &= \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1)p^{-N} + (p-1)p^{-N-1} \sum_{k=0,..} p^{-k} \;.
\end{aligned}
$$

$$(A\text{-}6.7)$$

The p-adic images associated with these expansions are different

$$
\begin{aligned}
y_1 &= \sum_{k=N_0}^{N} x_k p^{k} \;, \\
y_2 &= \sum_{k=N_0}^{N-1} x_k p^{k} + (x_N - 1)p^{N} + (p-1)p^{N+1} \sum_{k=0,..} p^{k} \\
&= y_1 + (x_N - 1)p^{N} - p^{N+1} \;,
\end{aligned}
$$

$$(A\text{-}6.8)$$

so that the inverse map is either two-valued for p-adic numbers having expansion with finite pinary digits or single valued and discontinuous and non-surjective if one makes pinary expansion unique by choosing the one with finite pinary digits. The finite pinary digit expansion is a natural choice since in the numerical work one always must use a pinary cutoff on the real axis.

2. The topology induced by canonical identification

The topology induced by the canonical identification in the set of positive real numbers differs from the ordinary topology. The difference is easily understood by interpreting the p-adic norm as a norm in the set of the real numbers. The norm is constant in each interval $[p^k, p^{k+1})$ (see **Fig. A-6.1**) and is equal to the usual real norm at the points $x = p^k$: the usual linear norm is replaced with a piecewise constant norm. This means that p-adic topology is coarser than the usual real topology and the higher the value of p is, the coarser the resulting topology is above a given length scale. This hierarchical ordering of the p-adic topologies will be a central feature as far as the proposed applications of the p-adic numbers are considered.

Ordinary continuity implies p-adic continuity since the norm induced from the p-adic topology is rougher than the ordinary norm. p-Adic continuity implies ordinary continuity from right as is clear already from the properties of the p-adic norm (the graph of the norm is indeed continuous from right). This feature is one clear signature of the p-adic topology.

Fig. 14. The real norm induced by canonical identification from 2-adic norm. `http://tgdtheory.fi/appfigures/norm.png`

The linear structure of the p-adic numbers induces a corresponding structure in the set of the non-negative real numbers and p-adic linearity in general differs from the ordinary concept of linearity. For example, p-adic sum is equal to real sum only provided the summands have no common pinary digits. Furthermore, the condition $x +_p y < max\{x, y\}$ holds in general for the p-adic sum of the real numbers. p-Adic multiplication is equivalent with the ordinary multiplication only provided that either of the members of the product is power of p. Moreover one has $x \times_p y < x \times y$ in general. The p-Adic negative -1_p associated with p-adic unit 1 is given by $(-1)_p = \sum_k (p-1)p^k$ and defines p-adic negative for each real number x. An interesting possibility is that p-adic linearity might replace the ordinary linearity in some strongly nonlinear systems so these systems would look simple in the p-adic topology.

These results suggest that canonical identification is involved with some deeper mathematical structure. The following inequalities hold true:

$$
\begin{aligned}
(x+y)_R &\leq x_R + y_R \;, \\
|x|_p |y|_R \leq (xy)_R &\leq x_R y_R \;,
\end{aligned}
\tag{A-6.9}
$$

where $|x|_p$ denotes p-adic norm. These inequalities can be generalized to the case of $(R_p)^n$ (a linear vector space over the p-adic numbers).

$$
\begin{aligned}
(x+y)_R &\leq x_R + y_R \;, \\
|\lambda|_p |y|_R \leq (\lambda y)_R &\leq \lambda_R y_R \;,
\end{aligned}
\tag{A-6.10}
$$

where the norm of the vector $x \in T_p^n$ is defined in some manner. The case of Euclidian space suggests the definition

$$
(x_R)^2 = (\sum_n x_n^2)_R \;.
\tag{A-6.11}
$$

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

$$
I_Q(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)}
\tag{A-6.12}
$$

is uniquely defined for rationals, maps rationals to rationals, has also a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$. It has turned out that it is this map which most naturally appears in the applications. The map is obviously continuous locally since p-adically small modifications of r and s mean small modifications of the real counterparts.

Canonical identification is in a key role in the successful predictions of the elementary particle masses. The predictions for the light elementary particle masses are within extreme accuracy same for I and I_Q but I_Q is theoretically preferred since the real probabilities obtained from p-adic ones by I_Q sum up to one in p-adic thermodynamics.

4. Generalization of number concept and notion of embedding space

TGD forces an extension of number concept: roughly a fusion of reals and various p-adic number fields along common rationals is in question. This induces a similar fusion of real and p-adic embedding spaces. Since finite p-adic numbers correspond always to non-negative reals n-dimensional space R^n must be covered by 2^n copies of the p-adic variant R_p^n of R^n each of which projects to a copy of R_+^n (four quadrants in the case of plane). The common points of p-adic and real embedding spaces are rational points and most p-adic points are at real infinity.

Real numbers and various algebraic extensions of p-adic number fields are thus glued together along common rationals and also numbers in algebraic extension of rationals whose number belong to the algebraic extension of p-adic numbers. This gives rise to a book like structure with rationals and various algebraic extensions of rationals taking the role of the back of the book. Note that Neper number is exceptional in the sense that it is algebraic number in p-adic number field Q_p satisfying $e^p \bmod p = 1$.

Fig. 15. Various number fields combine to form a book like structure. `http://tgdtheory.fi/appfigures/book.jpg`

For a given p-adic space-time sheet most points are literally infinite as real points and the projection to the real embedding space consists of a discrete set of rational points: the interpretation in terms of the unavoidable discreteness of the physical representations of cognition is natural. Purely local p-adic physics implies real p-adic fractality and thus long range correlations for the real space-time surfaces having enough common points with this projection.

p-Adic fractality means that M^4 projections for the rational points of space-time surface X^4 are related by a direct identification whereas CP_2 coordinates of X^4 at these points are related by I, I_Q or some of its variants implying long range correlates for CP_2 coordinates. Since only a discrete set of points are related in this manner, both real and p-adic field equations can be satisfied and there are no problems with symmetries. p-Adic effective topology is expected to be a good approximation only within some length scale range which means infrared and UV cutoffs. Also multi-p-fractality is possible.

The notion of p-adic manifold

The notion of p-adic manifold is needed in order to fuse real physics and various p-adic physics to a larger structure which suggests that real and p-adic number fields should be glued together along common rationals bringing in mind adeles. The notion is problematic because p-adic topology is totally disconnected implying that p-adic balls are either disjoint or nested so that ordinary definition of manifold using p-adic chart maps fails. A cure is suggested to be based on chart maps from p-adics to reals rather than to p-adics (see the appendix of the book)

The chart maps are interpreted as cognitive maps, "thought bubbles".

Fig. 16. The basic idea between p-adic manifold. `http://tgdtheory.fi/appfigures/padmanifold.jpg`

There are some problems.

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: (cognition-induced symmetry breaking) minimized if p-adic manifold structure is induced from that for p-adic embedding space with chart maps to real embedding space and assuming preferred coordinates made possible by isometries of embedding space: one however obtains several inequivalent p-adic manifold structures depending on the choice of coordinates: these cognitive representations are not equivalent.

A-6.2   Hierarchy of Planck constants and dark matter hierarchy

Hierarchy of Planck constants was motivated by the "impossible" quantal effects of ELF em fields on vertebrate cyclotron energies $E = hf = \hbar \times eB/m$ are above thermal energy is possible only if $\hbar$ has value much larger than its standard value. Also Nottale's finding that planetary orbits 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-determinism of the Kähler action predicting huge vacuum degeneracy allowing all space-time surfaces which are sub-manifolds of any $M^4 \times Y^2$, where Y^2 is Lagrangian sub-manifold of CP_2. For 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 light-likeness 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 **??**) has changed considerably towards the end 2021 [L129] 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 $p^k \to m^k = \hbar_{eff} p^k / p^2$ conforming in spirit with UP but turned out to be too naive.

The improved form [L129] 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 [L129] 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 [L95, L96]. 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 $X^4 \subset M^8$ [L80]. 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 [L129]. 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 [L117] 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 [L129]. 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 [L86] [K123].

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 [L86].

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 [L75] in atomic scale can be explained by the same mechanism [L75]. 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 [**?**] 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 [L79]. 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 [L83, L160].

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 [L83, L160]. 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 p-adicities

In TGD inspired theory of consciousness p-adic space-time sheets correspond to space-time correlates for thoughts and intentions. The intersections of real and p-adic preferred extremals consist of points whose coordinates are rational or belong to some extension of rational numbers in preferred embedding space coordinates. They would correspond to the intersection of reality and various p-adicities representing the "mind stuff" of Descartes. There is temptation to assign life to the intersection of realities and p-adicities. The discretization of the chart map assigning to real space-time surface its p-adic counterpart would reflect finite cognitive resolution.

At the level of "world of classical worlds" (WCW) the intersection of reality and various p-adicities would correspond to space-time surfaces (or possibly partonic 2-surfaces) representable in terms of rational functions with polynomial coefficients with are rational or belong to algebraic extension of rationals.

The quantum jump replacing real space-time sheet with p-adic one (vice versa) would correspond to a buildup of cognitive representation (realization of intentional action).

Fig. 23. The quantum jump replacing real space-time surface with corresponding p-adic manifold can be interpreted as formation of 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 possibiity 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`

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