

# TGD BASED VIEW ABOUT LIVING MATTER AND REMOTE MENTAL INTERACTIONS

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## 0.1 PREFACE

### Brief summary of TGD

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

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

### The basic ideas of TGD

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

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

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

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

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

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

## Physics as geometry

"Geometro-" in TGD refers to the idea about the geometrization of physics. The geometrization program of Einstein is extended to gauge fields allowing realization in terms of the geometry of surfaces so that Einsteinian space-time as abstract Riemann geometry is replaced with sub-manifold geometry. The basic motivation is the loss of classical conservation laws in General Relativity Theory (GRT)(see **Fig. 13.1**). 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  $H = M^4 \times CP_2$  [L216]. 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 [L99, L127](see **Fig. 13.6**). 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. 13.8**). The mere mathematical existence of WCW geometry requires that it has maximal isometries, which together twistor lift and number theoretic vision fixes it uniquely [L217].
- 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 [K129, L149].
- 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 [K26, K57] [L211].
- 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 [L214]. Space-time surfaces correspond to holomorphic imbeddings of the space-time surface to  $H$  with a generalized complex structure defined by the vanishing of 2 analytic functions of 4 generalized complex coordinates of  $H$ . These surfaces are automatically minimal surfaces. This is true for any general coordinate invariant action constructed in terms of the induced geometric structures so that the dynamics is universal. Different actions differ only in the sense that singularities at which the minimal surface property fails depend on the action. This affects the scattering amplitudes, which can be constructed in terms of the data related to the singularities [L219].
- Generalized conformal symmetries define an extension of conformal symmetries and one can assign to them Noether charges. Besides this the so called super-symplectic symmetries associated with  $\delta M_+^4 \times CP_2$  define isometries of the "world of classical worlds" (WCW), which by holography is essentially the space of Bohr orbits of 3-surfaces as particles so that quantum TGD is expected to reduce to a generalization of wave mechanics.

## Physics as number theory

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



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

Adelic physics [L97, L98] fusing real and various p-adic physics is part of the number theoretic vision, which provides a kind of dual description for the description based on space-time geometry and the geometry of "world of classical words". Adelic physics predicts two fractal length scale hierarchies: p-adic length scale hierarchy and the hierarchy of dark length scales labelled by  $h_{eff} = nh_0$ , where  $n$  is the dimension of extension of rational. The interpretation of the latter hierarchy is as phases of ordinary matter behaving like dark matter. Quantum coherence is possible in arbitrarily long scales. These two hierarchies are closely related. p-Adic primes correspond to ramified primes for a polynomial, whose roots define the extension of rationals: for a given extension this polynomial is not unique.

### $M^8 - H$ duality

The concrete realization of the number theoretic vision is based on  $M^8 - H$  duality (see **Fig. 13.7**). 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 [L218].  $M^8$  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. 13.9**). 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. 13.2**), and can be seen as a generalization of the momentum-position duality of wave mechanics, which fails to generalize to quantum field theories (QFTs).  $M^8 - H$  duality applies to particles which are 3-surfaces instead of point-like particles.

### p-Adic physics

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

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

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

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

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

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

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

## TGD as an analog of topological QFT

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

The space-time as 4-surface  $X^4 \subset H$  has a non-trivial topology in all scales and this together with the notion of many-sheeted space-time brings in something completely new. Topologically trivial Einsteinian space-time emerges only at the QFT limit in which all information about topology is lost (see **Fig. 13.3**).

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

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

## Zero energy ontology

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

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

In zero energy ontology (ZEO), the superpositions of space-time surfaces inside causal diamond (CD) having their ends at the opposite light-like boundaries of CD, define quantum states. CDs form a scale hierarchy (see **Fig. 13.11** and **Fig. 13.12**). 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. 13.13**). This has profound thermodynamic implications and the question about the scale in which the transition from classical to quantum takes place becomes obsolete. BSFRs can occur in all scales but from the point of view of an observer with an opposite arrow of time they look like smooth time evolutions.

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

## Equivalence Principle in TGD framework

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

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

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

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

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

could say that at the quantum level gravitational and gauge interactions are eliminated everywhere except at the singularities identifiable as defects of the ordinary smooth structure. The exotic smooth structures [L207], possible only in dimension 4, are ordinary smooth structures apart from these defects serving as vertex representing a creation of a fermion-antifermion pair in the induced gauge potentials. The vertex is universal and essentially the trace of the second fundamental form as an analog of the Higgs field and the gravitational constant is proportional to the square of  $CP_2$  radius.

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

## Quantum TGD as a generalization of Einstein's geometrization program

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

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

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

## The world of classical worlds and its symmetries

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

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

WCW geometry exists only if it has maximal isometries: this statement is a generalization of the discovery of Freed for loop space geometries [A26]. I have proposed [K50, K28, K125, K93, L217] 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  $\delta M_+^4$  are also natural candidates for isometries. The motivation for the proposal comes from physical intuition deriving from string models. Note they do not include Poincare symmetries, which act naturally as isometries in the moduli space of causal diamonds (CDs) forming the "spine" of WCW.
- The light-like orbits of partonic 2-surfaces might allow separate symmetry algebras. One must however notice that there is exchange of charges between interior degrees of freedom and partonic 2-surfaces. The essential point is that one can assign to these surface conserved charges when the dual light-like coordinate defines time coordinate. This picture also assumes a slicing of space-time surface by the partonic orbits for which partonic orbits associated with wormhole throats and boundaries of the space-time surface would be special. This slicing would correspond to Hamilton-Jacobi structure.
- Fractal hierarchy of symmetry algebras with conformal weights, which are non-negative integer multiples of fundamental conformal weights, is essential and distinguishes TGD from string models. Gauge conditions are true only the isomorphic subalgebra and its commutator with the entire algebra and the maximal gauge symmetry to a dynamical symmetry with generators having conformal weights below maximal value. This view also conforms with p-adic mass calculations.
- The realization of the symmetries for 3-surfaces at the boundaries of CD and for light-like orbits of partonic 2-surfaces is known. The problem is how to extend the symmetries to the interior of the space-time surface. It is natural to expect that the symmetries at partonic orbits and light-cone boundary extend to the same symmetries.

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

### About the construction of scattering amplitudes

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

- In ZEO [K129, L149] 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 [L215]. 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 [L202, L203] led to a stringy variant of the twistor diagrammatics.
- Fundamental fermions are off-mass-shell in the sense that their momentum components are real algebraic integers in an extension of rationals associated with the space-time surfaces inside CD with a momentum unit determined by the CD size scale. Galois confinement states that the momentum components are integer valued for the physical states.
- The twistorial approach suggests also the generalization of the Yangian symmetry to infinite-dimensional super-conformal algebras, which would determine the vertices and scattering amplitudes in terms of poly-local symmetries.

The twistorial approach is however extremely abstract and lacks a concrete physical interpretation. The holography=holomorphy vision led to a breakthrough in the construction of the scattering amplitudes by solving the problem of identifying interaction vertices [L219].

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

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

## Figures

## Basic ideas of TGD inspired quantum biology

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

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

Note that also the notion of electric body makes sense [L213]. Quite generally, long range classical gravitational, electric and magnetic fields give rise to very large values of effective Planck constants. The Nottale's hypothesis of gravitational Planck constant generalizes to electric interactions.

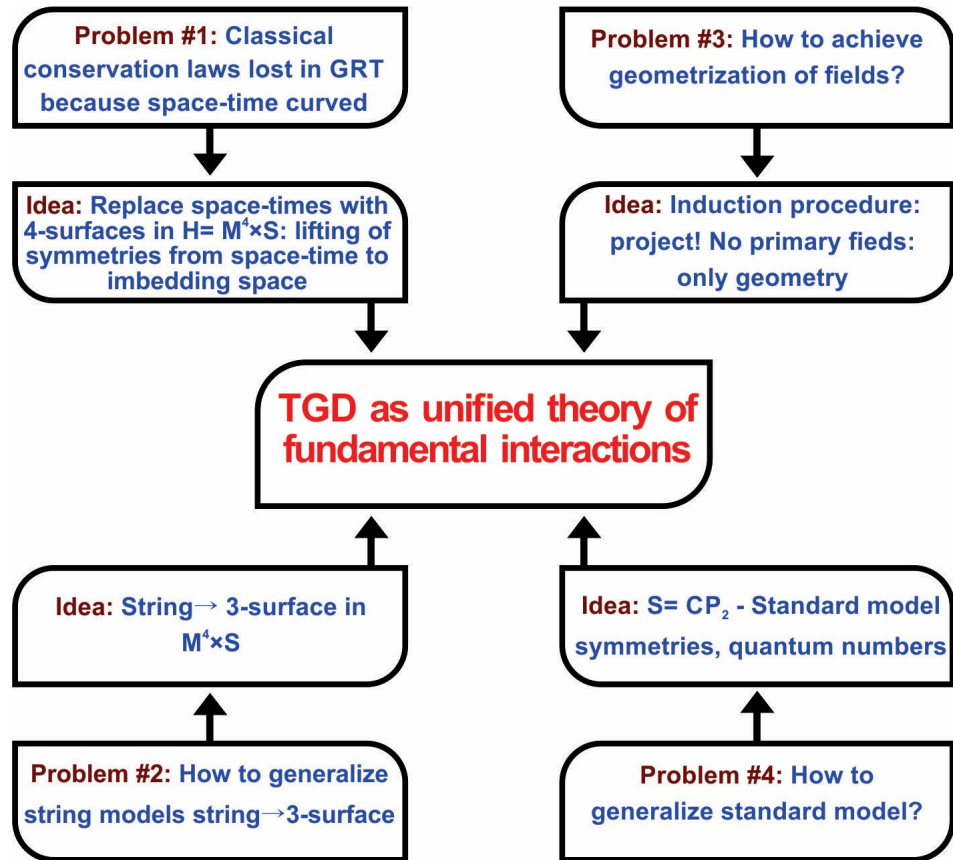


Figure 1: The problems leading to TGD as their solution.

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

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

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



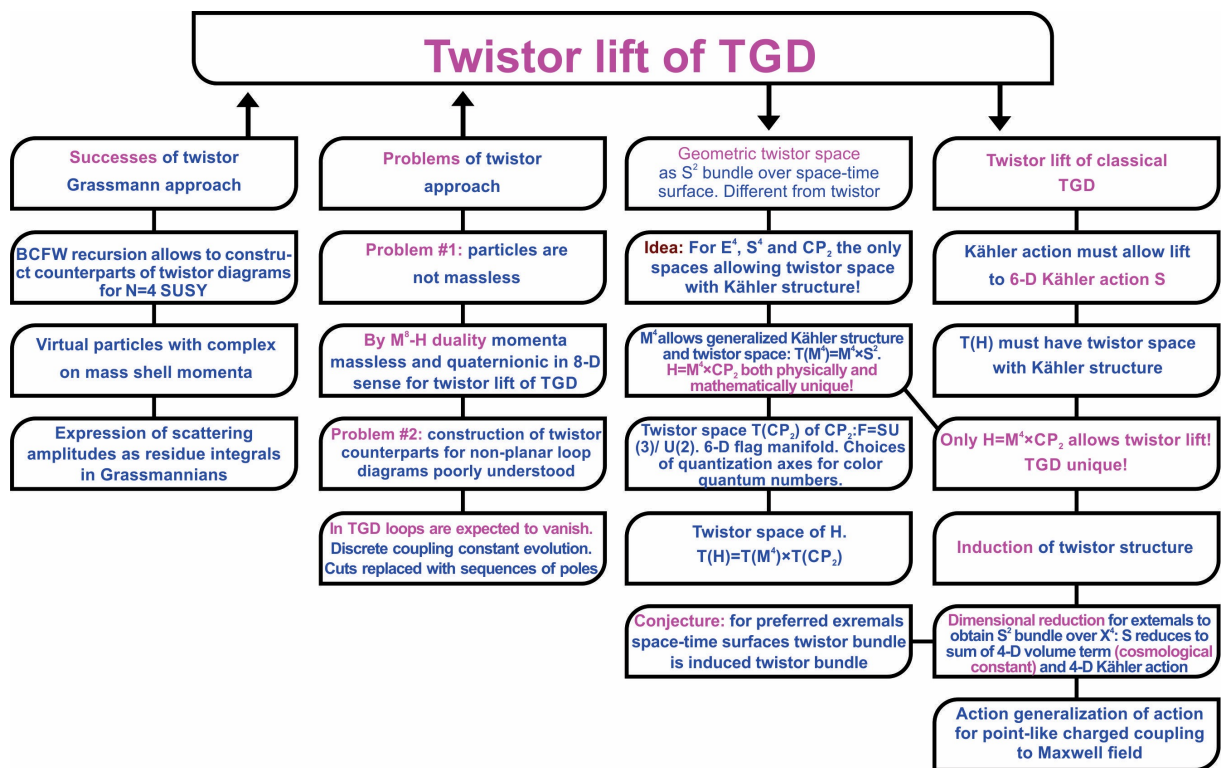
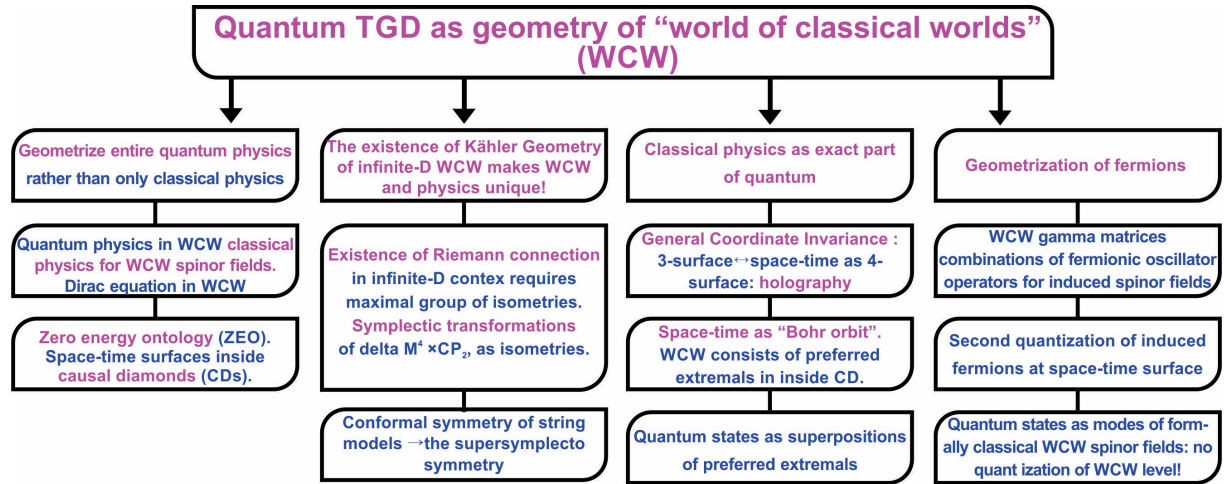


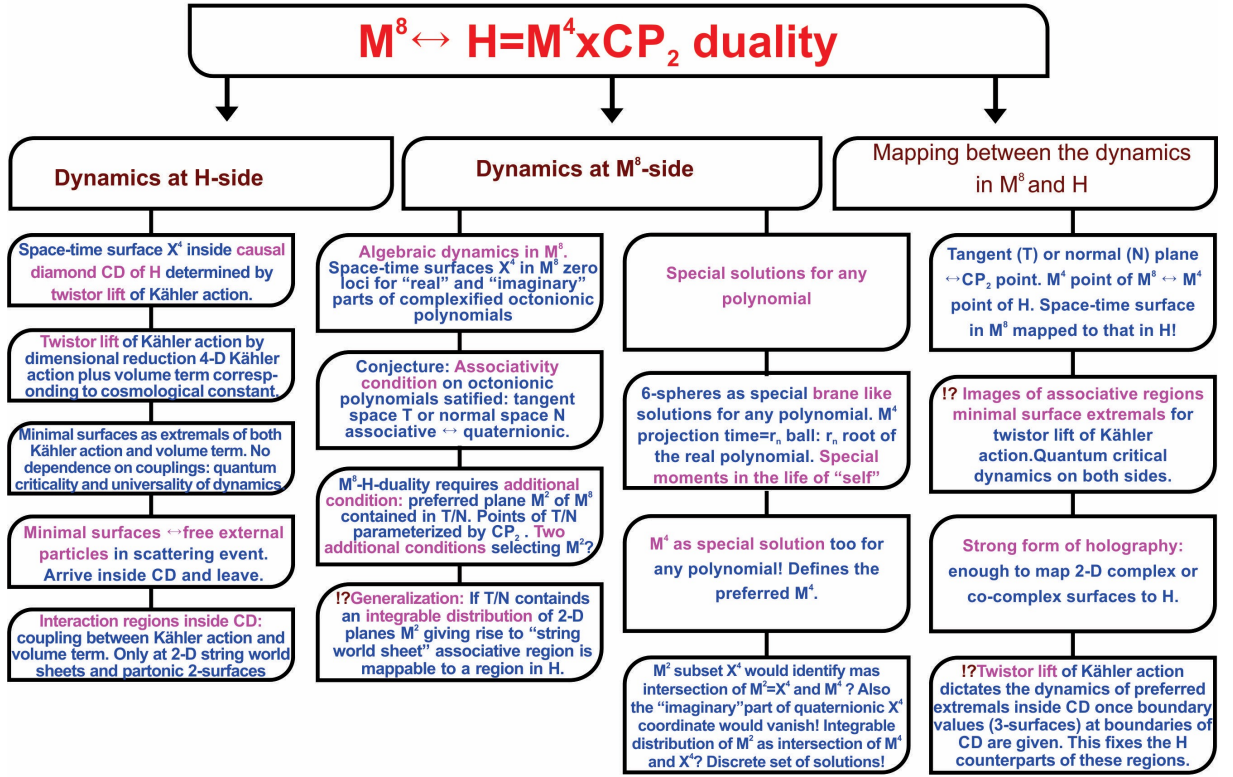
Figure 2: Twistor lift



**Figure 3:** Geometrization of quantum physics in terms of WCW

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

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

Figure 4:  $M^8 - H$  duality

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

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

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

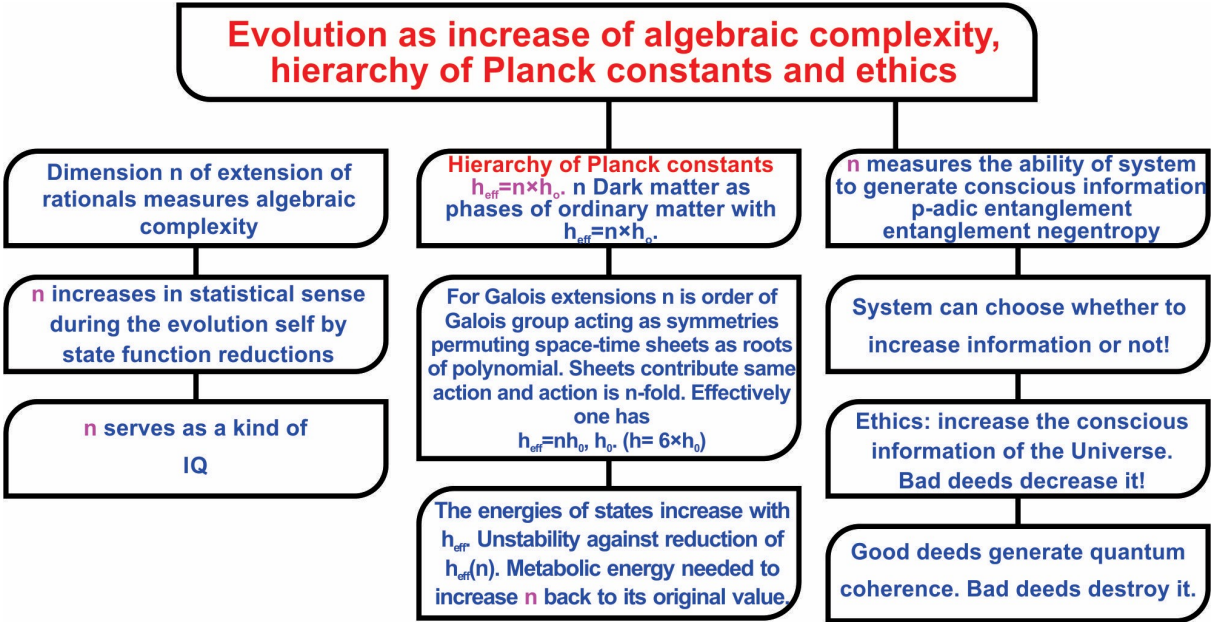
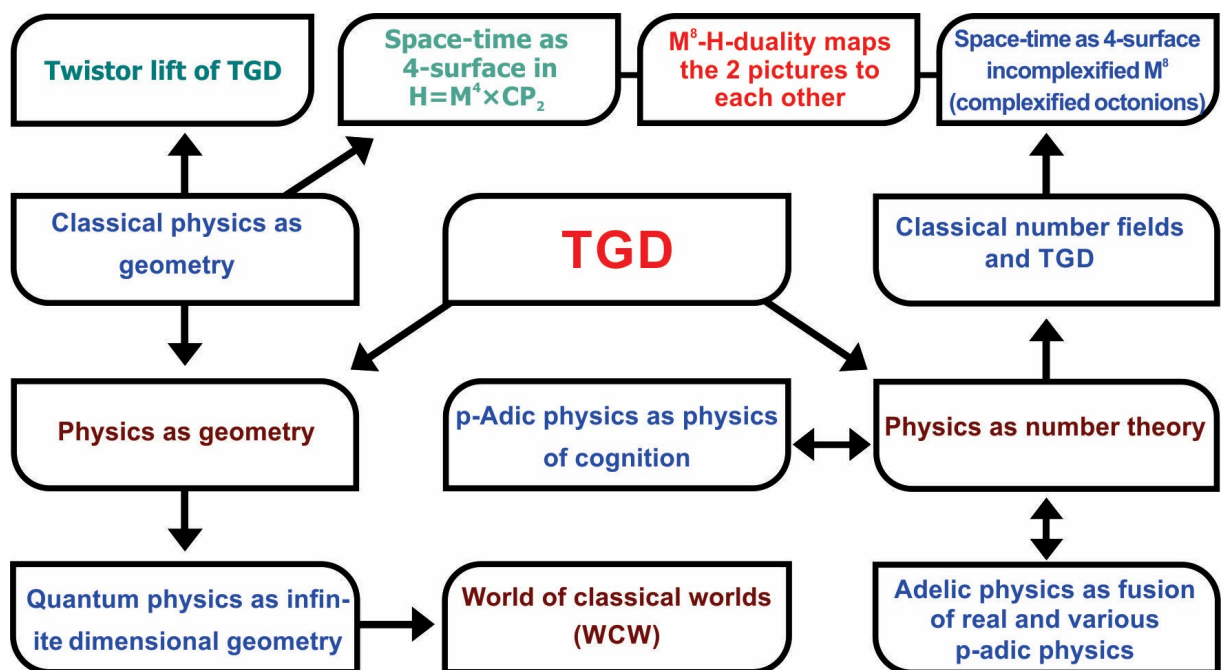


Figure 5: Number theoretic view of evolution



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

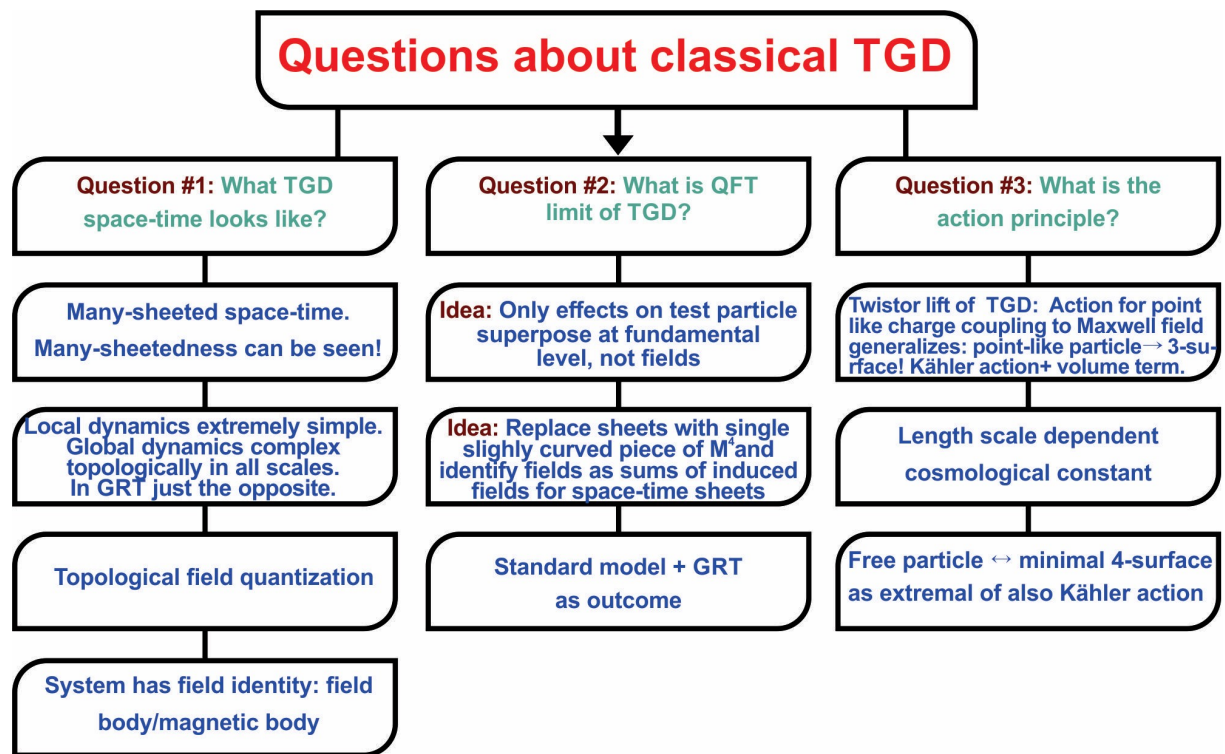
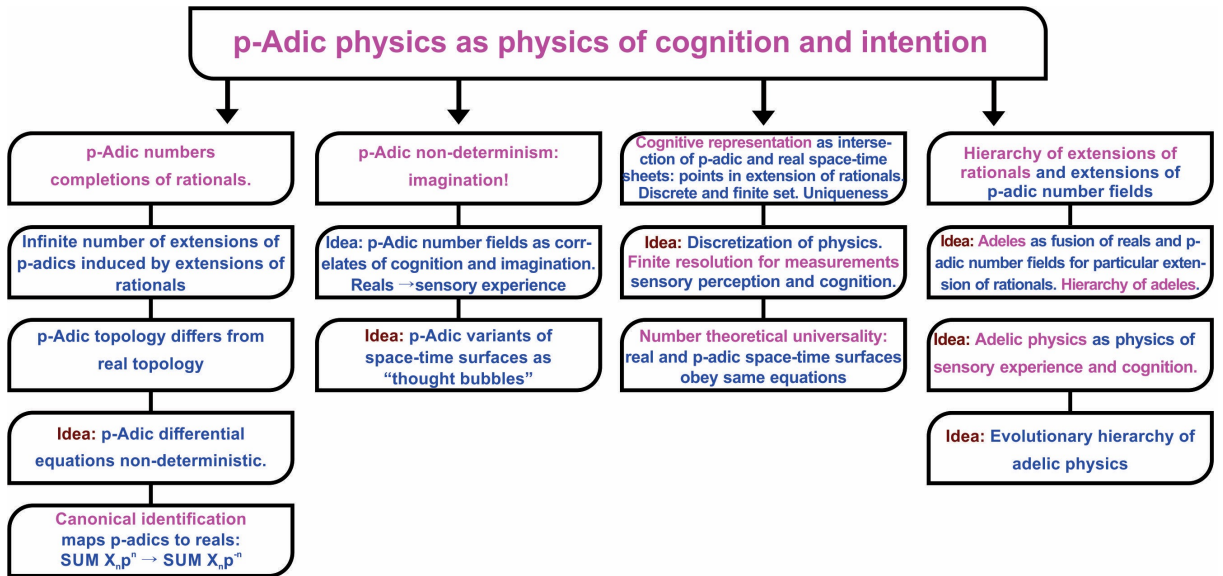


Figure 7: Questions about classical TGD.

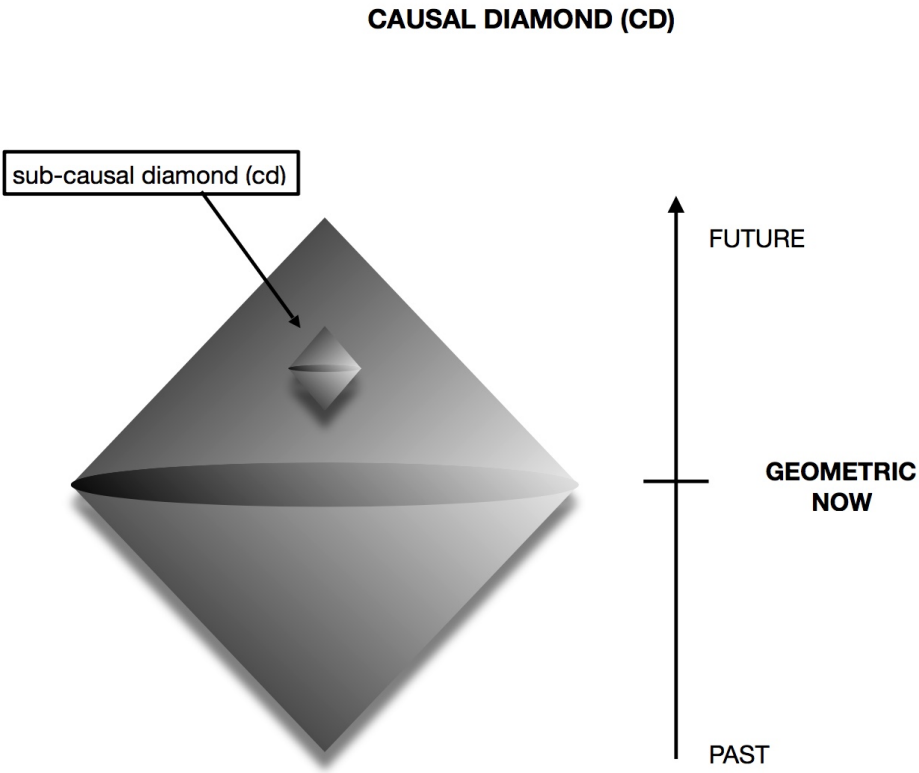




**Figure 8:** p-Adic physics as physics of cognition and imagination.

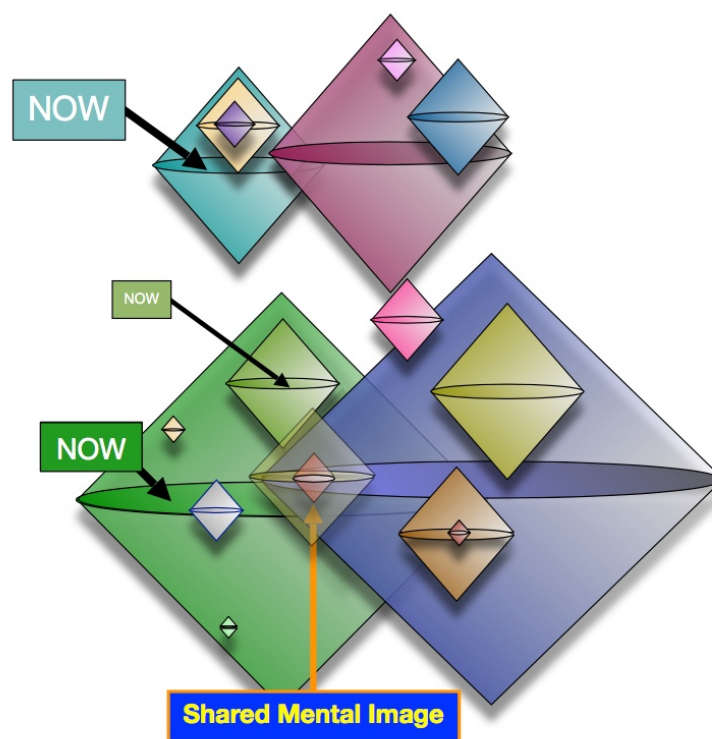
anomalies of water lead to a model for dark nuclei as dark proton strings with the surprising prediction that DNA, RNA, amino acids and even tRNA are in one-one correspondence with the resulting 3-quark states and that vertebrate genetic code emerges naturally. This leads to a vision about water as primordial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

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



**Figure 9:** Causal diamond





**Figure 10:** CDs define a fractal “conscious atlas”

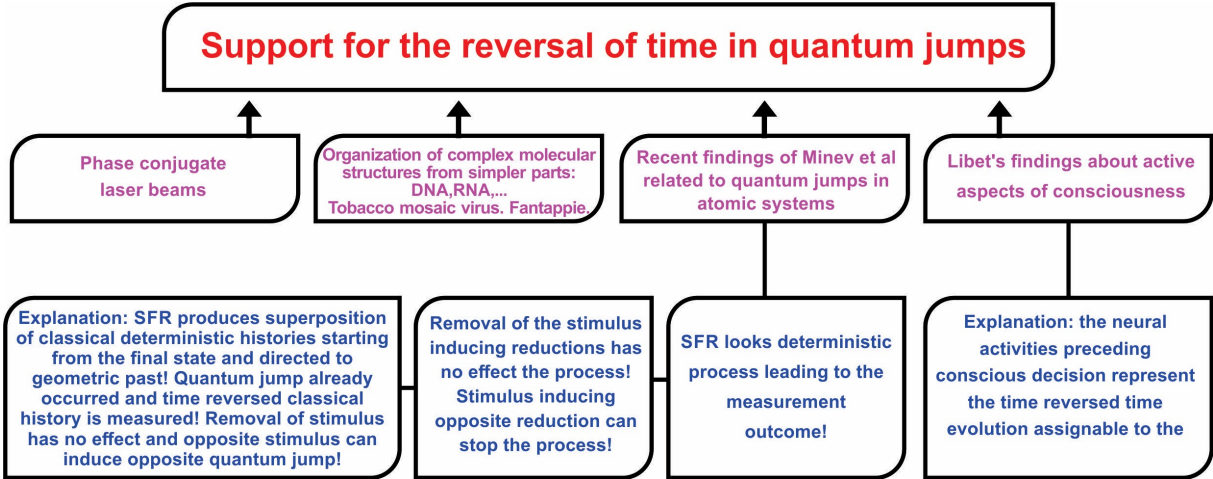
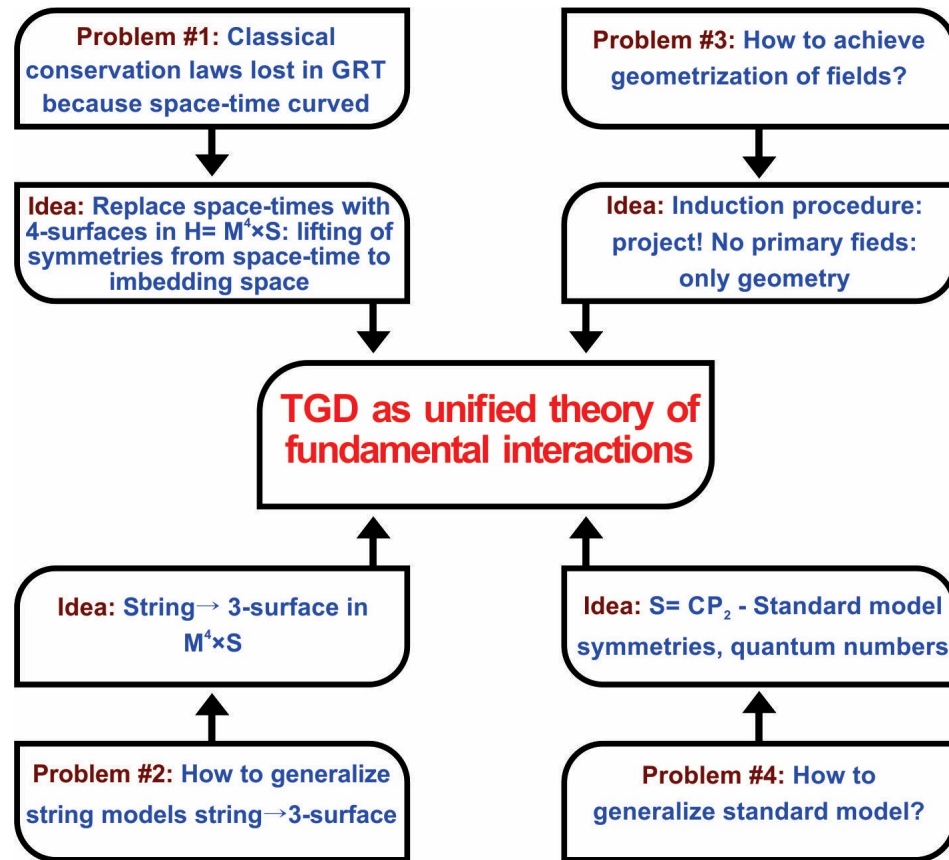


Figure 11: Time reversal occurs in BSFR

## Figures



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

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

Karkkila, April 22, 2024, Finland

**Matti Pitkänen**

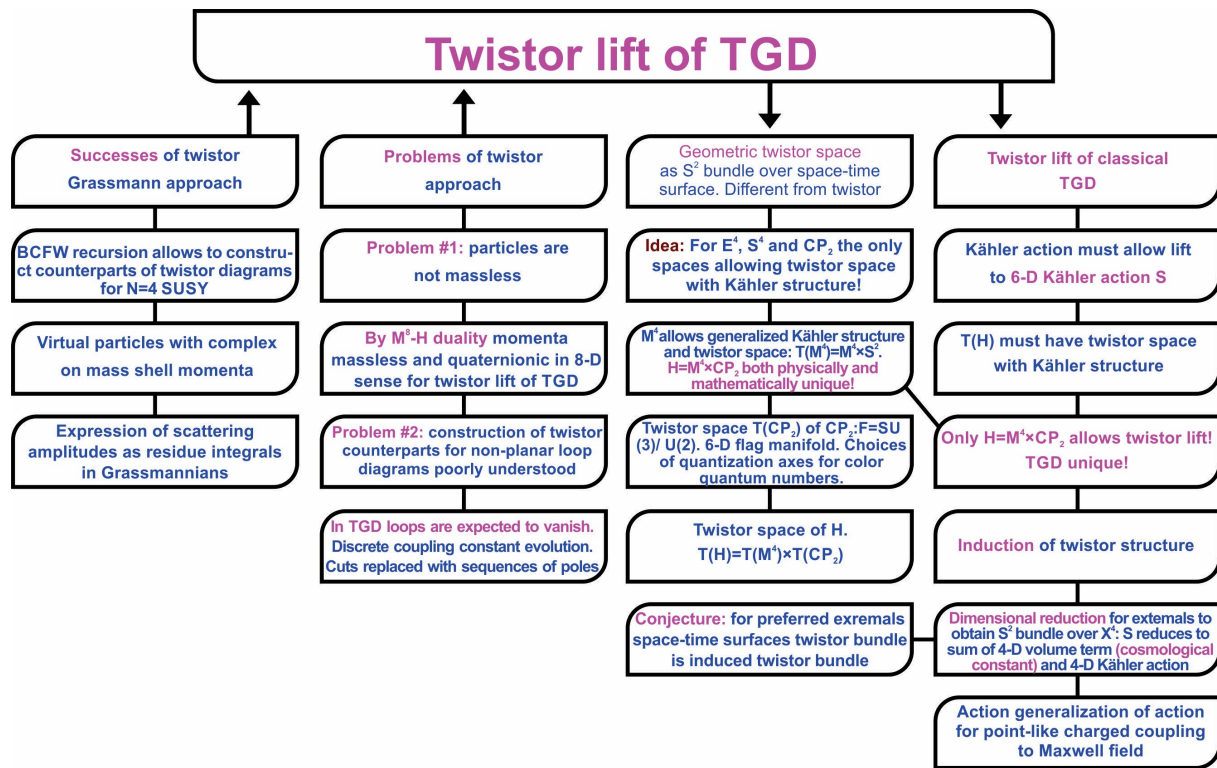


Figure 13: Twistor lift

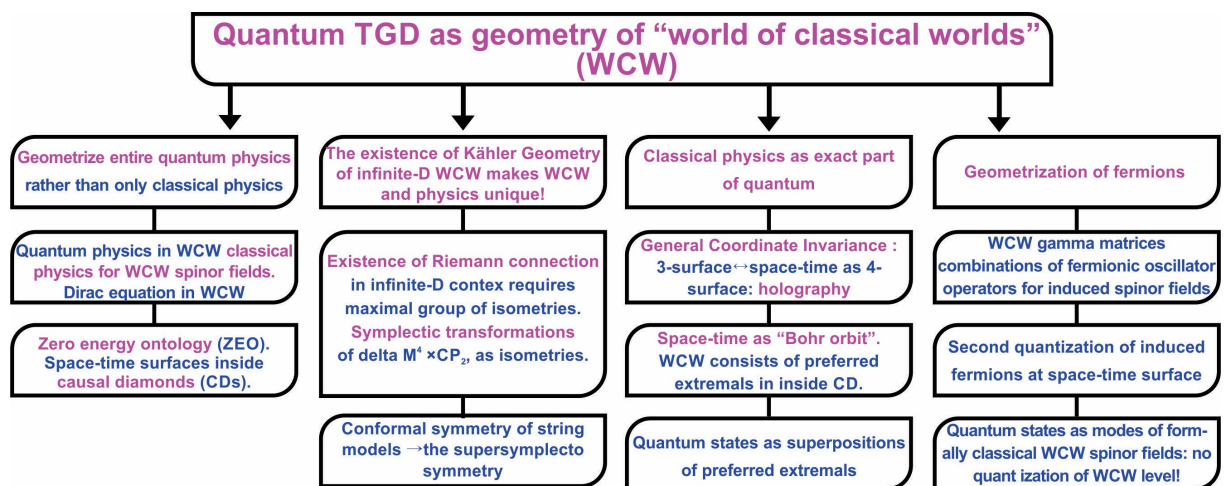
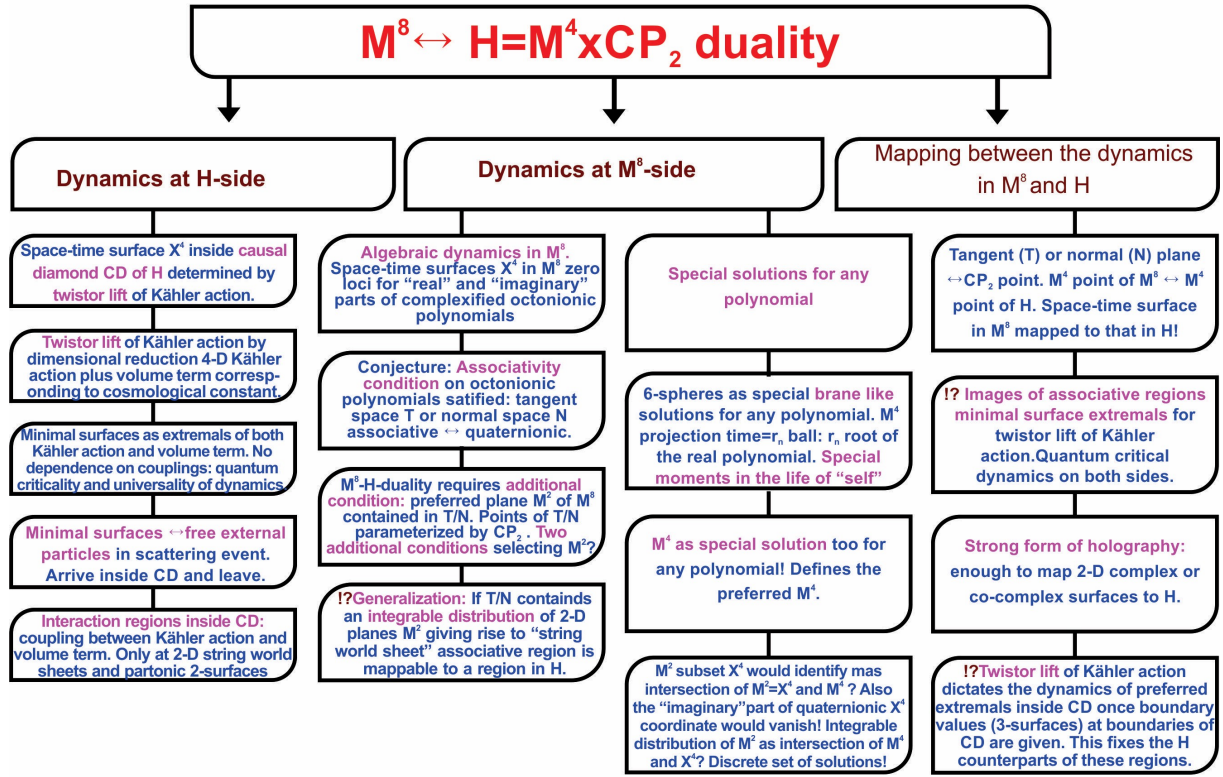


Figure 14: Geometrization of quantum physics in terms of WCW

Figure 15:  $M^8 - H$  duality

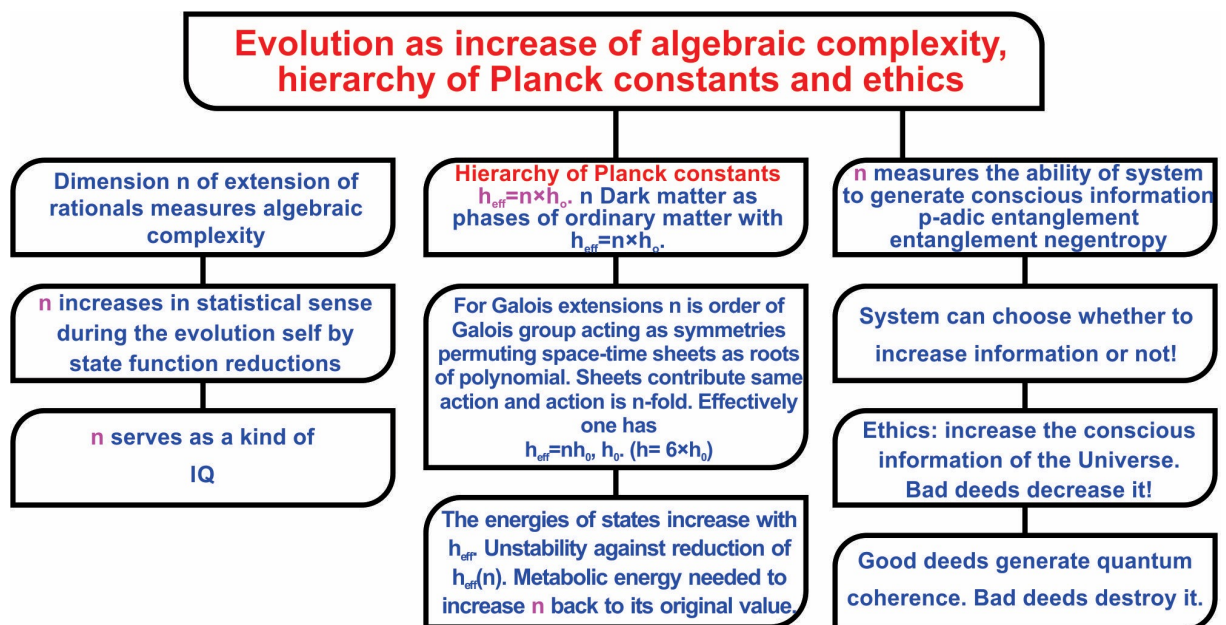
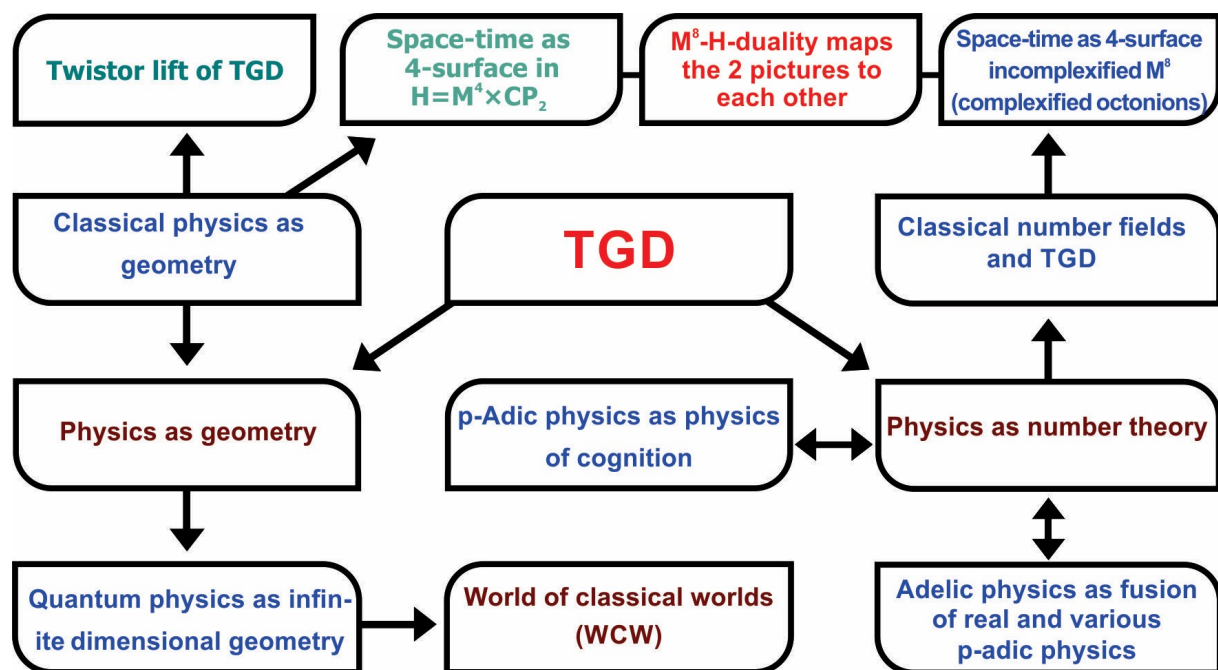


Figure 16: Number theoretic view of evolution





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



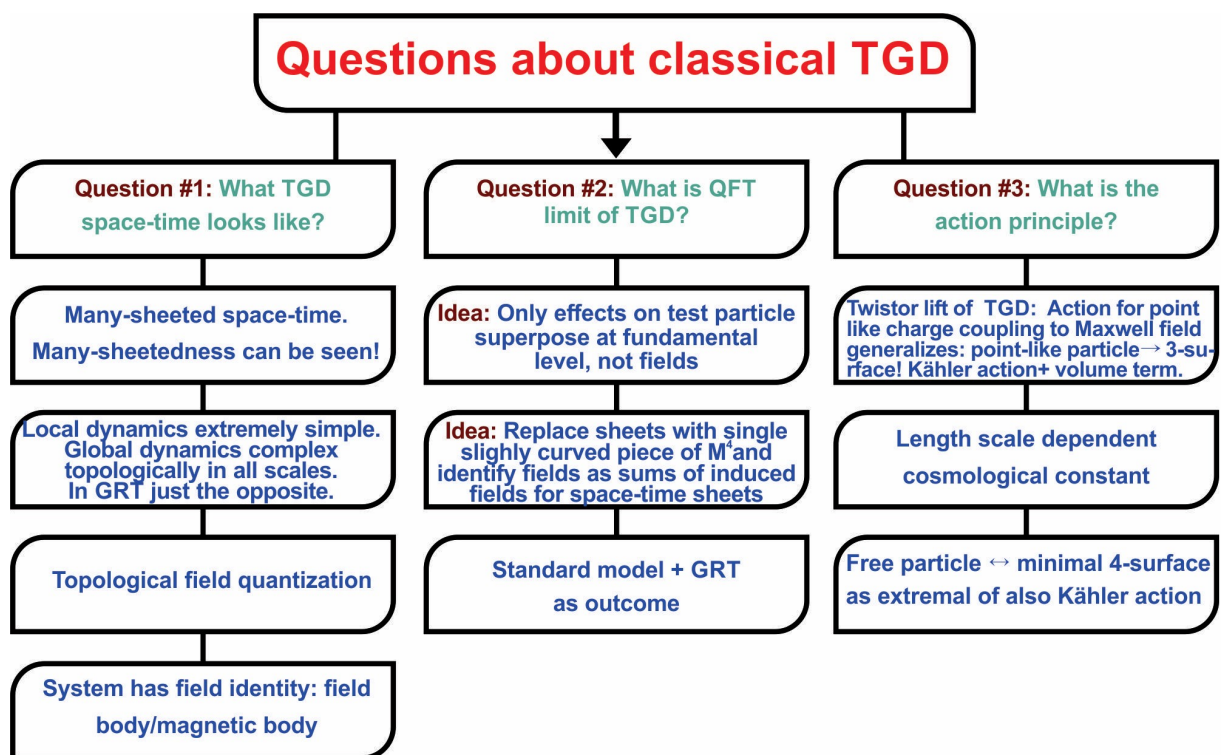


Figure 18: Questions about classical TGD.

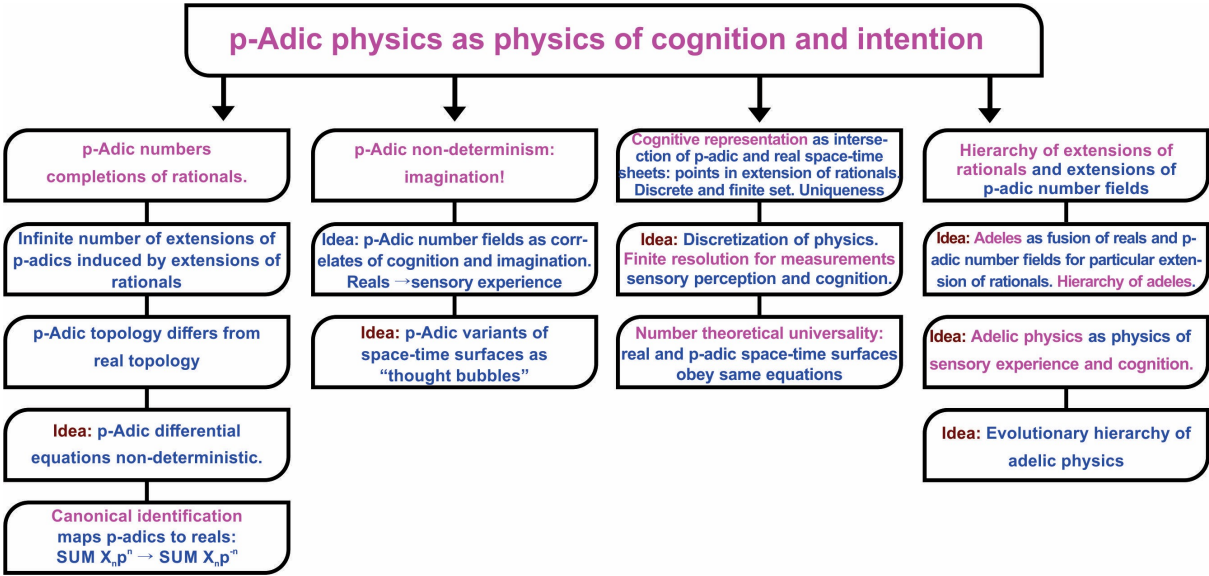
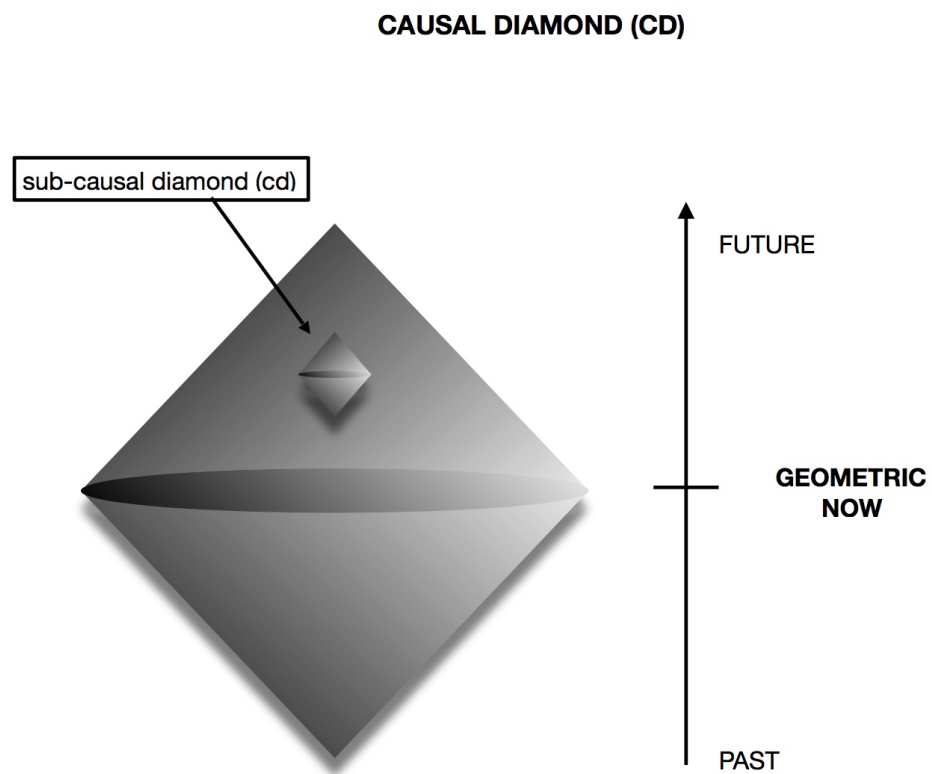
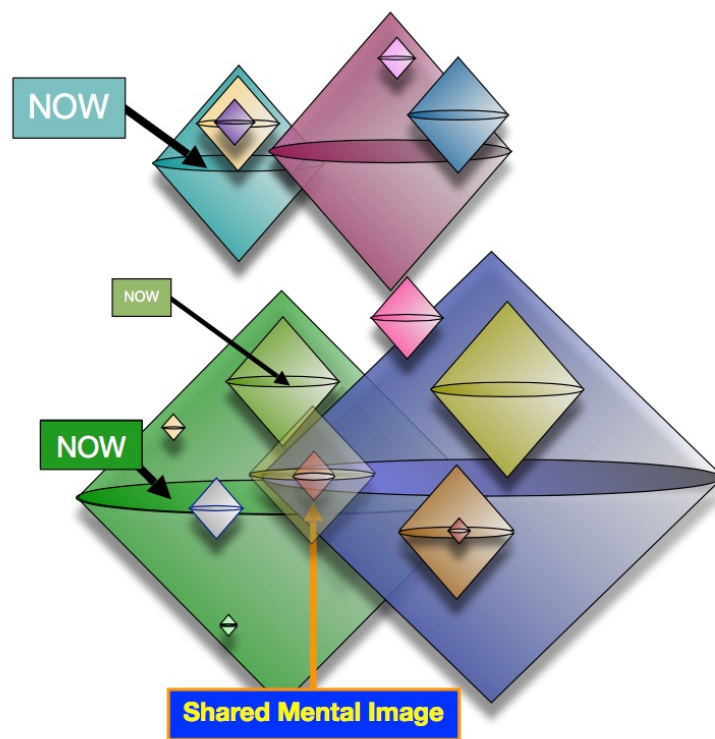


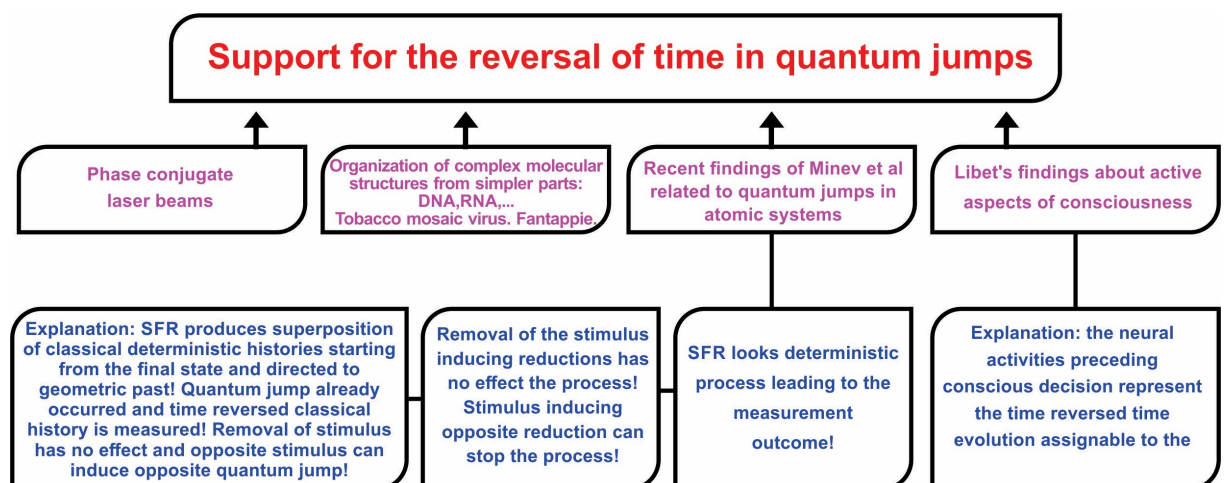
Figure 19: p-Adic physics as physics of cognition and imagination.



**Figure 20:** Causal diamond



**Figure 21:** CDs define a fractal “conscious atlas”



**Figure 22:** Time reversal occurs in BSFR



# ACKNOWLEDGEMENTS

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

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

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

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

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

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

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

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

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

Karkkila, August 30, 2023, Finland

**Matti Pitkänen**



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# Chapter 1

## Introduction

### 1.1 Basic Ideas of Topological Geometrodynamics (TGD)

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

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

#### 1.1.1 Geometric Vision Very Briefly

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

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

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

Twistor lift of TGD means that one can lift space-time surfaces in  $H$  to 6-D surfaces as 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 [A32]. The twistor structure would be induced in some sense, and should coincide with that associated with the induced metric. Clearly, the 2-spheres defining the fibers of twistor spaces of  $M^4$  and  $CP_2$  must allow identification: this 2-sphere defines the  $S^2$  fiber of the twistor space of the space-time surface. This poses a constraint on the embedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces. The existence of Kähler structure allows to lift 4-D Kähler action to its 6-D counterparts and the 6-D counterpart of twistor space is obtained by its dimensional reduction so that one obtains a sphere bundle. This makes possible twistorialization for all space-time surfaces: in general relativity the general metric does not allow this.

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

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

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

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

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

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

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



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

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

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

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

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

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

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

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

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

3. TGD is *not* a gauge theory. In TGD framework the counterparts of also ordinary gauge symmetries are assigned to super-symplectic algebra (and its Yangian [A17] [B8, B5, B6]), 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 [B4]) or something similar. Rather, TGD space-time is topologically non-trivial in all scales and even the visible structures of the everyday world represent non-trivial topology of space-time in the TGD Universe.
6. Twistor space - or rather, a generalization of twistor approach replacing masslessness in 4-D sense with masslessness in 8-D sense and thus allowing description of also massive particles - emerged originally as a technical tool, and its Kähler structure is possible only for  $H = M^4 \times CP_2$ . It however turned out that much more than a technical tool is in question. What is genuinely new is the infinite-dimensional character of the Kähler geometry making it highly unique, and its generalization to p-adic number fields to describe correlates of cognition. Also the hierarchy of Planck constants  $h_{eff} = n \times h$  reduces to the quantum criticality of the TGD Universe and p-adic length scales and Zero Energy Ontology represent something genuinely new.

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

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

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

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

### TGD as a Poincare Invariant Theory of Gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space  $H = M^4 \times CP_2$ , where  $M^4$  denotes Minkowski space and  $CP_2 = SU(3)/U(2)$  is the complex projective space of two complex dimensions [A27, A31, A25, A30].

The identification of the space-time as a sub-manifold [A28, A36] of  $M^4 \times CP_2$  leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity.

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

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

### TGD as a Generalization of the Hadronic String Model

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

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

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

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

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

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

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

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

. What one obtains is what I have christened as many-sheeted space-time (see **Fig.** <http://tgdtheory.fi/appfigures/manysheeted.jpg> or **Fig. 13.4** in the appendix of this book). One particular aspect is topological field quantization meaning that various classical fields assignable to a physical system correspond to space-time sheets representing the classical fields to that particular system. One can speak of the field body of a particular physical system. Field body consists of topological light rays, and electric and magnetic flux quanta. In Maxwell’s theory the physical system does not possess this kind of field identity. The notion of the magnetic body is one of the key players in TGD inspired theory of consciousness and quantum biology. The existence of monopole flux tubes requiring no current as a source of the magnetic field makes it possible to understand the existence of magnetic fields in cosmological and astrophysical scales.

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

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

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

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

### 1.1.3 Basic Objections

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

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

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

### Topological Field Quantization

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

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

#### 1.1.4 Quantum TGD as Spinor Geometry of World of Classical Worlds

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

#### World of Classical Worlds

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

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

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

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

### Identification of Kähler function

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

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

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

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

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

### WCW spinor fields

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

<sup>1</sup>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 [A33, A38, A42]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay  $A \rightarrow B + C$ . Classically this corresponds to a path of WCW leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.

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

#### Construction of the counterparts of S-matrices

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

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



### The notion of M-matrix

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

The M-matrices associated with CDs are obtained by a discrete scaling from the minimal CD and characterized by integer  $n$  are naturally proportional to a representation matrix of scaling:  $S(n) = S^n$ , where  $S$  is unitary S-matrix associated with the minimal CD [K66]. 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  $\lambda$  represents unitarily the discrete Lorentz boost relating the moduli of the active boundary of CD and  $H^i$  form an orthonormal basis of Hermitian square roots of density matrices.  $\circ$  tells that  $S$  acts at the active boundary of CD only. I have proposed a general representation for the U-matrix, reducing its construction to that of the S-matrix.

### 1.1.6 TGD as a generalized number theory

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

### The Threads in the Development of Quantum TGD

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

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

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

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

### Number theoretic vision very briefly

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

emerge as so called ramified primes of algebraic extension of rationals in question and characterizing string world sheets and partonic 2-surfaces. Preferred p-adic primes would be ramified primes for extensions for which the number of p-adic continuations of two-surfaces to space-time surfaces (imaginings) allowing also real continuation (realization of imagining) 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 [K61].

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

### Infinite primes

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

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

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

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

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

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

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

### Holography in $H$

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

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

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

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

### Number theoretic holography in $M_c^8$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### What could the number theoretic holography mean physically?

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

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

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

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

### Twistor lift of the holography

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

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

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

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

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

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



### 1.1.8 Hierarchy of Planck Constants and Dark Matter Hierarchy

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

#### Dark Matter as Large $\hbar$ Phases

D. Da Rocha and Laurent Nottale [E1] have proposed that Schrödinger equation with Planck constant  $\hbar$  replaced with what might be called gravitational Planck constant  $\hbar_{gr} = \frac{GmM}{v_0}$  ( $\hbar = c = 1$ ).  $v_0$  is a velocity parameter having the value  $v_0 = 144.7 \pm .7$  km/s giving  $v_0/c = 4.6 \times 10^{-4}$ . This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of  $v_0$  seem to appear. The support for the hypothesis coming from empirical data is impressive.

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

Nottale's hypothesis would predict a gigantic value of  $\hbar_{gr}$ . Equivalence Principle and the independence of gravitational Compton length on mass  $m$  implies however that one can restrict the values of mass  $m$  to masses of microscopic objects so that  $\hbar_{gr}$  would be much smaller. Large  $\hbar_{gr}$  could provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [K100].

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

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

#### Hierarchy of Planck Constants from the Anomalies of Neuroscience and Biology

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

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

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

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

Also the anomalies of biology (see for instance [K83, K84, K81] ) 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 [K114]. 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 [A32]. 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 [L125].

### 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 [L98]. Similar discretization would take place for momenta. Loops would vanish at the level of discretization but what would happen at the possibly existing continuum limit: does the sequence of poles integrate to cuts? Or is representation as sum of resonances something much deeper?
3. Maybe it is! The basic idea of behind the original Veneziano amplitudes (see <http://tinyurl.com/yyhwvqb>) was Veneziano duality. This 4-particle amplitude was generalized by Yoshiro Nambu, Holger-Bek Nielsen, and Leonard Susskind to N-particle amplitude (see <http://tinyurl.com/yyvkx7as>) based on string picture, and the resulting model was called dual resonance model. The model was forgotten as QCD emerged. Later came superstring models and led to M-theory. Now it has become clear that something went wrong, and it seems that one must return to the roots. Could the return to the roots mean a careful reconsideration of the dual resonance model?
4. Recall that Veneziano duality (1968) was deduced by assuming that scattering amplitude can be described as sum over s-channel resonances or t-channel Regge exchanges and Veneziano duality stated that hadronic scattering amplitudes have representation as sums over s- or t-channel resonance poles identified as excitations of strings. The sum over exchanges defined by t-channel resonances indeed reduces at larger values of  $s$  to Regge form.

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

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

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

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

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

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

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

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

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

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

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

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

## 1.2 TGD As A Generalization Of Physics To A Theory Consciousness

General Coordinate Invariance forces the identification of quantum jump as quantum jump between entire deterministic quantum histories rather than time=constant snapshots of single history. The new view about quantum jump forces a generalization of quantum measurement theory such that observer becomes part of the physical system. The basic idea is that quantum jump can be identified as momentum of consciousness. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [K112, K18, K80, K16, K45, K54, K58, K102, K110].

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

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

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

### 1.2.1 Quantum Jump As A Moment Of Consciousness

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

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

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

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

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

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

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

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

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

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

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

1. The basic objection is that the arrow of geometric time alternates at embedding space level but we know that arrow of time looks the same in the part of the Universe we live. Possible exceptions however exist, for instance phase conjugate laser beams seem to obey opposite arrow of time. Also biological phenomena might involve non-standard arrow of time at some levels. This led Fantappiè [J133] to introduce the notion of syntropy. This suggests that the arrow of time depends on the size scale of CD and of space-time sheet.
2. It took some time to realize that the solution of the problem is trivial in ZEO. In the ordinary quantum measurement theory one must assume that state function reduction can occur repeatedly: the assumption is that nothing happens to the state during repeated reductions. The outcome is Zeno effect: the watched pot does not boil.

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

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

### 1.2.2 Negentropy Maximization Principle (NMP)

Information is the basic aspect of consciousness and this motivates the introduction of Negentropy Maximization Principle (NMP) [K61] as the fundamental variational principle of consciousness theory. The amount of negentropy of zero energy state should increase in each quantum jump. The ordinary entanglement entropy is also non-negative so that negentropy could be at best zero. Since p-adic physics is assumed to be a correlate of cognition, it is natural to generalize Shannon entropy to its number theoretic variant by replacing the probabilities appearing as arguments of logarithms of probabilities with their p-adic norms. This gives negentropy which can be positive so that NMP can generate entanglement.

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

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

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



### 1.2.3 The Notion Of Self

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

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

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

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

### 1.2.4 Relationship To Quantum Measurement Theory

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

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

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

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

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

### 1.2.5 Selves Self-Organize

The fourth basic element is quantum theory of self-organization based on the identification of quantum jump as the basic step of self-organization [K92]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization. Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken's classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the "energy" landscape.

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

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

### 1.2.6 Classical Non-Determinism Of Kähler Action

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

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

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

### 1.2.7 P-Adic Physics As Physics Of Cognition

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

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

A more precise formulation of this vision requires a generalization of the number concept obtained by fusing reals and p-adic number fields along common rationals (in the case of algebraic extensions among common algebraic numbers). This picture is discussed in [K106]. The application of this notion at the level of the embedding space implies that embedding space has a book like structure with various variants of the embedding space glued together along common rationals (algebraics, see **Fig. <http://tgdtheory.fi/appfigures/book.jpg>** or **Fig. ??** in the appendix of this book). The implication is that genuinely p-adic numbers (non-rationals) are strictly infinite as real numbers so that most points of p-adic space-time sheets are at real infinity, outside the cosmos, and that the projection to the real embedding space is discrete set of rationals (algebraics). Hence cognition and intentionality are almost completely outside the real cosmos and touch it at a discrete set of points only.

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

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

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

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

1. Macroscopic quantum coherence can be understood since a particle with a given mass can in principle appear as arbitrarily large scaled up copies (Compton length scales as  $\hbar$ ). The phase transition to this kind of phase implies that space-time sheets of particles overlap and this makes possible macroscopic quantum coherence.
2. The space-time sheets with large Planck constant can be in thermal equilibrium with ordinary ones without the loss of quantum coherence. For instance, the cyclotron energy scale associated with EEG turns out to be above thermal energy at room temperature for the level of dark matter hierarchy corresponding to magnetic flux quanta of the Earth's magnetic field with the size scale of Earth and a successful quantitative model for EEG results [K33].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [K33]. 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 [K33]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K56, K33]. 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 [K33].

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 [K32, K33]. The larger the value of Planck constant, the longer the life-time of self measured as the increase of the average distance between tips of CDs appearing in the quantum superposition during the period of repeated reductions not affecting the part of the zero energy state at the other boundary of CD- Quantum jumps form also a hierarchy with respect to p-adic and dark hierarchies and the geometric durations of quantum jumps scale like  $\hbar$ .

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

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

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

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

Dark matter hierarchy brings additional finesse. For the higher levels of dark matter hierarchy  $\tau$  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  $\tau$ .

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 [K33]. 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 [K56, K33]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible

social rules and moral.

## 1.3 Quantum Biology And Quantum Neuroscience In TGD Universe

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

### 1.3.1 Basic Physical Ideas

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

1. Many-sheeted space-time allows the interpretation of the structures of macroscopic world around us in terms of space-time topology. Magnetic/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 understand the real function of various information molecules and corresponding receptors by interpreting the receptors as addresses in quantum computer memory and information molecules as ends of flux tubes which attach to these receptors to form a connection in quantum web.
2. Magnetic body carrying dark matter and forming an onion-like structure with layers characterized by large values of Planck constant is the key concept of TGD inspired view about Quantum Mind to biology. Magnetic body is identified as intentional agent using biological body as sensory receptor and motor instrument. EEG and its fractal variants are identified as a communication and control tool of the magnetic body and a fractal hierarchy of analogs of EEG is predicted. Living system is identified as a kind of Indra's net with biomolecules representing the nodes of the net and magnetic flux tubes connections between them.

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

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

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

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

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

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

### 1.3.2 Brain In TGD Universe

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

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

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

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

### 1.3.3 Anomalies

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

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

## 1.4 Motivations for “TGD Based View About Living Matter and Remote Mental Interactions”

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

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

As usually happens, also now I realized that I am not able to write this kind of short article. The amount of topics has grown during years quite large and is scattered around to several books and gradually I began to feel desperate. I simply could not decide what should I take and what should I leave. Finally I drifted to the predictable outcome: I decided to write several articles with



topic restricted to the recent state of quantum TGD itself, TGD inspired views about consciousness, and some basic aspects of biology, neuroscience, and remote mental interactions. The decision was made easy after recalling that I had written a series of three articles to the journal *Journal of Consciousness Exploration and Research* founded by Huping Hu. It was rather easy to add the developments that had happened during last three years to these articles and write a new article about remote mental interactions and about testing the vision. The final step was the realization that it is natural to organize the article in a form of book.

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

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

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

#### 1.4.1 Organization of “TGD Based View About Living Matter and Remote Mental Interactions: Part II”

The book consists of 2 parts.

1. In the 1st part TGD inspired neuroscience is discussed. There is a chapter about the experiments by Michael Persinger’s group related to the possible role of bio-photons identified as decay products of dark photons in neuroscience. There is a chapter proposing that emotions could be regarded as sensory percepts about the state of the magnetic body (MB), a chapter about the possible role of dark valence electrons in color vision, and a chapter about geometric theory of bio-harmony suggesting that the “music of light” realized as 3-chords defining bio-harmony provides a realization of genetic code and could serve as a correlate of emotions at molecular level. The last chapter about artificial intelligence in relation to natural intelligence was inspired by the well-known claims about Sophie robot.
2. In 2nd part remote mental interactions are discussed. A chapter describing a general model is followed by several chapters devoted to possible applications. These chapters have appeared also as articles in the journal devoted to remote mental interactions edited by Lian Sidoroff.

## 1.5 Sources

The eight online books about TGD [K122, K115, K91, K71, K22, K67, K49, K103] and nine online books about TGD inspired theory of consciousness and quantum biology [K112, K18, K80, K16, K45, K54, K58, K102, K110] 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/yd6j3o7>).

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: QUANTUM NEUROSCIENCE IN TGD UNIVERSE

#### Quantum Mind and Neuro Science

The article discusses some applications of TGD inspired view about Quantum Mind to neuroscience. Magnetic body carrying dark matter and forming an onionlike structure with layers characterized by large values of Planck constant is the key concept.

A general model for qualia is introduced. The identification of the correlates of the fundamental qualia as quantum number increments for a subsystem is in a complete analogy with the identification of quantum numbers as characterizers of physical states. A general classification of qualia based on thermodynamical notions is discussed and a mechanism generating sensory qualia is proposed. Also the question whether some qualia could correspond also to those of magnetic body is raised.

The interaction of subsystem  $S$  representing self with environment  $E$  is assumed to generate a negentropic entanglement between  $S$  and environment  $E$ . As long as this negentropic entanglement lasts, qualia are experienced. After the state function reduction eliminating this entanglement, there can be only a memory of qualia. There is clearly a resemblance with Orch OR of Penrose and Hameroff. During negentropic entanglement there is polarization in scale of  $S \otimes E$  and  $S$  and  $E$  carry opposite quantum numbers. After the state function reduction negentropic entanglement and polarization prevail only in the scale  $S$  and  $S$  has vanishing net quantum numbers. “Quantum number increments  $\Delta Q$  in quantum jump” therefore correspond to the reduction of charges of subsystem in the state function reduction process. The system is analogous to a capacitor whose size scale is that of  $S \otimes E$  during the sensation of quale and that of  $S$  after it. In ZEO one can consider states of  $S$  at both upper and lower boundaries of  $CD$  and assign  $\Delta Q$  with this time evolution so that quantum classical correspondence is realized.

The capacitor model for sensory receptor based on the idea that sensory qualia are generated in the analog of di-electric breakdown introducing a flow of large number of particles with quantum numbers characterizing the quale. A model for the cell membrane as sensory receptor and as qualia chart with lipids serving as its pixels is developed. Although sensory organs are assumed to define the seats of the fundamental qualia, also neurons would define sensory homunculi not necessarily responsible for sensory mental images at our level of self hierarchy. Cell membrane is assumed to be a quantum critical system taken to mean that it is near to a vacuum extremal of so called Kähler action. This explains large parity breaking in living matter (chiral selection) very difficult to understand in standard model. The model explains the peak frequencies of visible light for photoreceptors and predicts that bio-photons and bunches of EEG photons result as decay products of same dark photons with energies mostly in visible range.

Few years after the writing of the first version of this chapter a progress in the understanding of self. Self can be identified as a sequence of quantum jumps as originally proposed but assuming that the quantum jump sequence correspond to a repeated state function reduction at the same boundary of  $CD$ . In ordinary quantum measurement theory repeated reduction would not change the state at all. This also the case for the second boundary of  $CD$ , say positive energy boundary. Now the parts of zero energy states associated with the negative energy boundary change. Besides this one has a wave function in the moduli space of the second boundary. Moduli include also the temporal distance between the tips of  $CD$ . The statistical increase of this distance gives rise to the flow and arrow of psychological time and self can be identified as the sequence of quantum jumps giving rise to a state function reduction at the same boundary of  $CD$ . The capacitor discharge corresponds to a sequence of state function reductions to a fixed boundary of  $CD$ .

The model of nerve pulse relies on the hypothesis that axonal membrane defines a Josephson junction. The ground state of the axon corresponds to a propagating soliton sequence for the phase difference over the membrane mathematically analogous to a sequence of coupled gravitational penduli with a constant phase difference between neighboring penduli. Nerve pulse is generated as one kicks one of the oscillating penduli. The model of nerve pulse explains the generation of EEG. The resonance frequencies of EEG can be understood as sums and differences of the harmonics of cyclotron frequencies of biologically important dark ions and of Josephson frequency.

A model of bio-photons is discussed. The motivation comes from the observations that bio-photons could be interpreted as decay products of large  $\hbar$  EEG photons resulting in the energy

conserving transformation to ordinary photons at visible and UV energies.

### Comments on the recent experiments by the group of Michael Persinger

Michael Persinger's group reports three very interesting experimental findings related to EEG, magnetic fields, photon emissions from brain, and macroscopic quantum coherence. The findings also provide support for the proposal of Hu and Wu that nerve pulse activity could induce spin flips of spin networks assignable to cell membrane. In this article I analyze the experiments from TGD point of view. It turns out that the experiments provide support for several TGD inspired ideas about living matter - namely, magnetic flux quanta as generators of macroscopic quantum entanglement, dark matter as a hierarchy of macroscopic quantum phases with large effective Planck constant, DNA-cell membrane system as a topological quantum computer with nucleotides and lipids connected by magnetic flux tubes with ends assignable to phosphate containing molecules, and the proposal that "dark" nuclei consisting of dark proton strings could provide a representation of the genetic code. The proposal of Hu and Wu translates into the assumption that lipids of the two layers of the cell membrane are accompanied by dark protons which arrange themselves to dark protonic strings defining a dark analog of DNA double strand.

### Emotions as sensory percepts about the state of magnetic body?

What emotions are? How emotions are created? How they are represented: in brains, at body, or somewhere else? Emotions can be divided into lower level emotions and higher level emotions. What does this correspond to?

1. TGD inspired answer to the questions is that emotions are sensory percepts about the state of magnetic body (MB). Sensory-motor loop generalizes: various glands excreting hormones to blood stream and binding to receptors give rise to the analog of motor output.
2. Neural transmitters binding to receptors serve as bridges allowing to build connected networks of neurons from existing building bricks. They are accompanied by flux tube networks giving rise to tensor networks as quantum coherent entangled structures serving as correlates of mental images and allowing classical signalling with light velocity using dark photons.

In a similar manner hormones give rise to networks of ordinary cells implying in particular that emotional memories are realized in (biological) body (BB). Nervous system gives information about the state of these networks to brain. Hypothalamus serves as the analog of motor cortex excreting hormones controlling the excretion of hormones at lower level glands.

3. The hierarchy of Planck constants defines a hierarchy of dark matters and  $h_{eff} = n \times$  defines a kind of IQ. The levels of MB corresponding to large/small values of  $n$  would correspond to higher/lower emotions.

MB decomposes to two basic parts: the part in the scale of BB and formed by networks having cells and larger structures as nodes (forming a fractal hierarchy) and the part in the scales larger than BB.

1. In the scales of BB (short scales) the dynamics involves topological dynamics of the flux tube network and sensory percepts can be accompanied by conscious-to-us desire to change the state of MB and thus of BB and could be seen as intentions induced by the comparison between what happened and what were the expectations. The outcome would be state function reduction replacing the behavioral pattern with a new one giving better hopes for achieving the goal. In zero energy ontology (ZEO) behavioral pattern is represented as quantum superposition of 4-D MBs so that time aspect is naturally involved with emotions.
2. In the scales larger than that of BB (long scales) the change the topology is not easy and the dynamics involves oscillations of MB - analogs of Alfvén waves - and analogs of ordinary motor actions changing the shape of flux tubes but leaving its topology unaffected.

Alfvén waves with cyclotron frequencies and generalized Josephson frequencies assignable to cell membrane as Josephson junction would be involved. The size scale of particular

anyon-like layer of MB corresponds to the wavelength scale for cyclotron frequencies and is proportional to  $h_{eff}/h = n$  for dark photons. For instance, alpha band in EEG corresponds to the scale of Earth but the energy scale of dark photons is that of bio-photons.

The TGD inspired model of music harmony gives as a side product a model of genetic code predicting correctly the numbers of codons coding for amino-acids for vertebrate code. The model allows to see sensory percepts about the dynamics in large scales as analog of music experience. The notes of 3-chords of the harmony correspond to light as dark photons and frequencies defining the notes of the chord: cyclotron radiation and generalized Josephson radiation from cell membrane would represent examples of dark light. Music expresses and creates emotions and music harmonies would correspond to various emotional states/moods realized at the level of DNA and its dark counterpart (dark nuclei represented as dark proton sequences). MB would be like a music instrument with flux tubes serving as strings. It is difficult to assign any specific desire to large scale sensory percepts about MB and the interpretation as higher emotions - or rather feelings - makes sense.

### Dark valence electrons and color vision

By its large orbital radius dark valence electron (dark in TGD sense,  $h_{eff} = n \times h$ ) sees atomic nucleus and other electrons, which are ordinary, effectively as an object of charge  $Z_{eff} = 1$ . The spectrum of bound state energies and transition energies is scaled down by the factor  $(h/h_{eff})^2$ . This irrespective of what the atom is. The only condition is that there is single unpaired valence electron guaranteed if  $Z$  for the atom is odd. For even  $Z$  odd number of valence electrons must be associated with valence bonds: this would be the case for OH radical for instance.

The dynamics of dark valence electrons is universal with universal transition energy spectrum. One obtains a fractal hierarchy of dynamics labelled by the value of  $(h/h_{eff})^2$ , where  $h_{eff} = n \times h_0$ ,  $h_0$  the minimal value of Planck constant, not necessary equal to  $h$  so that one has  $h = n_0 \times h_0$ . The quantum critical dynamics characterizing living matter in TGD Universe is indeed universal.

The dark photon communications in living matter could utilize these universal energy spectra besides cyclotron energy spectrum and Larmor spectrum assignable to dark particles at flux tubes and the spectrum of generalized Josephson frequencies assignable to cell membrane.

In particular, vision and even other sensory modalities could rely on the transitions induced by the absorption of dark valence electron. In TGD also other sensory percepts are communicated from sensory receptors to the sensory areas of cortex and also here same universal transitions of dark valence electrons might be involved. This hypothesis when combined with the earlier ideas about color qualia leads to a highly predictive and testable model for the perception of colors. In particular the condition  $h = n_0 \times h_0$ ,  $n_0 > 1$ , is necessary for the model to work.  $n_0 = 4$  and  $n_0 = 6$  look the most realistic options. For  $n_0 = 4$  the number of values of  $n = 8, 9, 10$  and correspond to the number 3 of color sensitive receptors whereas  $n_0 = 6$  the number of values  $n = 12, 13, 14, 15$  suggests the existence of a fourth color receptor sensitive to red light.

The statistical aspects of color summation can be understood from TGD inspired theory of consciousness in terms of the hypothesis that self experiences the mental images of sub-self as kind of statistical averages. The identification of quark colors as fundamental color qualia, the entanglement of quarks and antiquarks to form states in one-one correspondence with charged gluons, and the twistor space of  $CP_2$  play key roles in the model of color summation.

### Geometric Theory of Bio-Harmony

For some years ago I developed a model of music harmony. As a surprising side product a model of genetic code predicting correctly the number of codons coding given amino-acid emerged. Since music expresses and creates emotions, one can ask whether genes could have “moods” characterized by these bio-harmonies. The fundamental realization could be in terms of dark photon triplets replacing phonon triplets for ordinary music.

1. The model relies on the geometries of icosahedron and tetrahedron and representation of 12-note scale as so called Hamiltonian cycle at icosahedron going through all 12 vertices of icosahedron. The 20 faces correspond to allowed 3-chords for harmony defined by given Hamiltonian cycle. This brings in mind 20 amino-acids (AAs).

2. One has three basic types of harmonies depending on whether the symmetries of icosahedron leaving the shape of the Hamiltonian cycle is  $Z_6$ ,  $Z_4$  or  $Z_2$ . For  $Z_2$  there are two options:  $Z_{2,rot}$  is generated by rotation of  $\pi$  and  $Z_{2,refl}$  by reflection with respect to a median of equilateral triangle.
3. Combining together one harmony from each type one obtains union of 3 harmonies and if there are no common chords between the harmonies, one has 20+20+20 3-chords and a strong resemblance with the code table. To given AA one assigns the orbit of given face under icosahedral isometries so that codons correspond to the points of the orbit and orbit to the corresponding AA. 4 chords are however missing from 64. These one obtains by adding tetrahedron. One can glue it to icosahedron along chosen face or keep is disjoint.
4. The model in its original form predicts 256 different harmonies with 64 3-chords defining the harmony. DNA codon sequences would be analogous to sequences of chords, pieces of music. Same applies to mRNA. Music expresses and creates emotions and the natural proposal is that these bio-harmonies correlate with moods that would appear already at molecular level. They could be realized in terms of dark photon triplets realized in terms of light and perhaps even music (living matter is full of piezo-electrets). In fact, also the emotions generated by other art forms could be realized using music of dark light.

The model of music harmony is separate from the model of genetic code based on dark proton triplets and one of the challenges has been to demonstrate that they are equivalent. This inspires several questions.

1. Could the number of harmonies be actually larger than 256 as the original model predicts? One could rotate the 3 fused Hamilton's cycles with respect to each by icosahedral rotations other leaving the face shared by icosahedron and tetrahedron invariant. There are however conditions to be satisfied.
  - (a) There is a purely mathematical restriction. If the fused 3 harmonies have no common 3-chords the number of coded AAs is 20. Can one give up the condition of having no common 3-chords and only require that the number of coded AAs is 20?
  - (b) There is also the question about the chemical realizability of the harmony. Is it possible to have DNA and RNA molecules to which the 3-chords of several harmonies couple resonantly? This could leave only very few realizable harmonies.
2. The model predicts the representation of DNA and RNA codons as 3-chords. Melody is also an important aspect of music. Could AAs couple resonantly to the sums of the frequencies (modulo octave equivalence) of the 3-chords for codons coding for given AA? Could coding by the sum of frequencies appear in the coupling of tRNA with mRNA by codewords and coding by separate frequencies to the letterwise coupling of DNA and RNA nucleotides to DNA during replication and transcription?
3. What about tRNA. Could tRNA correspond to pairs of harmonies with 20+20+444 codons? What about single 20+4=24 codon representation as kind of pre-tRNA?
4. What is the origin of 12-note scale? Does genetic code force it? The affirmative answer to this question relies on the observation that 1-1 correspondence between codons and triplets of photons requires that the frequency assignable to the letter must depend on its position. This gives just 12 notes altogether. Simple symmetric arguments fix the correspondence between codons and 3-chords highly uniquely: only 4 alternatives are possible so that it would be possible to listen what DNA sequences sounds in given mood characterized by the harmony.
5. What disharmony could mean? A possible answer comes from 6 Hamiltonian cycles having no symmetries. These disharmonies could express "negative" emotions.

### An Overall View about Models of Genetic Code and Bio-harmony

During last years kind of brain storming period has occurred in the TGD inspired models of bio-harmony and genetic code. A lot of ideas, some of them doomed to be short lived, have emerged, and it seems that now it is time for a thorough cleanup and integration with the general ideas of TGD inspired quantum biology.

TGD leads to 3 basic realizations of the genetic code. One can also consider 3 realization also for bio-harmony. The question is which of them is the realistic one or whether several options can be considered. In this article these ideas are discussed critically and open problems are summarized.

The three genetic codes correspond to a fundamental realization in terms of dark proton sequences (dark nuclei) with 3-proton representing codon. Second realization is the chemical realization and the third realization is in terms of dark photon 3-chords mediating the interaction between various realizations. Frequency resonance is very natural interaction between dark levels and energy resonance between dark level and chemical level. The possibility to modify the value of  $h_{eff}$  for flux tube makes possible to have for given codon single resonance energy.

The homonymy of the genetic codes at various levels is discussed. At the dark level the fact that icosahedral harmonies can have common 3-chords implies the first homonymy. The basic difficulty of Pythagorean scale realized in terms of quint cycle realized already by Pythagoras becomes the solution of this problem. The well-known homonymies in RNA-tRNA correspondence and even in RNA-AA correspondence can be understood in the model in which dark photon 3-chords mediate the interactions.

Also questions related to the relationship of bio-harmony with ordinary genetic code are considered. Why 3 copies of icosahedral harmony and only one copy of tetrahedral harmony? A special triangle assignable to the 3 copies of icosahedron and tetrahedron is analogous to a singular point of covering: do these 4 triangles correspond to exceptional codons breaking symmetries? How do the dissonant 3-chords present in some icosahedral harmonies relate to stop codons? How do the codons of bio-harmony and ordinary codons relate and is this relation consistent with what is known about transcription and translation?

### About honeycombs of hyperbolic 3-space and their relation to the genetic code

$M^8 - H$  duality and the realization of holography in  $M^8$  strongly suggests the importance of tessellations of  $H^3$  (analogous to lattices of  $E^3$ ) in the TGD based physics. These tessellations form a scale hierarchy and can thus appear in all scales. The hierarchy of effective Planck constants labelling dark matter as phases of ordinary matter indeed predicts quantum coherence in arbitrarily long scales and gravitational quantum coherence corresponds to the largest scales of quantum coherence among basic interactions.

There are 5 Platonic tessellations known as honeycombs: the 4 regular honeycombs correspond to cubic, icosahedral, and 2 dodecahedral honeycombs and a quasiregular icoso-tetrahedral honeycomb having tetrahedra, octahedra and icosahedra as cells. The icoso-tetrahedral honeycomb might define a universal realization of the genetic code as an induced structure so that the genetic code would be much more than a biochemical accident. These 5 Platonic honeycombs could occur also in astrophysical scales as gravitational tessellations. The recent discovery of gravitational hum might have an explanation as gravitational diffraction in this kind of a honeycomb.

In this chapter the properties of hyperbolic honeycombs are considered in detail and also a detailed view about the realization of DNA double strand in terms of the icoso-tetrahedral honeycomb is considered. The emerging model is surprisingly quantitative. Also a connection with the notion of memetic code and the realization of memetic codons in terms of 21 DNA codons are suggested by the model.

### Artificial Intelligence, Natural Intelligence, and TGD

Recently a humanoid robot known as Sophia has gained a lot of attention in net. Sophia uses AI, visual data processing, and facial recognition. Sophia imitates human gestures and facial expressions and is able to answer questions and make simple conversations on predefined topics. The AI program used analyzes conversations, extracts data, and uses it to improve responses in the future. To a skeptic Sophia looks like a highly advanced version of ELIZA.

Personally I am rather skeptic view about strong AI relying on a mechanistic view about intelligence. This leads to transhumanism and notions such as mind uploading. It is however good to air out one's thinking sometimes.

Computers should have a description also in the quantal Universe of TGD and this forces to look more precisely about the idealizations of AI. This process led to a change of my attitudes. The fusion of human consciousness and presumably rather primitive computer consciousness but correlating with the program running in it might be possible in TGD Universe, and TGD inspired quantum biology and the recent ideas about prebiotic systems provide rather concrete ideas in attempts to realize this fusion.

TGD also strongly suggests that there is also what might be called Natural Intelligence relying on 2-D cognitive representations defined by networks consisting of nodes (neurons) and flux tubes (axons with nerve pulse patterns) connecting them rather than linear 1-D representation used by AI. The topological dynamics of these networks has Boolean dynamics of computer programs as a projection but is much more general and could allow to represent objects of perceptive field and number theoretic cognition.

### Arrow of time and neuroscience: TGD based view

The question that inspired this article is whether memories about the future - precognitions - are possible in some sense. This requires retrocausality. The criticism of retrocausality relies on the assumption that time, in particular the thermo-dynamical time, has always the same arrow. TGD inspired theory of consciousness as quantum measurement theory based on zero energy ontology (ZEO) predicts that the arrow of time can vary and changes in ordinary - "big" -state function reductions (BSFRs): self dies (falls asleep) and re-incarnates with a opposite arrow of time. This leads to a generalisation of thermodynamics and allows to see self-organisation basically as a consequence of the generalised second law.

Precognition as a recall of future geometric memories would rely on sensory perception with an opposite arrow of time by some sub-selves assignable to the structures of the brain. The arrow of time would be reversed at some layer of the magnetic body in a master-slave relation with the biological body and induce an effective change of arrow at the level of ordinary biomatter in longer time scales than usual. The sensory perceptions with reversed arrow time would be communicated to the self as dreams meaning BSFR for the time reversed mental and its death and reincarnation with standard arrow of time. There are findings about Alzheimer patients supporting this hypothesis.

This proposal deviates from standard neuroscience in that ZEO and the notion of magnetic body carrying phases of ordinary matter with effective Planck constant  $\hbar_{eff} = n\hbar_0 > \hbar$  behaving like dark matter. Also a purely biochemistry based hypothesis that biochemical factors responsible for the buildup of memory traces select the arrow of time: perhaps their shortage could lead to the selection of the opposite arrow of time.

### TGD View about Language

Human languages differ dramatically from their analogos for animals. Animal languages consist mainly of simple signals, warnings and threats for instance. The emotional expression dominates. There seems to be no grammar. Birds can have repertoire of different song patterns and monkeys have gesture language. There is a huge variety of human languages. One can also regard music as a kind language expressing emotions and creating them. Also pictures define linguistic representations. Children and animals learn speech by mimicry and the grammar and syntax without conscious efforts. Human language is also special in that it involves conceptualization, metaphors, and analogies representing abstract concepts in terms of objects and actions of the external world.

One might understand the semantic aspect of language in terms of association and conditioning. Language acquisition involves showing the object and saying the word describing it. This suggests conditioning and association so that a mere word generates an imagined percept of the object. Conditioning and formation of associations is a very general form of learning assumed to relate to the increase of synaptic strengths leading to a generation of association pathways. In computer science pattern recognition and completion models it mathematically.

Amazingly, only a few point mutations for relatively few genes seems so have led to human languages and transformed biological evolution to cultural evolution? What happened for these genes? In the biochemistry framework it is difficult to imagine an answer to this question. Here TGD could come in rescue.

Number theoretic physics is part of quantum TGD and essential for understanding evolution as an increase of algebraic complexity. Evolutionary hierarchies would correspond to hierarchies of algebraic extensions of rationals. The dimension  $n$  of extension defines effective Planck constant  $h_{eff}/h_0 = n$ . The larger the dimension, the larger the scale of quantum coherence at corresponding layer of magnetic body (MB) associated with the system:  $n$  would be analogous to IQ. One can assign a value of  $h_{eff}$  characterizing the evolutionary level also to genes. The genes with larger  $h_{eff}$  would serve as control genes and the increase of  $h_{eff}$  would mean an evolutionary step. Perhaps a dramatic increase of  $h_{eff}$  occurred to FOXP2 and some other genes as human language emerged.

### 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  $\Delta f_c$  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  $1 \mu\text{m}$  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.

### Does Consciousness Survive Bodily Death?

*“What is the best possible evidence for the survival of human consciousness after bodily death?”* is the question of this essay. It is very difficult to provide water tight evidence for life after death since near-death experiences are subjective and do not provide objective proof.

The situation changes if one has a testable theory of consciousness. The theory of consciousness presented here is inspired by Topological Geometrophysics (TGD). TGD was born as a proposal for a unification of fundamental interactions, and indeed provides a general theory of consciousness as a generalization of quantum measurement theory predicting that consciousness, life and death are universal phenomena. The theory relies on new views of space-time and classical fields, and provides a new ontology behind quantum theory that predicts that state function reduction involves time reversal.

The proposed hypothesis forces a new view of the relationship between experienced time and physicist’s time, and generalizes thermodynamics so that the second law is replaced with what I call the Negentropy Maximization Principle. Also cognition is included and forces the extension of real number based physics to adelic physics including not only reals but also p-adic number fields. Adelic physics predicts a hierarchy of phases of ordinary matter with a non-standard value  $h_{eff}$  of the Planck constant interpreted as dark matter which for large values  $h_{eff}$  is quantum coherent at arbitrarily long scales. Theory makes testable predictions at all scales supporting the proposed view of the continuation of life beyond biological death. A model for what happens in biological death and an explanation for various aspects of near-death experiences emerges.



## 1.6.2 PART II: REMOTE MENTAL INTERACTIONS

### TGD inspired view about remote mental interactions and paranormal

I have proposed a general vision about what remote mental interactions and related phenomena could be in TGD Universe around 2003. A lot of progress that has taken place since then, and this motivates the reconsideration of this vision. The general vision is that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal are predicted to share the same basic mechanisms, and that the proposed vision provides basic concepts and the language allowing to speculate and build simple models. One cannot of course take the proposed models too seriously at the level of details.

The new ideas that have emerged since 2003 are summarized and parapsychological phenomena are discussed at general level. Also some applications of the basic vision are discussed. The notion of conscious hologram is discussed from the point of view of remote mental interactions. The notion of magnetic body is in decisive role as it is also in the understanding of quantum biology in TGD framework. TGD inspired model for OBEs relying on the notion of magnetic body is summarized. The idea is that OBEs could correspond to sensory experiences assignable to magnetic body rather than real body. Also the connections with the work of other researchers, such as Shnoll, Persinger, and Tiller are discussed briefly. The challenge of testing the vision is also considered.

### How to test TGD based vision about living matter and remote mental interactions?

The general TGD inspired vision is that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal share the same basic mechanisms. This purpose of this chapter is to summarize the new physics effects involved with the TGD inspired quantum view about consciousness and living matter and its applications to remote mental interactions and related phenomena. Also tests are discussed when possible. By the universality of the mechanisms most of the tests reduce to tests for a new physics predicted by TGD.

### Hypnosis as remote mental interaction

In TGD framework one can argue that hypnosis represents an example about the fact that brain is not “private property”: hypnotist uses the biological body and brain of the subject as instrument. Therefore remote mental interaction is in question. This idea generalizes: if one accepts self hierarchy, one can assign to any kind of higher level structure - family, organization, species, .... - a higher level self and magnetic body carrying dark matter, and these magnetic bodies can use lower level magnetic bodies as their instruments to realize their intentions. Biological bodies would be an important level in the hierarchy, which would continue down to cellular, molecular, and perhaps to even lower levels.

This view challenges the prevailing views about brain as a sole seat of consciousness and the assumption that conscious entities assigned with brains are completely isolated. Given magnetic body can use several biological bodies although one can assign to it the one providing the sensory input - at least during wake-up state. Note however that it is easy to produce illusion that some foreign object is part of biological body.

For more than decade ago I proposed a model for so called bicamerality based on the notion of semitrance. In semitrance the brain of subject becomes partially entangled with a higher level self - in this case the self of family or more general social group uses the biological body of member for its purposes. Higher level self gives its commands and advice interpreted by the bicameral as “God’s voice”. The consciousness of schizophrenic might be basically bicameral. Also hypnotic state and dream consciousness are candidates for bicameral consciousness.

In this article I develop essentially this idea but using as input the recent understanding of about TGD inspired theory of consciousness and quantum biology and end up with a proposal for a detailed mechanism for how the magnetic body hijacks some parts of the brain of the subject: prefrontal cortex and anterior cingulate cortex are argued to be the most plausible targets of hijacking. Also a mechanism explaining how the sensory hallucinations and motor actions are induced by hypnotist by inhibiting a halting mechanism preventing imagined motor actions to become real and sensory imagination to become “qualiafied”.

### **Meditation, Mind-Body Medicine and Placebo: TGD point of view**

The chapter represents TGD inspired answers to Lian Sidorov's questions concerning meditation, mind-body medicine and placebo in quantum biology framework. To help the reader, some aspects of TGD inspired theory of consciousness and quantum biology are summarized since several new insights inspired by the notions of magnetic body and dark matter have emerged lately. This includes improved views about quantum metabolism and prebiotic life: the basic input comes from the claimed free energy phenomena interpreted in TGD framework. Water structures representing simplified analogs of basic biomolecules suggested by water splitting producing so called Brown's gas might be highly relevant also for the ordinary metabolism. The main new input concerning remote mental interactions comes from a possible answer to the question whether TGD based ontology of physics could allow the "shamanistic" view that the experiences (say encounters with strange life forms assigned with distant civilizations) induced by various psychedelics used in the spiritual practices of indigenous people could be genuine remote sensory perceptions rather than hallucinations. Affirmative answer would mean a direct and testable connection between neuropharmacology and remote sensory perception with serotonin defining the crucial neurotransmitter and pineal gland ("third eye") serving as a candidate for the brain area of special importance in this respect.

Concerning the questions about meditation, mind-body medicine and placebo, the key concept is that of magnetic body. Usually organism and environment are seen as members of an interacting pair: organism receives sensory data from environment and controls it. Now magnetic body appears as a third party, "intentional agent" using biological body as a kind of interface between magnetic body and environment. Various "motor actions" of the magnetic body are highly relevant for both consciousness and biochemistry. The pairs formed by various information molecules and corresponding receptors could define plug-ins to the Indra's net (or Internet) defined by the magnetic bodies and Josephson radiation emitted by Josephson currents assignable to receptors would propagate along flux tubes. Meditation can be seen as "bodily exercise" of the magnetic body and a method to improve the communications between magnetic body and biological body. In healing magnetic body would be the active participant and healing would be also the healing of magnetic body. The placebo effect could be seen as an outcome of intentions of magnetic body affecting biological body.

### **Non-locality in quantum theory, in biology and neuroscience, and in remote mental interactions: TGD perspective**

Non-locality seems to be a basic aspect of what it is to be living. Living system is elementary particle like coherent unit. The phenomenon of memory suggests temporal non-locality. Also remote mental interactions - if real - suggest non-locality. In fact, non-locality - both spatial and temporal - is the basic element of entire quantum TGD, and in particular, of its applications to quantum biology, neuroscience, theory of consciousness, and also of remote mental interactions.

In the sequel I make kind of pseudo deduction of the picture provided by Topological Geometrodynamics (TGD) by starting from empirical findings loosely related to non-locality rather than problems of General Relativity or of particle physics. The hope is that this could make the basic ideas of TGD easier to grasp. Also the mathematical framework and its interpretation as they are now are briefly discussed and the some applications to TGD inspired theory of consciousness and quantum biology are discussed.

### **Some Questions About IIT**

Integrated Information Theory (IIT) is a neuro- and computer science based theory of consciousness proposed originally by Tononi. This article is a critical summary of IIT and its comparison with TGD inspired theory of consciousness. Basic criticism relates to the circular definition of consciousness leading to a paradox. The printing of a text by printer is a conscious process if no-one knows the text but not so if some-one knows the text. One could test IIT by looking if a system with large  $\Phi$  (say classical computer in which program is running) has the properties associated with living conscious systems (self-organization in presence of energy feed, metabolism, responsiveness,...). Also the questions about possible experimental testing of IIT raised by the participants of the panel are discussed.

## Part I

# QUANTUM NEUROSCIENCE IN TGD UNIVERSE



## Chapter 2

# Quantum Mind and Neuro Science

### 2.1 Introduction

Quantum biology-rather than only quantum brain- is an essential element of Quantum Mind in TGD Universe. Cells, biomolecules, and even elementary particles are conscious entities and the biological evolution is evolution of consciousness so that it would be very artificial to restrict the discussion to brain, neurons, or microtubules. The basic new physics inspired ideas behind TGD inspired quantum biology have been discussed already in the first article but deserve to be listed.

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 understand the real function of various information molecules and corresponding receptors by interpreting the receptors as addresses in quantum computer memory and information molecules as ends of flux tubes which attach to these receptors to form a connection in quantum web.
2. 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.

3. 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 way 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 imbedding 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 way 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 ways to the hierarchy of Planck constants as effective hierarchy hierarchy and integer multiples of Planck constants emerge naturally.

4. 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. The hologram idea has also rather abstract mathematical generalizations inspired by TGD. Infinite primes lead to the idea that each space-time point has a complex number theoretic anatomy and that one could see evolution also as evolution of this number theoretic anatomy. Quantum Mathematics replacing elements of number fields with Hilbert spaces characterizing their number theoretic anatomy is very similar idea and leads to holography also since one can replace the points of Hilbert spaces involved with Hilbert spaces repeatedly. In both cases this process is analogous to a repeated second quantization.
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 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. An attractive idea is that the negentropic entanglement can be assigned with magnetic flux tube 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.
6. The view about the function of brain differs from the standard view. The simplest option is that brain is 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 the two options. 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.

In the following I briefly summarize some applications. I am of course forced to leave details to the books about TGD inspired theory of consciousness at my homepage [K112, K18, K80, K45, K17, K54, K58, K102].

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> [L30].

## 2.2 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.

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 [K4]. 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.
2. 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 [J78], and 160 Hz to cerebellar synchrony [J76]. 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 [K86] remain to be disentangled.
3. The understanding of the Negentropy Maximization Principle [K61] 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.
4. One of the basic challenge has been to construct a quantitative model for cell membrane.
  - (a) The first model was based on the assumption that long range weak forces however play a key role [K11]. 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.
  - (b) Second model is based on Gerald Pollack's findings about fourth phase of water and exclusion zones [L34]. 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.

- (c) 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).

### 2.2.1 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.

1. The basic assumption is that sensory qualia correspond to increments of various quantum numbers in quantum jump. Standard model quantum numbers- color quantum numbers, electromagnetic charge and weak isospin, and spin are the most obvious candidates. Also cyclotron transitions changing the integer characterizing cyclotron state could corresponds to some kind of quale- perhaps “a feeling of existence”. This could make sense for the qualia of the magnetic body.
2. Geometric qualia could correspond to the increments of zero modes characterizing the induced  $CP_2$  Kähler form of the partonic 2-surface and of the moduli characterizing the causal diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in  $CP_2$  and relative position of two  $CP_2$  points assigned to the future and past boundaries of CD. There are good motivations for proposing that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could 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 boosts of sub-CD representing mental image about the object.
3. One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images. The simplest starting assumption consistent with neuro-science is that sensory qualia are assigned with the cell membrane of sensory receptor and perhaps also with the neurons receiving data from it carried by Josephson radiation coding for the qualia and possibly partially regenerating them if the receiving neuron has same value of membrane potential as the sensory receptor when active. Note that during nerve pulse also this values of membrane potential is achieved for some time.



### Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the “feeling of existence” type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

1. Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. On the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the “feeling of existence” at magnetic body entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.
2. If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about  $10^{14}$  Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of  $\hbar$  must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of bio-photons and EEG. One expects that only high level qualia can correspond to a very large values of  $\hbar$  needed.

For the sake of completeness it should be noticed that one might do without large values of  $\hbar$  if the carrier wave with frequency defined by the metabolic energy quantum assignable to the kicking and that the small modulation frequency corresponds to the cyclotron frequency. This would require that Josephson frequency corresponds to the frequency defined by the metabolic quantum. This is not consistent with the fact that very primitive organisms possess sensory systems.

3. If all primary qualia are assigned to the magnetic body, Josephson radiation must include also gluons and light counterparts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification of sensory qualia in terms of quantum numbers of quark pair restricts them to the cell membrane. The coding of qualia by Josephson frequencies is however possible and makes it possible to regenerate them in nervous system. The successful model explaining the peak frequencies of photoreceptors in terms of ionic cyclotron frequencies supports this view and provides a realization for an old idea about spectroscopy of consciousness which I had already been ready to give up.

### 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 change 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 [K86] 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.

## 2.2.2 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 [K4].

1. Zero energy ontology brings in the size scale of CD assignable to the field body of the elementary particle. Zero energy states with negentropic time-like entanglement between positive and negative energy parts of the state might provide a key piece of the puzzle. The negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) between positive energy parts of the states associated with the sub-CD assignable to the cell membrane and sub-CD at the magnetic body is expected to be an important factor.
2. For the standard value of  $\hbar$  the basic prediction would be 1 ms second time scale of  $d$  quark, 6.5 ms time scale of  $u$  quark, and .1 second time scale of electron as basic characterizes of sensory experience if one accept the most recent estimates  $m(u) = 2$  MeV and  $m(d) = 5$  MeV for the quark masses [C2]. 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 [J76] ). Hence quarks could be the most interesting particles as far as qualia are considered and the first working hypothesis would be that the fundamental quantum number increments correspond to those for quark-anti-quark pair. The identification in terms of quantum numbers of single quark is inconsistent with the model of color qualia.
3. The model of DNA as topological quantum computer led to the proposal that DNA nucleotides are connected to the lipids of the cell membrane by magnetic flux tubes having quark and antiquark at its ends such that the  $u$  and  $d$  quarks and their antiquarks code for the four nucleotides. The outer lipid layer was also assumed to be connected by flux tubes to the nucleotide in some other cell or in cell itself.
4. The model for DNA as topological quantum computer did not completely specify whether the flux tubes are ordinary flux tubes or wormhole flux tubes with possibly opposite signs of energy assigned with the members of the flux tube pair. Although it is not necessary, one could assume that the quantum numbers of the two parallel flux tubes cancel each other so that wormhole flux tube would be characterized by quantum numbers of quark pairs at its ends. It is not even necessary to assume that the net quantum numbers of the flux tubes vanish. Color confinement however suggests that the color quantum at the opposite ends of the flux tube are of opposite sign.
  - (a) The absence of a flux tube between lipid layers was interpreted as an isolation from external world during the topological quantum computation. The emergence of the

flux tube connection means halting of topological quantum computation. The flux tube connection with the external world corresponds to sensory perception at the level of DNA nucleotide in consistency with the idea that DNA plays the role of the brain of cell [K94]. The total color quantum numbers at the ends of the flux tubes were assumed to sum up to zero. This means that the fusion of the flux tubes ending to the interior and exterior cell membrane to single one creates a flux tube state not localized inside cell and that the interior of cell carries net quantum numbers. The attractive interpretation is that this process represents the generation of quale of single nucleotide.

- (b) The formation of the flux tube connection between lipid layers would involve the transformation of both quark-antiquark pairs to an intermediate state. There would be no kinematic constraints on the process nor to the mass scales of quarks. A possible mechanism for the separation of the two quark-antiquark pairs associated with the lipids from the system is double reconnection of flux tubes which leads to a situation in which the quark-antiquark pairs associated with the lipid layers are connected by short flux loops and separated to a disjoint state and there is a long wormhole flux tube connecting the nucleotides possibly belonging to different cells.
  - (c) The state of two quark pairs need not have vanishing quantum numbers and one possibility is that the quantum numbers of this state code for qualia. If the total numbers of flux tubes are vanishing also the net quantum numbers of the resulting long flux tube connecting two different cells provide equivalent coding. A stronger condition is that this state has vanishing net quantum numbers and in this case the ends of the long flux tube would carry opposite quantum numbers. The end of flux tube at DNA nucleotide would characterize the quale.
5. Two identification of primary qualia are therefore possible.
    - (a) If the flux tubes have vanishing net quantum numbers, the primary sensory quale can be assigned to single receptor cell and the flow of the quantum numbers corresponds to the extension of the system with vanishing net quantum numbers in two-cell system.
    - (b) If the net quantum numbers of the flux tube need not vanish, the resulting two cell system carries non-vanishing quantum numbers as the pair of quark-antiquark pairs removes net quantum numbers out of the system.
  6. If the net quantum numbers for the flux tubes vanish always, the specialization of the sensory receptor membrane to produce a specific quale would correspond to an assignment of specific quantum numbers at the DNA ends of the wormhole flux tubes attached to the lipid layers of the cell membrane. The simplest possibility that one can imagine is that the outer lipid layer is connected to the conjugate DNA nucleotide inside same cell nucleus. This option would however assign vanishing net quantum number increments to the cell as whole and is therefore unacceptable.
  7. The formation of a temporary flux tube connection with another cell is necessary during the generation of quale and the question is what kind of cell is in question. The connection of the receptor to cells along the sensory pathway are expected to be present along the entire sensory pathway from DNA nucleotide to a nucleotide in the conjugate strand of second neuron to DNA nucleotide of the third neuron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.
  8. The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are

considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same qualia and at the level of neurons sensory maps assigning different qualia to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the CDs of electron and quarks.

1. Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore have long enough confinement length scales. The first possibility is provided by almost vacuum extremals with a long confinement scale also at the flux tubes. Large  $\hbar$  for the cell membrane space-time sheet seems to be unavoidable and suggests that color is free in much longer length scale than cell length scale.
2. Since the length of the flux tubes connecting DNA and cell membrane is roughly 1 micrometer and by a factor of order  $10^7$  longer than the  $d$  quark Compton length, it seems that the value of Planck constant must be of this order for the flux tubes. This however scales up the time scale of  $d$  quark CD by a factor of  $10^{14}$  to about  $10^4$  years! The millisecond and 160 ms time scales are much more attractive. This forces to ask what happens to the quark-anti-quark pairs at the ends of the tubes.
3. The only possibility seems to be that the reconnection process involves a phase transition in which the closed flux tube structure containing the two quark pairs assignable to the wormhole contacts at lipid layers is formed and leaks to the page of the Big Book with pages partially labeled by the values of Planck constant. This page would correspond to the standard value of Planck constant so that the corresponding  $d$  quark CDs would have a duration of millisecond. The reconnection leading to the ordinary situation would take place after millisecond time scale. The standard physics interpretation would be as a quantum fluctuation having this duration. This sequence of quark sub-CDs could define what might be called memetic codon representation of the nerve pulse sequence.
4. One can also consider the possibility is that near vacuum extremals give rise to a copy of hadron physics for which the quarks associated with the flux tubes are light. The Gaussian Mersennes corresponding to  $k = 151, 157, 163, 167$  define excellent p-adic time scales for quarks and light variants of weak gauge bosons. Quark mass 5 MeV would with  $k = 120$  would be replaced with  $k = 163$  (167) one would have mass 1.77 eV (.44 eV). Small scaling of both masses gives 2 eV and .5 eV which correspond to basic metabolic quanta in TGD framework. For quark mass of 2 MeV with  $k = 123$   $k = 163$  (167) one would give masses .8 eV (.05 eV). The latter scale correspond to Josephson energy assignable with the membrane potential in the ordinary phase.

In this case a phase transition transforming almost vacuum extremal to ordinary one takes place. What this would mean that the vacuum extremal property would hold true below much shorter p-adic length scale. In zero energy ontology the scaling up of quark masses is in principle possible. This option looks however too artificial.

### 2.2.3 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.

1. All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into

$3 \times 15$  qualia with vanishing increments of color quantum numbers and  $6 \times 16$  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  $3 \times 7$  *resp.*  $6 \times 8$  combinations of colorless *resp.* colored qualia.

2. There is a huge number of various combinations of these fundamental qualia if one assumes that each nucleotide defines its own quale and fundamental qualia would be analogous to constant functions and more general qualia to general functions having values in the space with  $9 \times 16 - 1$  points. Only a very small fraction of all possible qualia could be realized in living matter unless the neurons in brain provide representations of body parts or of external world in terms of qualia assignable to lipid-nucleotide pairs. The passive DNA strand would be ideal in this respect.
3. The basic classification of qualia is as color qualia, electro-weak quale, and spin quale and products of these qualia. Also combinations of color qualia and electroweak and spin quale are possible and could define exotic sensory qualia perhaps not yet realized in the evolution. Synesthesia is usually explained in terms of sensory leakage between sensory pathways and this explanation makes sense also in TGD framework if there exists a feedback from the brain to the sensory organ. Synesthesia cannot however correspond to the product qualia: for “quantum synesthesia” cross association works in both directions and this distinguishes it from the ordinary synesthesia.
4. The idea about brain and genome as holograms encourages to ask whether neurons or equivalently DNA could correspond to sensory maps with individual lipids representing qualia combinations assignable to the points of the perceptive field. In this framework quantum synesthesia would correspond to the binding of qualia of single nucleotide (or lipid) of neuron cell membrane as a sensory representation of the external world. DNA is indeed a holographic representation of the body (gene expression of course restricts the representation to a part of organism). Perhaps it is this kind of representation also at the level of sensory experience so that all neurons could be little sensory copies of body parts as holographic quantum homunculi. In particular, in the associative areas of the cortex neurons would be quantum synesthetes experiencing the world in terms of composite qualia.
5. The number of flux tube connections generated by sensory input would code for the intensity of the quale. Josephson radiation would do the same at the level of communications to the magnetic body. Also the temporal pattern of the sequence of quale mental images matters. In the case of hearing this would code for the rhythmic aspects and pitch of the sound.

### 2.2.4 About Detailed Identification Of The Qualia

One can make also guesses about detailed correspondence between qualia and quantum number increments.

1. Visual colors would correspond to the increments of only color quantum numbers. Each biologically important ion would correspond to its own color increment in one-one correspondence with the three pairs of color-charged gluons and these would correspond to blue-yellow, red-green, and black white [K86]. Black-white vision would mean a restriction to the  $SU(2)$  subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide a manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.
2. Also tastes and odours define qualia with “colors”. Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give  $c 3 \times 4$  basic combinations are possible and can certainly explain

the 5 or 6 basic tastes (counted as the number of different receptors). Whether there is a finite number of odours or not has been a subject of a continual debate and it might be that odours already correspond to a distribution of primary qualia for the receptor cell. That odours are coded by nerve pulse patterns for a group of neurons [J128] would conform with this picture.

3. Hearing seems to represent a rather colorless quale so that electroweak isospin suggests again itself. If we had a need to hear transversely polarized sound also spin would be involved. Cilia are involved also with hair cells acting as sensory receptors in the auditory system and vestibular system. In the case of hearing the receptor itself does not fire but induces a firing of the higher level neuron. The temporal pattern of qualia mental images could define the pitch of the sound whereas the intensity would correspond to the number of flux tube connections generated.

The modulation of Josephson frequencies -rather than Josephson frequencies as such- would code for the pitch and the total intensity of the Josephson radiation for the intensity of the sound and in fact any quale. Pitch represents non-local information and the qualia sub-selves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggest that right and left brain have different kind of specializations already at the level of sensory receptors.

4. Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nociceptors, mechanoreceptors, thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

### 2.2.5 Recent TGD based view about qualia

The TGD inspired theory of qualia [K44] has evolved gradually and the recent view differs from the above described picture in some aspects.

1. The original vision was that qualia and other aspects of consciousness experience are determined by the change of quantum state in the reduction: the increments of quantum numbers would determine qualia. I had not yet realized that repeated state function reduction (Zeno effect) realized in ZEO is central for consciousness. The objection was that qualia change randomly from reduction to reduction.
2. Later I ended up with the vision that the rates for the changes of quantum numbers would determine qualia: this idea was realized in terms of sensory capacitor model in which qualia would correspond to kind of generalized di-electric breakdown feeding to subsystem responsible for quale quantum numbers characterizing the quale. The Occamistic objection is that the model brings in an additional element not present in quantum measurement theory.
3. The view that emerged while writing the critics of IIT of Tononi 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 [K61] is wrong as such since the rate for the transfer of the quantum numbers

would not define the quale. A possible modification of the model simple: the analog of dielectric breakdown generates Bose-Einstein condensate and the quantum numbers for the BE condensate give rise to qualia assignable to sub-self.

## 2.3 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. 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 [K86].

### 2.3.1 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.

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [I50] 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 [L9], [L9] and the vision has been that it is sensible to speak about two basic configurations.
  - (a) Almost vacuum extremals (homologically trivial geodesic sphere).
  - (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge  $Z^0$  component (homologically non-trivial geodesic sphere).

The latter space-time surfaces are excellent candidates for configurations identifiable as TGD counterparts of standard electroweak physics. Note however that the charged part of electroweak fields is present for them.

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.
  - (a) The action of color rotations in the holonomy algebra of  $CP_2$  is non-trivial and corresponds to the action in  $U(2)$  sub-group of  $SU(3)$  mapped to  $SU(2)_L \times U(1)$ . Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local  $U(1)$  sub-group local with respect to  $CP_2$  point.
  - (b) Kähler form remains certainly invariant under color group and the right handed part of  $Z^0$  field reducing to  $U(1)_R$  sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local  $U(1)_L$  gauge rotation acting on the neutral left handed part of  $Z^0$  in the same manner as it acts on the right handed part. This is true if the  $U(1)_L$  sub-group does not depend on point of  $CP_2$  and corresponds to  $Z^0$  charge. If only  $Z^0$  part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If  $Z^0$  part vanishes and non-vacuum extremal is in question, then color rotation rotation of  $W$  components mixing them but acts as a pure  $U(1)$  gauge transformation on the left handed component.
  - (c) It might not be without importance that for any partonic 2-surface induced electro-weak gauge fields have always  $U(1)$  holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.
4. The unavoidable presence of long range  $Z^0$  fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to  $T_p = 1/2$ , the mass scale would be multiplied by a factor  $\sqrt{M_{89}}$  and Compton lengths of weak bosons would be around  $10^{-4}$  meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.
5. From the equations for classical induced gauge fields in terms of Kähler form and classical  $Z^0$  field [L9], [L9]



$$\gamma = 3J - \frac{p}{2}Z^0, \quad Q_Z = I_L^3 - pQ_{em}, \quad p = \sin^2(\theta_W) \quad (2.3.1)$$

it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for  $p = 0$  so that only the left-handed couplings to the weak gauge bosons remain. The absence of electroweak symmetry breaking and vanishing or at least smallness of  $p$  would make sense below the Compton length of dark weak bosons. If this picture makes sense it has also implications for astrophysics and cosmology since small deformations of vacuum extremals are assumed to define the interesting extremals. Dark matter hierarchy might explain the presence of unavoidable long ranged  $Z^0$  fields as being due to dark matter with arbitrarily large values of Planck constant so that various elementary particle Compton lengths are very long.

6. The simplest option is that the dark matter -say quarks with Compton lengths of order cell size and Planck constant of order  $10^7 \hbar_0$  - are responsible for dark weak fields making almost vacuum extremal property possible. The condition that Josephson photons correspond to EEG frequencies implies  $\hbar \sim 10^{13} \hbar_0$  and would mean the scaling of intermediate gauge boson Compton length to that corresponding to the size scale of a larger neuron. The quarks involved with DNA as topological quantum computer model could be in question and membrane potential might be assignable to the magnetic flux tubes. The ordinary ionic currents through cell membrane -having no coupling to classical  $Z^0$  fields and not acting as its source- would be accompanied by compensating currents of dark fermions taking care that the almost vacuum extremal property is preserved. The outcome would be large parity breaking effects in cell scale from the left handed couplings of dark quarks and leptons to the classical  $Z^0$  field. The flow of  $\text{Na}^+$  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 to 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 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

$$f_\nu = \frac{m_e}{m_\nu} \frac{1}{2\sin^2(\theta_W)} f_e.$$

From  $f_e \simeq .57 \times \text{MHz}$  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 conclude that the value of Weinberg angle in the phase near vacuum extremal must be  $p = .0295$  if one wants to reproduce 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

$$E = \sqrt{g_Z Q_Z B_Z 2\pi} \simeq .48 \text{ eV}$$

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.

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

$$E = \sqrt{n} r^{1/2} \sqrt{g_Z Q_Z B_Z 2\pi} \simeq r^{1/2} \times .48 \text{ eV} , \quad r = \sqrt{\hbar/\hbar_0} .$$

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 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 expectation 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 [J14] 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  $\hbar$ .

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.
2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical  $Z^0$  field whereas the coupling to classical em field vanishes. Both  $K_+$ ,  $Na_+$ , and  $Cl_-$   $A - Z = Z + 1$  so that by p-n pairing inside nucleus they have the weak isospin of neutron (opposite to that of neutrino) whereas  $Ca_{++}$  nucleus has a vanishing weak isospin. This might relate to the very special role of  $Ca_{++}$  ions in biology. For instance,  $Ca_{++}$  defines an action potential lasting a time of order .1 seconds whereas  $Na_+$  defines a pulse lasting for about 1 millisecond [J3]. These time scales might relate to the time scales of CDs associated with quarks and electron.
3. The basic question is whether only nuclei couple to the classical  $Z^0$  field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from  $Z^0$  coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical  $Z^0$  field, one ends up with difficulties with atomic physics. If only quarks couple to the  $Z^0$  field and one has  $Z^0 = -2\gamma/p$  for vacuum extremals, and one uses average vectorial coupling  $\langle I_L^3 \rangle = \pm 1/4$  with + for proton and - for neutron, the resulting vector coupling is following

| $E(Ion)/eV$ | $V = -40 \text{ mV}$ | $V = -60 \text{ mV}$ | $V = -70 \text{ mV}$ |
|-------------|----------------------|----------------------|----------------------|
| $Na^+$      | 1.01                 | 1.51                 | 1.76                 |
| $Cl^-$      | 1.40                 | 2.11                 | 2.46                 |
| $K^+$       | 1.64                 | 2.47                 | 2.88                 |
| $Ca^{++}$   | 1.68                 | 2.52                 | 2.94                 |

**Table 2.1:** Values of the Josephson energy of cell membrane for some values of the membrane voltage for  $p = .23$ . The value  $V = -40 \text{ mV}$  corresponds to the resting potential for photoreceptors and  $V = -70 \text{ mV}$  to the resting state of a typical neuron.

$$\begin{aligned}
 \left(\frac{Z-N}{4} - pZ\right)Z^0 + q_{em}\gamma &= Q_{eff}\gamma, \\
 Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em}.
 \end{aligned}
 \tag{2.3.2}$$

Here  $\gamma$  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 2.1** below gives the values of Josephson energies for some values of resting potential for  $p = .23$ . Rather remarkably, they are in IR or visible range. This is basically due to the large value of weak isospin for nuclei.

### 2.3.2 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 [L115, J14]. 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  $\lambda$ , which is largest for smallest  $\lambda$ . Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

From **Table 2.1** it is clear that the energies of Josephson photons are in visible range for reasonable values of membrane voltages, which raises the question whether Josephson currents of nuclei in the classical em and  $Z^0$  fields of the cell membrane could relate to vision.

Consider first the construction of the model.

1.  $Na^+$  and  $Ca^{++}$  currents are known to present during the activation of the photoreceptors.  $Na^+$  current defines the so called dark current [J14] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also  $K^+$  current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.

2. One ends up with the model in the following manner. For  $Ca^{++}$  the Josephson frequency does not depend on  $p$  and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to  $V = .055$  V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of  $p = .0295$ .

The predictions of the model come as follows summarized also by the **Table 2.2**.

1. The resting potential for photoreceptors is  $V = -40$  mV [J17]. In this case all Josephson energies are below the range of visible frequencies for  $p = .23$ . Also for maximal hyper-polarization  $Na^+$  Josephson energy is below the visible range for this value of Weinberg angle.
2. For  $V = -40$  mV and  $p = .0295$  required by the model the energies of  $Cl^-$  and  $K^+$  Josephson photons correspond to red light. 2 eV for  $Cl^-$  corresponds to a basic metabolic quantum. For  $Na^+$  and  $Ca^{++}$  the wave length is below the visible range.  $Na^+$  Josephson energy is below visible range. This 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  $Na^+$ ,  $Ca^{++}$ , and  $K^+$  correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also  $Cl^-$  is in the blue region.  $Ca^{++}$  Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to  $V = -59$  mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ( $V \simeq -55$  mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of  $\hbar$  the frequency scales is that of EEG).
4. In a very bright illumination the hyper-polarization is  $V = -65$  mV [J17], 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.

1. The maximum value of the action potential is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.
2. For neurons the value of the resting potential is -70 mV.  $Na^+$  and  $Ca^{++}$  Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that  $Ca^{++}$  Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.
3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case  $Ca^{++}$  Josephson frequency corresponds to 4 eV metabolic energy quantum as **Table 2.1** shows.

| Ion                                | $Na^+$    | $Cl^-$    | $K^+$     | $Ca^{++}$ |
|------------------------------------|-----------|-----------|-----------|-----------|
| $E_J(.04 \text{ mV}, p = .23)/eV$  | 1.01      | 1.40      | 1.51      | 1.76      |
| $E_J(.065 \text{ V}, p = .23)/eV$  | 1.64      | 2.29      | 2.69      | 2.73      |
| $E_J(40 \text{ mV}, p = .0295)/eV$ | 1.60      | 2.00      | 2.23      | 1.68      |
| $E_J(50 \text{ mV}, p = .0295)/eV$ | 2.00      | 2.49      | 2.79      | 2.10      |
| $E_J(55 \text{ mV}, p = .0295)/eV$ | 2.20      | 2.74      | 3.07      | 2.31      |
| $E_J(65 \text{ mV}, p = .0295)/eV$ | 2.60      | 3.25      | 3.64      | 2.73      |
| $E_J(70 \text{ mV}, p = .0295)/eV$ | 2.80      | 3.50      | 3.92      | 2.94      |
| $E_J(75 \text{ mV}, p = .0295)/eV$ | 3.00      | 3.75      | 4.20      | 3.15      |
| $E_J(80 \text{ mV}, p = .0295)/eV$ | 3.20      | 4.00      | 4.48      | 3.36      |
| $E_J(90 \text{ mV}, p = .0295)/eV$ | 3.60      | 4.50      | 5.04      | 3.78      |
| $E_J(95 \text{ mV}, p = .0295)/eV$ | 3.80      | 4.75      | 5.32      | 3.99      |
| Color                              | R         | G         | B         | W         |
| $E_{max}$                          | 2.19      | 2.32      | 3.06      | 2.49      |
| energy-interval/eV                 | 1.77-2.48 | 1.97-2.76 | 2.48-3.10 |           |

**Table 2.2:** 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.

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.

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

$Na^+ \leftrightarrow 2.19 \text{ eV (R) and } eV = 86.8 \text{ eV},$

$Cl^- \leftrightarrow 2.32 \text{ eV (G) and } eV = 65.8 \text{ eV},$

$K^+ \leftrightarrow 2.49 \text{ eV (W) and } eV = 60.2 \text{ eV},$

$Ca^{++} \leftrightarrow 3.06 \text{ eV (B) and } eV = 67.3 \text{ meV}.$

For  $Na^+$  the value of the membrane potential is suspiciously large.

It is interesting to look what happens when the model is generalized so that Josephson energy includes the difference of cyclotron energies at the two sides of the cell membrane and Weinberg angle has its standard model value.

1. Consider first *near to vacuum extremals*. In the formula for cyclotron frequencies in the effective magnetic field the factor  $Z/A$  in the formula of is replaced with

$$\frac{\frac{N-Z}{2p} + 2Z + q_{em}}{A},$$

which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic  $Z^0$  fields. Cyclotron frequency would be almost particle independent so that cyclotron contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

The weak independence of the cyclotron frequency on particle properties does not conform with the idea that EEG bands correspond to bosonic ions or Cooper pairs of fermionic ions.

2. For *far from vacuum extremals* the proportionality of cyclotron energy to  $h_{eff}$  and  $B_{end}$  allows easy reproduction the energies for which photon absorption is maximal if one allows the cyclotron energies to differ at the two sides of the membrane for sensory receptors.

*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 [K65]. 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  $E_J = V_{rest}/2p = 2.086 \times V_{rest}$ .

## 2.4 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 [I9] (<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.

### 2.4.1 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 [L34].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is  $H_{1.5}O$ . The

layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [H2, H1].

2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.
3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by  $H_{1.5}O$ .
4. In the splitting of water producing Brown's gas [H2, 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...

### 2.4.2 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.

1. The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King's lectures charge separation is poorly understood.
2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of  $CP_2$ .
3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the  $H_{1.5}O$  blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K48, K65].
4. The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the dark proton sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiples of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J47].

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.

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of  $ZeV$ , where  $V$  is membrane potential about .06 V and  $Z = 2$  is the charge of electron Cooper pair. This gives  $E = .12$  eV.
2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function  $x^3/(e^x - 1)$ ,  $x = E/T$  given by  $e^{-x} + x/3 - 1 = 0$ . The maximum is given approximately by  $x = 3$  and thus  $E_{max} \simeq 3T$  (in units  $c = 1, k_B = 1$ ). At physiological temperature  $T = 310$  K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at  $E \simeq 5T$  corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.
3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

“Electric expansion” of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H2, H1].

- (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with  $f$  degrees of freedom for particle ( $f = 3$  if there are no other than translational degrees of freedom) is  $(T/T_0) = (V/V_0)^{-\gamma}$ ,  $\gamma = (f + 2)/f$ . This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.
- (c) The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

### 2.4.3 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.



1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (<http://tinyurl.com/y8ubjgnc>), which forms the basic element of both photosynthesis (<http://tinyurl.com/yauwzkho>) and cellular respiration (<http://tinyurl.com/ybeefxmb>), involves electron transport chain (<http://tinyurl.com/yat3m4vk>) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.
2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (<http://tinyurl.com/yd5ndcyk>) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.
3. ATP is generated also in glycolysis (<http://tinyurl.com/ybzgdgve>), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (<http://tinyurl.com/y8v7aq9s>)).
4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (<http://tinyurl.com/ybzgdgve>) the net reaction  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l) + \text{heat}$  takes place. The Gibbs free energy change is  $\Delta G = -2880$  kJ per mole of  $C_6H_{12}O_6$  and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce  $N = 38$  ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From  $\text{Joule} = 6.84 \times 10^{18}$  eV and  $\text{mol} = 6.02 \times 10^{23}$  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  $\mu$  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  $\mu_i$  at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

### 1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.
2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of  $h_{eff}$  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.

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system  $(\Psi_1, \Psi_2)$  obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 \quad ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_1 \quad .$$

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  $1/h_{eff}$ .

2. One can solve for  $R_2$  assuming  $\Phi_1 = eVt/\hbar_{eff}$ . This gives

$$R_2(t) = \sin(\Phi_0) + \frac{k_1}{\hbar_1} \sin\left(\frac{eVt}{\hbar_1}\right) \quad .$$

$R_2$  oscillates around  $\sin(\Phi_0)$  and the concentration difference is coded by  $\Phi_0$  taking the role of chemical potential as a phenomenological parameter.

3. The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = \sin(\phi_0) = \exp\left(\frac{ZeV(t)}{2T}\right) .$$

Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

### 2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential:  $ZeV \rightarrow ZeV + \mu_I$ . This would however require a concrete physical interpretation.

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy  $E_c = \hbar_{eff} ZeB_{end}/m$  of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to  $\hbar_{eff}$  and can be rather large as assumed in the model for the effects of ELF em fields on brain.
2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on  $\hbar_{eff}$  and  $B_{end}$ . The scales of ionic chemical potential and ion concentrations would also depend on value of  $\hbar_{eff}$ .
3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

The earlier proposal [K44] was that cell membrane can be in near vacuum extremal configuration in which classical  $Z^0$  field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weinberg angle. Second problem is that for proton the  $Z^0$  contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

4. The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency  $f_J$  is at resonance identical with the cyclotron frequency  $f_c(MB)$  at particular part of the flux tube of the magnetic body:  $(f_c(MB) = f_J)$ .  $f_c(MB)$  corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing  $\hbar_{eff} = n \times h$  to  $h$ .

In the modified model the sum  $f_c + f_{J,n}$  ( $f_{J,n} = E_J/n \times h$ ) of  $\hbar_{eff}$ -independent cyclotron frequency and Josephson frequency proportional to  $1/\hbar_{eff}$  equals to cyclotron frequency  $f_c(MB)$  at "personal" magnetic body varying slowly along the flux tube:  $f_c + f_{J,n} = f_c(MB)$ . If also the variation of  $f_J$  assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} .$$

If dark photons correspond to biophotons the energy of cyclotron photon is in visible and UV range one has  $nf_c = E_{bio}$  and

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} .$$

The prediction is scale invariant and same for all ions and also electron unless  $E_{bio}$  depends on ion. For  $eV = .05$  eV,  $Z = 1$ , and  $E_{bio} = 2$  eV ( $f \simeq 5 \times 10^{14}$  Hz) one has  $\Delta f/f \sim .1$  giving 10 per cent width for EEG bands assumed in the simpler model.

If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of  $h_{eff}$  so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing  $h_{eff}$  and  $B_{end}$  by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibrium 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 [K104] explaining anomalously large gravimagnetic effect claimed by Tajmar *et al* [E5, E10] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order  $10^{-4}$  and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional  $h_{eff}^2$  in TGD and if one uses  $h_{gr}$  for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

1. By Equivalence Principle  $h_{gr}$  has the general form  $h_{gr} = GMm/v_0$ , where  $M$  and  $m$  are the interacting masses and  $v_0$  is a parameter with dimensions of velocity. For 4 inner planets one has  $v_0/c \simeq 2^{-11}$ .
2. The notion of  $h_{gr}$  generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which  $h_{em} = Z_1 Z_2 e^2 / v_0$  is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.
3. Since the natural expansion parameter of perturbative expansion is the  $g^2/4\pi\hbar$ , one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

$h_{em}$  might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

1. EZ carries very large negative charge with positive charge outside the exclusion zone.
2. TGD interpretation is in terms of  $H_{1.5}O$  phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of  $h_{eff}$ . The proposal is that primitive life form is in question.
3. The pair formed by EZ and its complement could have large value of  $h_{eff} = h_{em} = Z^2 e^2 / v_0$ .
4. The velocity parameter  $v_0$  should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and  $v_0$  is the rotation velocity at the surface of Earth. The prediction for  $h_{eff}$  would be of order  $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$ .

5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large  $h_{em}$  or  $h_{gr}$  could be formed.

I have proposed that metabolic machinery generates large  $h_{eff}$  phase somehow.  $h_{eff} = h_{em}$  hypothesis allows to develop this hypothesis in more detail.

1. I have speculated earlier [K52] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity  $v_0$  of the shaft appears in the formula for  $h_{em}$ . Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge  $Z$  associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving  $h_{em} = 2e \times Z/v_0$ .
2. The value of  $v_0/c$  is expected to be of order  $10^{-14}$  from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for  $h_{em}$  could be same as for  $h_{gr}$  associated with Earth-particle system.

$h_{eff}(ATPsynthase) = h_{gr}(2e, Earth)$  would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K84].

#### Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.
2. There is very interesting article (see <http://tinyurl.com/ycdhd4fd>) [?]eorting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.
3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K48, K65] 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.

#### 2.4.4 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  $6.242 \times 10^{18}$  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 manganese 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 discovered 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/8xqsab>) consists of two distinct electrochemical cells (see <http://tinyurl.com/jq8ljmo>). Cell consists of electrode and electrolyte. The electrodes are called anode and cathode. By definition electron current along external wire flows to cathode 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 electrochemical 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 electrolytic 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 exceeds the energy needed for ionization and the situation becomes more stable.

5. This model could also allow to understand the effect of anesthetes [K82] [L45]. 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 anesthetic correlates with its solubility to the lipid membrane. This is the case if the presence of anesthetic 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 [K86]. 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.

## 2.5 Constraints On The Fermionic Realization Of Genetic Code From The Model For Color Qualia

The original model for DNA as topological quantum computer assigns to DNA nucleotides quarks at ends of flux tubes or quark pairs at the ends of wormhole flux tubes. This is only the realization that came first to my mind in TGD Universe where dark variants of quarks can define QCD like physics even in cellular length scales. One can actually imagine several realizations of the genetic code and the first realization is far from being the simplest one. It is enough to have four different particles or many-particle quantum states to build at least formally a map from A, T, C, G to four states. It is obvious that the number of possible formal realizations is limited only by the imagination of the theoretician. Additional conditions are required to fix the model.

### 2.5.1 Fermionic Representation

Consider first the fermionic representations in the general case without specifying what fermions are.

1. The original proposal was that DNA nucleotides correspond to flux tubes with quark  $q$  and antiquark  $\bar{q}$  at the ends of the parallel flux sheets extremely near to each other. Second options relies on wormhole magnetic flux tubes in which case quark pair  $q\bar{q}$  is at both ends. Quarks  $u, d$  and their antiquarks would code for A, T, C, G. The spin of quarks is not taken into account at all in this coding: why not restrict the consideration to single quark. The total quark charge at given end of flux tube pair vanishes and flux tube ends carry opposite quark charges.

The nice feature of this option is that one could understand the generation of color qualia in the model of sensory receptor in simple manner to be discussed below. Even if one accepts the arguments supporting the view that dark quarks in cell scale are natural outcome of the hierarchy of Planck constants, one could argue that the presence of both quarks and antiquarks does not conform with matter antimatter asymmetry (not that one can however identify the analog of matter antimatter asymmetry at DNA level).

2. Spin states for fermion pairs assigned with two parallel magnetic flux tubes with the magnetic field generated by spin provide much simpler representation for nucleotides. Similar fermion pair would reside at the second end of flux tube pair.
  - (a) It is essential that rotational symmetry is broken and reduces to rotational symmetry around the direction of flux tubes so that spin singlet and spin 0 state of triplet mix to form states for which each fermion is in spin eigenstate. The states must be antisymmetric under exchange of the protons and spin 1/0 states are antisymmetric/symmetric in spatial degrees of freedom (wave functions located to the ends of flux tubes). The states with definite spin for given flux tube are mixtures of  $s=1$  states with vanishing spin projection and  $s=0$  state.
  - (b) It is not quite clear whether one should treat fermion pairs as identical bosons with 3+1 spin states since in TGD framework one considers disjoint partonic 2-surfaces and the situation is not that of QFT in  $M^4$ . This interpretation would require totally symmetry of the states under permutations of bosonic states defined by the 3+1 spin states. Coding by spin requires that each nucleotide corresponds to a state with a well defined spin. In field theory language the state would be obtained by applying bosonic oscillator operators generating states of given spin localized to a given nucleotide position.
  - (c) The classical correlate for the permutations of coordinates of fermions has interpretation as braiding for the flux tubes of the flux tube pair. In the similar manner the permutation

of the flux tube pairs associated with nucleotides has interpretation as braiding of the 3-braids formed from flux tube pairs. Braiding therefore gives a representation of spin analogous to the well-known orientation entanglement relation invented by Dirac and providing geometric representation of spin  $1/2$  property.

### 2.5.2 Various Options For The Fermionic Representation Of A, T, C, G

Fermionic representations allows several options since fermion can be electron, u or d quark, or proton. Wormhole magnetic fields would not be needed in this case.

1. The problem of electron and proton options is that it does not allow realization of color qualia. There is also the well-known problem related to the stability of DNA caused by the phosphate charge of -2 units per nucleotide. Somehow this charge should be screened. In any case, the charge -2 should correspond to the electron pair at the DNA end of the flux tube for electron option. For proton option the charge would be screened completely. One could of course consider also the large  $\hbar$  color excitations of ordinary protons instead of quark at its nucleotide ends. This option would however require the modification of quark wave functions inside proton and this option will not be discussed here.
2. Quark option would give rise to both color and allow also to reduce the electronic charge of -2 units by  $4/3$  units to  $-2/3$  units in the case of u quark pair. This would help to stabilize DNA. In the case of d quarks the charge would increase to  $-10/3$  units and is not favored by stability argument. Flux tube pairs assigned to single nucleotide define diquarks with spin 1 or spin 0.
  - (a) Diquarks behave as identical bosons with  $3+1$  spin states and  $3 \times 3$  color states. The states with well defined symmetry properties in spin degrees of freedom have such properties in spatial degrees of freedom. This means that one obtains a superposition of flux tube pairs which are either braided or unbraided. Triplet/singlet state is symmetric/antisymmetric and total asymmetry could be guaranteed by assuming symmetry/antisymmetry in spatial degrees of freedom and antisymmetry/symmetry in color degrees of freedom. This would give anti-triplet/6-plet in color degrees of freedom. Spatial symmetry would favor antitriplet and diquark would behave like antiquark with respect to color. Let us assume antitriplet state for definiteness.
  - (b) DNA codon corresponds to three-di-quark state. This state must be totally symmetric under the exchange of bosons. One can have total symmetry in both spatial and color degrees of freedom or total antisymmetry/symmetry in spatial and total antisymmetry/symmetry in color degrees of freedom. The first option gives 10-dimensional color multiplet and the second one color singlet. Braiding is maximal and symmetric/antisymmetric in these cases. One can consider also mixed symmetries. In this case one has color octet which is antisymmetric with respect to the first nucleotide pair and symmetric with respect to first nucleotide pair and third nucleotide. The braiding of the first two nucleotides must be antisymmetric and the braiding of this pair with third nucleotide. The conclusion would be that color multiplets correspond to well defined braidings and one would therefore have directed connection with topological quantum computation. Color octet is especially interesting concerning the representation of color qualia.

The challenge of all these options (note that the representability of color selects quark option) is to find a good justification for why the assignment of A, T, C, G to quark states or spin states is unique dynamically. Stability argument is expected to help here.

### 2.5.3 Realization Of Color Qualia For Quark Option

Consider now how one could understand the generation of qualia for quark option.

1. The generation of qualia involves interaction with external world giving rise to a sensory percept. In the case of visual colors it should correspond to a measurement of quark color

and should give rise to eigenstages of color at the ends of flux tubes at DNA nucleotides for a nucleus or cell of photoreceptor. A modification of capacitor model is needed. Color polarization is still essential but now polarization in nucleus or cell scale is transformed in the generation of color quale to a polarization in longer length scale by the reconnection of flux tubes so that their ends attach to “external world”. The nucleus/cell becomes color and state function reduction selects well defined quantum numbers. It is natural to assume that the entanglement in other degrees of freedom after color measurement is negentropic.

2. Does the “external world” correspond to another cell or to the inner lipid layers of the cell membrane containing the nucleus. In the first case flux tubes would end to another cell. If the nuclei of receptor cells are integrate to a larger structure by magnetic flux sheets traversing through them one can also consider the possibility that the polarization in the scale of cell nucleus (recall that the nucleus has also double lipid layer) is transformed to a polarization in cell scale so that similar process in cell scale gives rise to qualia.
3. The entire receptor unit must have net color charge before the state function reduction. This requires that there are flux tubes connecting the receptor unit to a unit representing “external world” and having vanishing color charge. If second cell is the “external world” these flux tubes must go through the pair of lipid layers of both cell membrane and end up to the nucleus of cell in the environment. If external world correspond to the complement of nucleus inside cell the inner layers of cell membrane represents external world. Cell membrane indeed serves as sensory receptor in cell length scale. One can of course have sensory qualia in various length scales so that both options are probably correct and a kind of fractal hierarchy is very natural giving rise also to our qualia at some higher level. Living matter as conscious hologram metaphor suggests a fractal hierarchy of qualia.

After state function reduction reducing the entanglement the flux tubes split and the receptor becomes un-entangled with external world and has vanishing color charges. At the level of conscious experience this means that there can be only memory about the quale experience. The sensation of quale lasts with respect to subjective time as long as the negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) prevails. There is an obvious analogy with Orch-OR (see <http://tinyurl.com/y1fv6pp>) proposal of Hameroff and Penrose in which also conscious experience ends with state function reduction.

4. Consider now how the color qualia are generated.
  - (a) There must be two flux tube states. In the first state there are two flux tube beginning from cell nucleus A and ending to the inner lipid layer  $a_1$  and flux tube beginning from the outer lipid layer  $a_2$  and ending cell nucleus B. Both flux tubes have vanishing net color so that cells have vanishing net colors. This could be regarded as the resting state of the receptor. The lipids in layers  $a_1$  and  $a_2$  are connected by another short flux tube. Same for  $b_1$  and  $b_2$ .
  - (b) The second flux tube state corresponds to long flux tubes connecting the nuclei of cells A and B. The ends carry opposite color charges. In this case the net color of both A and B is non-vanishing. This state would be an outcome of a reconnection process in which the flux tubes from A to  $a_1$  and B to  $a_2$  re-connect with the short flux tube connecting lipid layers  $a_1$  and  $a_2$ .
  - (c) When these flux tubes carry opposite colors numbers at their ends, the cell possess net color charge and can represent color quale. Or rather, creation of this kind of flux tube connections would give rise to the color charging of the receptor cell with external world carrying opposite color charge.

One can argue that this mechanism is not quite in spirit with color capacitor model for sensory receptor. Polarization is still essential but now polarization in receptor scale is transformed to polarization in longer length scale by the reconnection of flux tubes. The analog of di-electric breakdown however still applies in the sense that its analog induces large polarization. Several mechanisms generating larger polarization are of course possible. One can ask how essential the

electromagnetic polarization of cell membrane is for the generation of qualia at cell level. Note also that biomolecules are quite generally polar molecules.

The unexpected prediction of the model is that braiding would correlate directly with qualia. This would mean also a connection between quantum computation and qualia. This condition emerges from Fermi/Bose-Einstein statistics correlating braiding with symmetric properties of color states and spin states. Quite generally, the correlation of braiding with the symmetries of wave functions as functions of points of braid end points would allow to have direct geometric correlate between induced entanglement and braiding as naïve intuitive expectations have suggested.

This model is not consistent with the naïve expectation that the quale is generated after state function reduction. Rather, the beginning of sensation of quale means beginning of negentropic entanglement and fusion with external world and state function usually associated with the quantum measurement would mean the end of the sensation and separation from the external world! Maybe one can say that state function reduction means that experience is replaced with a memory “I had the sensation of quale” ! Krishnamurti would certainly agree!

## 2.6 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 identifications 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 the predicted 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 [K19, K20] providing interpretation for the basic scales of cell in terms of the p-adic length scale hypothesis and Gaussian Mersennes.

### 2.6.1 Background

The model for nerve pulse is discussed in detail in [K86]. TGD inspired model for high  $T_c$  superconductivity involving dark electrons with large  $\hbar$  in an essential manner is a prerequisite for the model and is discussed in [K19, K20]. The basic philosophy behind the model discussed in detail in is following.

1. 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.
2. 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 generalization of EXG to a hierarchy of ZXGs, WXGs, and GXGs corresponding to  $Z^0$ ,  $W$  bosons and gluons.
3. Dark matter hierarchy and the associated hierarchy of Planck constants plays 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, the newest 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.
4. 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 [I45] 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.

### 2.6.2 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 ways for how this could happen. According to [J15] 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 [K86].

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. 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 1 kHz soliton sequence. The velocity of 1 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 1 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. 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 since 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.
4. New physics would enter in several ways [K11]. Ions should form Bose-Einstein cyclotron condensates. 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 [K65]. 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 dark scaled up variants of ordinary  $W^\pm$  bosons is a natural manner to achieve this if new nuclear physics is indeed present. A lot of unknown is involved but model builder assuming that dark matter is responsible for the special properties of living matter must tolerated this.

### 2.6.3 The Function Of Neural Transmitters

TGD leads to a general view about the functions of membrane oscillations, nerve pulse and neural transmitters. 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 are coded 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.

### 2.6.4 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 with size scale of 5 Angstrom ( $p \simeq 2^k$  labels space-time sheets for which electronic Compton scale  $L_e(k) = \sqrt{5}L(k)$  is given by  $L_e(k) = 2^{(151-k)/2}L_e(151)$ , where  $L_e(151) \simeq 10$  nm corresponds to cell membrane thickness) 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 (topological light rays) 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 [K74] becomes precisely defined.

The model of DNA as topological quantum computer [K4] 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. The entire sensory pathway from sensory receptor to brain would define linear representations of nerve pulse patterns and this might explain why the lengths of sensory pathways are maximized. 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.

## 2.7 Model For EEG

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 and color forces play a key role. Long range weak forces 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 far form vacuum extremals with large Planck constant classical  $Z^0$  fields are very weak and long range color forces strong. In this phase color forces 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. 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 extending over a wide frequency range beginning from visible photon frequencies 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. The fractal hierarchy of EEGs is described in two chapters of the book “TGD and EEG” [K33, K89].

### 2.7.1 Fractal Hierarchy Of EEGs

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

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 to the Josephson frequencies  $f_J$  associated with Josephson junctions assigned with cell membranes. If Josephson radiation modulates cyclotron radiation also the frequencies  $mf_J \pm nf_c$  appear in the spectrum.
2. In standard model  $f_J = ZeV/\hbar$  would be 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 [K65].

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 genome expression. This picture might be too naïve. 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. 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.

### 2.7.2 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 correspond 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 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.



### 2.7.3 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.

1. 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 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 competition 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 sense. 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 wave-length 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.

### 2.7.4 Evidence for the notion of magnetic body from brain synchrony without corpus callosum

I received a link to a rather baffling finding about brain [J105] (see <http://tinyurl.com/3gjhtgb>). Neuroscientists have believed that the two hemispheres communicate via the neural pathways associated with corpus callosum: kind of communication cables would be in question. Many areas of brain behave synchronously, which has led to the notion of resting state network.

The team led by Michael Tyszka, associate director of Caltech Brain Imaging Center, has however discovered that the resting state network seems to work normally in people born without corpus callosum! As if brain hemispheres were communicating by some other means than neural signalling! This finding challenges not only the views about the origin of brain synchrony as being created by neural circuits but also the models of autism and schizophrenia explaining them in terms of impaired communications between hemispheres.

One can for instance speculate with the possibility that there is electromagnetic communication between brain hemispheres. This does not look a bad idea at all: nowadays it is possible to extract information about EEG so that pilots are able to control the flight of tiny flying object by imagining what the object should do. Technological applications will probably appear in the market soon so that anyone can have robots controllable by thoughts.

This mechanism is consistent with the TGD inspired view about brain. This view however encourages to consider also a more imaginative explanation. In TGD Universe living system involves besides organism and environment also magnetic body (MB) acting as an intentional agent receiving sensory input from organism and controlling it. MB has hierarchical onion-like

structure. For instance, brain hemispheres have their own MBs, and entire brain its own MB serving as a "boss" for the MBs of hemispheres.

Communications between magnetic body and part of organism take place using dark photons having non-standard value  $h_{eff} = n \times h$  of Planck constant and thus energy  $E = h_{eff}f$ , which should correspond to ordinary photons with energies above thermal energy: otherwise quantal effects are masked by thermal fluctuations. Bio-photons in the visible and UV range could result in the transformation of dark photons to ordinary photons. The frequency range of dark photons depends on the level of the layer of MB characterized by  $h_{eff}$  and wavelength corresponds to the size scale of the layer.

In the case of brain the transfer of sensory information to MB would be realized as EEG - wavelength of 7.8 Hz radiation is order of the circumference of Earth so that MBs for brain would be really large. In Zero Energy Ontology (ZEO) control signals would be realized as negative energy signals propagating backwards in geometric time and having phase conjugate laser light as a counterpart in ordinary physics. This explains Libet's finding that neural activity precedes conscious decision. Coordination by using EEG rhythms would be part of control analogous to work songs.

The MB of entire brain controls it and could naturally do this via the intermediate control of brain hemispheres forcing them to operate in the same rhythm. Brain synchrony and resting network would not be produced by resonant neuro-circuits as usually believed but by the spatiotemporal coherence of the EEG radiation from the MB of entire brain forcing brain hemisphere MBs to oscillate in the same rhythm and in turning synchronizing the brain hemispheres. This would be like forcing soldiers to march in the same pace and brain hemispheres could co-operate without any neural communication between hemispheres. The communication between hemispheres would be needed for more refined collaboration involving "discussion" between hemispheres: hemispheres of a person without corpus callosum would be like soldiers obeying blindly the orders. This might be also an essential element of autism and schizophrenia.

### 2.7.5 Vision About Biological Evolution And Evolution Of Brain

The proposed model for EEG, the idea that Gaussian Mersennes (four electron Compton lengths associated with 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 increase of the largest Planck constant in the hierarchy of Planck constants associated with the organism would mean increase of the time scales of planned action and memory and therefore evolutionary leap. 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. Also cells and neurons could be classified according the their evolutionary level characterized by the largest Planck constant involved.

The evolution at our level of hierarchy would most naturally correspond to cultural evolution taking mainly place at the level of magnetic bodies responsible for higher levels of collective consciousness. This would explain why we differ so dramatically from our cousins although genomes are virtually identical. Evolution of quantum computer programs associated with DNA would be one aspect of this evolution.

### 2.7.6 Does Memory Code Exist?

Stuart Hameroff is one of the pioneers of the quantum conscious and quantum biology. Quite recently Hameroff and collaborators publishes a proposal for memory code based on microtubules. The simplest version would identify code words as 6 bit sequences just as in case of genetic code. The bit would be represented by the presence or absence of phosphate. TGD suggests a different interpretation in terms of flux tubes connecting microtubule surface with lipid layer and now the presence of ATP would mean that flux tube is in active state and gives rise to negentropic entanglement: see the article "A Proposal for Memory Code" (see <http://tinyurl.com/y9bh32tg>) [L20].

In an article in the March 8 issue of the journal PLoS Computational Biology, physicists Travis Craddock and Jack Tuszynski of the University of Alberta, and anesthesiologist Stuart Hameroff of the University of Arizona propose a mechanism for encoding synaptic memory in microtubules, major components of the structural cytoskeleton within neurons. The self-explanatory title of the article is “Cytoskeletal Signaling: Is Memory Encoded in Microtubule Lattices by CaMKII Phosphorylation?” (see <http://tinyurl.com/7dcgjwf>) [J111].

The basic ideas of the model of the model of memory code are following.

1. The hexagonal cylindrical lattice of microtubule suggests the possibility of lattice consisting of bits and probably very many proposals have been made. One such idea is that bit is represented in terms of the two basic conformations of tubulin molecules called  $\alpha$  and  $\beta$ . The recent proposal is that bit corresponds to the phosphorylation state of tubulin. Also a proposal that the bits form 6-bit bytes is considered: 64 different bytes are possible which would suggest a connection with the genetic code.
2. The motivation for the identification of byte is that CaMKII enzyme has in the active state insect like structure: 6 + 6 legs and the legs are either phosphorylated or not. This geometry is indeed very suggestive of connexion with 6 inputs and 6 outputs representing genetic codons representable as sequences of 6 bits. The geometry and electrostatics of CaMKII is complementary to the microtubular hexagonal lattice so that CaMKII could take care of the phosphorylation of microtubulins: 6 tubulins at most would be phosphorylated at one side. The presence of  $Ca^{+2}$  or calmodulin flux flowing to the neuron interior during nerve pulse is responsible for self-phosphorylation of CaMKII: one can say that CaMKII takes itself care that it remains permanently phosphorylated. I am not sure whether this stable phosphorylation means complete phosphorylation.

It is however difficult to imagine how  $Ca^{+2}$  and calmodulin flux could contain the information about the bit sequence and how this information could be coded in standard manner to phosphorylation pattern of legs. The only possibility which looks natural is that phosphorylation is a random process and only the fraction of phosphorylated legs depends on  $Ca^{+2}$  and calmodulin fluxes. Another possibility would be that the subsequent process of phosphorylation MT by completely phosphorylated CaMKII manages to do it selectively but it is very difficult to imagine how the information about codon could be transferred to the phosphorylation state of MT.

For these reasons my cautious conclusion is that phosphorylation/its absence cannot represent bit. What has been however found is a mechanism of phosphorylation of MTs, and the question is what could be the function of this phosphorylation. Could this phosphorylation be related to memory but in different manner? The 6+6 structure of CaMKII certainly suggests that the analog of genetic code based on 6 bits might be present but realized in some other manner. The presence of ATP would make a bit active and a rather natural expectation is that typically all bits are either in-active or active. This would give a direction connection with negentropic entanglement. The negative energy signal from future would naturally transform ATP to ADP and mean transfer of mental image made possible by negentropic entanglement to geometric now. The original mental image representing memory would be destroyed in accordance with no-cloning theorem.

## 2.8 Bio-Photons

MEs (massless extremals) can be carriers of light like vacuum currents generating coherent light. Bio-photons [I37, I72, I42] were the first proposed identification for this coherent light in living matter [K74]. In absence of material about bio-photons I did not develop these ideas in any quantitative detail. Situation has changed with the development of web and recently I learned from Lian Sidorov about home page containing online articles of Fritz-Albert Popp and colleagues about bio-photons and related phenomena. I am grateful for Lian also for very useful discussions and keen questions helping me to become and stay conscious about the many poorly understood aspects of the “great vision”. This homepage is recommended also to the reader and the data used below mostly derive from the articles therein [J74].

### 2.8.1 What Bio-Photons Are?

The web articles [J74] provide the basic facts about bio-photons and in the following I summarize my novice view about bio-photons.

Bio-photons have frequencies in the range 200-800 nm (at least). The intensity of bio-photons is extremely low: from one photon to few hundred photons/ $cm^2s$ , which is 20 orders of magnitude weaker than common fluorescence of photophosphorence. There is evidence for coherent radiation also at longer wave length scales. A far from thermal equilibrium situation is in question: the intensity of photons is about  $10^{10}$  times higher than that associated with the thermal visible photons at body temperature. The spectral density  $f(\nu)$  defined as the counterpart of Boltzmann weight is essentially constant. This means that the effective temperature increases linearly with frequency. The experimental work of Popp and colleagues provides support for the view that bio-photons are indeed coherent light rather than some waste radiation resulting as a by-product of biological processes [J74]. Poisson statistics for the number of photons in coherent state ( $p_n = \exp(-\alpha)\alpha^n/n!$ ) is the basic signature for the coherent light and it is found that photon counts obey this distribution.

Since  $\tau \sim 1$  nanoseconds is the characteristic time constant for em emissions and absorptions at visible wave lengths, one can argue that the length scale  $L = c\tau \sim 10$  cm defines the length scale below which it is not sensible to speak about localized photon and thus bio-systems must be treated as macroscopic quantum systems as far as coherent photons are considered. The timescale means also that  $10^9$  reactions per second can in principle catalyzed by absorption and emission of single photon in single cell: the typical number of reactions is  $10^5$  per second inside single cell [J74]. If bio-photons Bose-Einstein condense at magnetic mirrors (ME-magnetic flux tube pairs), extremely sharp control of biological reactions could be indeed achieved. Of course, if Bose-Einstein condensed bio-photons are most important for bio-control, one cannot exclude the interpretation of the observed bio-photons as some kind of leakage radiation from living matter (of course, these bio-photons might serve communication purposes).

Even the wave length of the visible photons, which is somewhat below the cell size, implies that molecules see classical em field like boat sees the sea. One could argue that photons as  $CP_2$  type extremals are essentially point-like. One the other hand, if MEs are classical correlates for photons or if the classical interaction of atoms and molecules with MEs is additional aspect of their interaction with em fields, this is not the case. The situation is not conceptually completely clear in this respect.

Interference effects provide also support for the notion of macroscopic coherent states. Popp proposes that in a healthy organism constructive interference tends to occur inside cells for bio-photons whereas destructive interference takes place outside [I71, I42]. Or stating it differently, cells are able to store visible bio-photons inside them. For healthy cells the bio-photon emission and well as delayed luminescence have been found to increase as a function of cell density up to some critical density and to decrease after that. For cancer cells the intensity increases indefinitely and nonlinearly [I71]. This supports the view that in cancer cell population bio-photons leak out and do not properly participate to the bio-control.

Bio-photon emission is a signature of living matter in the sense that the presence of oxidative process accompanies always the emission. This is true also for the delayed luminescence resulting as a delayed response to electromagnetic or some other perturbation. The dependence of the delayed luminescence on temperature suggests that the activation energy for the process controlling photoluminescence is roughly .53 eV [I82]: this is rather near to the energy .49 eV stored in the ATP molecule. The experiments involving the insertion of inert molecules to DNA indicate that DNA is a source of bio-photons [I39], [J74]. The spectrum of bio-photons and delayed luminescence correlates strongly with various biological processes. For this reason bio-photons have several applications to bio-search, food quality control, cancer research, pharmacology and heal prophylaxis.

### 2.8.2 Some Phenomena Related To Bio-Photons

There are several interesting and theoretically challenging phenomena involving bio-photons.

1. Delayed luminescence [I81, I66] results after an exposure to an external perturbation, which can be light or ultrasound. Delayed luminescence accompanies also biological processes like cell mitosis. The intensity of the coherent light varies from few photons to  $10^5$  photons/ $cm^2s$ .

The characteristic feature of the delayed luminescence is hyperbolic ( $I(t) \propto 1/(1 + \lambda t)$ ) decay instead of the exponential one expected if incoming light just scatters from the system. The intensity involves oscillatory modulations with respect to a variable  $u$  which depends logarithmically on time coordinate ( $u = \log(1 + \lambda t)$ ). As a function of cell density delayed luminescence increases up to some critical cell density for a healthy cell population and begins to decrease after that. For cancer cell population there is no such critical cell density.

2. Some animal populations can “see” each other. For instance, when populations of dinoflagellates become to optical contact they begin to flicker synchronously [I82] (also fireflies in mangrove trees in Thailand flicker in a synchronous manner). In TGD framework this could be interpreted as evidence for magnetic mirror bridges connecting the populations such that the MEs associated with visible light propagate along them from population to another one. The bridges could also contain ELF em waves serves as synchronizers in the time scale in which flickering occurs.
3. Bacteria absorb bio-photons from nutrition media in a way that the absorption is highest for some critical cell density [I71]. Female inbred daphnia in the same developmental stage and about the same size do not display the increasing bio-photon emission with increasing number [I71]. Rather, a typical interference pattern of emission is observed showing maxima and minima of the bio-photon intensity at definite average distances between the animals. This could be seen as evidence for the hypothesis that the pattern of coherent light from DNA serves as kind of hologram representing 4-D template for the self-organization.

### 2.8.3 General TGD Based Model For Coherent Bio-Photons

MEs with light like vacuum currents indeed generate coherent photons so that bio-photons indeed have a place in TGD Universe. ATP energy about .49 eV and near to the rough estimate .53 eV for the activation energy deduced by studying the temperature dependence of the delayed luminescence [I82]. This encourages to think that the MEs are closely related with the process transforming ADP to ATP serving as energy batteries (see [K51] for the TGD based model of ATP). This assumption conforms also with the fact that coherent light is associated with the oxidative process.

#### Bio-photons and MEs

The empirical data are consistent with the assumption that the MEs are associated with DNA (at least) and are perhaps responsible for the electromagnetic expression of the genetic information below cellular length scales (and corresponding scaled up dark length scales since there is no reason to exclude the dark variants of MEs).

MEs can carry Bose-Einstein condensates of parallel photons and the observed coherent photons represent leakage of the coherent light from cells. Both positive and negative energy MEs are possible and most naturally they are created in a pairwise manner: pairs (which do not form bound states) with a vanishing net energy and momenta are especially interesting since classical conservation laws do not pose any constraints on their creation and annihilation by p-adic-to-real transition. The buy now-pay later energy production by feeding negative energy to the environment might be closely related with the generation of pairs of MEs which vanishing net energy. It must be emphasized that also magnetic mirrors with positive and negative energies might be in question.

#### Bio-photons as a signature of dark matter hierarchy

Dark matter hierarchy allows perhaps the most plausible interpretation of bio-photons and is also in spirit with the general ideas about quantum holograms. The model of EEG (actually hierarchy of them) based on dark matter hierarchy [K33] assumes that the basic structures assignable to cell have fractal scaled up variants at higher levels of dark matter hierarchy. These higher level structures could generate dark photons with energies in the range corresponding to visible photons.

At the  $k_d^{th}$  level of the hierarchy predicted by Mersenne hypothesis the wavelength of photon is scaled up by a factor  $2^{k_d}$  with possible values of  $k_d$  fixed by the Mersenne hypothesis [K33] so that communications using “visible dark” light become possible in arbitrarily long length scales.

The model for cell membrane as a sensory receptor leads to the identification of these photons in terms of dark Josephson radiation and EEG and bio-photons have identification in terms of decay products of dark Josephson photons.

MEs would have lengths of order wave length (which are below cell size for visible light), and there would be a constant distribution of MEs with respect to the direction and length of ME in the scaled up length scale interval corresponding to wavelengths of visible light. The scaled up wavelengths would correspond to the distances between source and receiver of bio-photons and  $k_d \equiv 0$  would correspond to intracellular bio-photons assignable to MEs connecting sub-cellular structures having distance distribution which is more or less constant. The higher level contributions would tend to smooth out the wavelength distribution even if this is not strictly the case.

The general vision about quantum control of motor actions and sensory representations is consistent with the interpretation of positive energy MEs as space-time correlates for the emission of photons responsible for communications and negative energy MEs as correlates for phase conjugate photons involved with generalized motor control. In this framework bio-photons could result from the de-coherence of  $k_d > 0$  dark photons and also as a leakage of  $k_d = 0$  photons from cell interior. The synchronous flickering of dinoflagellates suggests  $k_d > 0$  bio-photons are indeed present.

### About the anatomy of dark MEs

MEs at the  $k_d^{th}$  level of dark matter hierarchy correspond to  $r = 2^{k_d}$ -fold covering of  $M^4$ , which are analogs of multi-sheeted Riemann surfaces (note that the meaning of “sheet” in this context is different from that in the context of many-sheeted space-time). Each sheet of the covering corresponds to scaled up variant of the space-time sheet associated with ordinary photon with  $r$ -fold size scale and classical energy  $E/r$ . This allows to interpret the formula  $E = \hbar(k)f = r\hbar_0 f$  at space-time level.

$r$ -fold MEs could be generated by  $r$ -sheeted magnetic flux sheets containing Bose-Einstein condensates of bosonic ions in quantum coherent manner such that each sheet is responsible for one sheet of  $r$ -fold ME.

The decay to ordinary photons can occur in two ways.

1. In de-coherence a downwards scaling of the structure by a factor  $1/r$  and collapse to a single sheeted structure with energy  $E$  representing ordinary photon occurs. Since frequency is replaced with  $rf$  and  $\hbar$  by  $\hbar_0$ , energy does not change.
2. The multi-sheeted structure could also decay to  $r$  single sheeted structures with energy  $E/r$ .

### Constraint to the intensity of the vacuum current

The decomposition of dark MEs to  $r$  ordinary MEs cannot correspond to the generation of coherent photons by vacuum current since the frequencies involved would be much lower than the frequencies  $\sim 10^{14}$  Hz associated with the visible light. Thus one can restrict the consideration to  $k_d = 0$  case. This process might however also occur as the experimental findings of Gariaev [I30] about laser light induced radio-wave emission to be discussed in the next section indicate.

The source of photons at the second end of ME is responsible for the Bose-Einstein condensate of photons associated with ME. These photons are not observed unless some kind of leakage occurs at the receiving end of ME: suppose that this does not happen. Physical intuition suggests that the light-like vacuum currents associated with MEs generate coherent states of ordinary photons and that these photons leak out and give rise to the observed bio-photons. MEs lose their energy in the process and become eventually vacuum extremals.

These assumptions allow to deduce a constraint to the intensity of the vacuum current associated with ME.

The interaction Lagrangian of the vacuum current with the vector potential of the quantized photon field is given by

$$L_{int} = e \int d^4x j \cdot A \quad (2.8.1)$$

where the indices of the second quantized vector potential and vacuum current have been dropped away for simplicity and the units  $\hbar = c = 1$  are used and  $e$  denotes the electromagnetic coupling.

This interaction term describes an infinite number of harmonic oscillators coupled to an external oscillatory force. In each Fourier mode initial vacuum state is transformed to a coherent state which is an eigenstate of the corresponding annihilation operator. By standard calculations [B12] one can deduce the expression for the effective classical vector potential defined by the eigenvalues of the annihilation operators is given by

$$\begin{aligned} A(x, t) &= \frac{ie}{(2\pi)^3} \int d^3k \frac{1}{2\omega(k)} \exp[-ik \cdot x - i\omega(k)t] j(k, \omega(k)) , \\ \omega(k) &= |k| . \end{aligned} \quad (2.8.2)$$

The eigenvalues  $\alpha(\epsilon, k)$  for the annihilation operator  $a(\epsilon, k)$  associated with polarization  $\epsilon$  is given by the expression

$$\alpha(\epsilon, k) = \frac{ie}{2(2\pi)^3 \omega(k)} \epsilon \cdot j(k, \omega(k)) . \quad (2.8.3)$$

$\alpha(k)$  indeed has the dimension length to  $3/2$  as it should be on basis of the commutation relations in the continuous momentum basis. If finite quantization volume with a discrete momentum basis is used,  $\alpha(k)$  contains additional  $1/\sqrt{V}$  factor guaranteeing that the eigenvalues are dimensionless.

The eigenvalues characterizing the coherent states are proportional to the massless Fourier components of the vacuum current so that the intensities of bio-photons determining the values of the parameters  $\alpha(k)$  allow to deduce the on mass shell Fourier components of the light like vacuum current. Of course, the coherent field of photons is superposition of several interfering contributions coming from MEs with light like currents and only the sum of these contributions appears in the detected field.

### Sucking force in TGD framework

The mechanism by which sun flowers turn towards Sun as well as the attraction between cells are not very well well-understood processes. Popp and Chang introduce as an explanation an interaction which they call sucking force [I71]. The notion is inspired by the assumed analogy with the vacuum cleaner which is a particular kind of a pump. The pressure gradient along the tube of the vacuum cleaner generates airflow towards the tube. Since pumping is always done when dissipative processes are present, a process involving essentially the dynamics of quantum jumps is in question and the force does not have counterpart at the level of the irreversible classical dynamics.

In case of em fields radiation pressure gradient replaces the ordinary pressure gradient. The counterpart of the tube of vacuum cleaner is naturally a ME along which Bose-Einstein condensed photons propagate and are absorbed at the second end of the tube, most naturally cell in case of visible photons. The pumping implies an attractive force between living systems connected by MEs. This force would be present at all levels of the length scale hierarchy. The force is only between systems having common characteristic frequencies so that they can be connected by MEs. For instance, this force could explain why tRNA carrying amino-acids finds the corresponding mRNA in the translation of DNA to proteins.

The sucked MEs can propagate along larger ME serving as an em bridge to the receiving system and the absorption most naturally corresponds to the annihilation with MEs of opposite energy. Both negative and positive energy MEs can be sucked. The sucking of negative energy MEs makes possible very flexible buy now-pay later type energy consumption: the user (say DNA) generates pairs of positive and negative energy MEs and utilizes the positive energy MEs, whereas the negative energy MEs are received by the payer, most naturally mitochondria where they annihilate with the positive energy MEs produced by ATP process.

### 2.8.4 The Interpretation Of Bio-Photons And EEG's Decay Products Of Dark Josephson Radiation

The foregoing considerations have been classical in the sense that MEs have been taken as a model for bio-photons. The model of EEG [K33] leads to the prediction that cell membranes act as Josephson junctions generating Josephson radiation. If the cell membrane is assumed to be almost vacuum extremal which brings in classical  $Z^0$  field proportional to em field and raises the energy scale of Josephson junction from 0.07 eV for neuron to UV range. The electromagnetic charge of ion must be replaced with effective charge which is non-vanishing also for neutral atoms and molecules.

The energies of dark photons involved are in visible and UV range for most ions in the range of resting potentials just as the energies of bio-photons. The model also predicts correctly the peak frequencies of maximal sensitivity for the four kinds of photoreceptors. The frequencies are inversely proportional to the value of Planck constant characterizing the cell membrane. Quite generally, the value of Planck constant characterizes the evolutionary level of neuron.

Both EEG photons and bio-photons can be identified as decay products of dark Josephson photons producing either a bunch of EEG photons or single bio-photon. The frequency modulation of Josephson frequencies provides a general coding of sensory percepts and other information in terms of Josephson radiation communicating this data to the magnetic body. This modulation could also explain the observed periodic modulations.

## 2.9 Is it possible to reverse Alzheimer's disease?

Dale Bredesen has written a marvellous book titled "*The End of Alzheimer's*" [J52] (see <http://tinyurl.com/ya8nkan9>) - thanks for my friend Pertti for an excellent Christmas gift.

Alzheimer's disease (just AD in the sequel) has been regarded as a disease without any effective treatment. A lot of progress has however occurred during last years in the understanding of AD and related diseases causing neuro-degeneration. Bredesen's group has developed a programme to stop and even reverse the development of cognitive decline and dementia.

### 2.9.1 Programme for reversing AD

The first chapter of the book contains a long list about the symptoms of AD. One must be cautious while reading this list. A strongly introvert and unpractical person like me having suffered from strong social fears during childhood, youth and mid age might conclude having been AD patient for all his life. Our personality however means that we have our strengths and weaknesses. Only if we begin to lose our strengths, there is a good reason to get worried.

AD involves brain inflammation causing a generation of amyloid, a plaque that destroys synaptic connections crucial for various learned skills. This leads to the symptoms of AD. Amyloids were for long time thought to be the cause of AD but it turned out to be only a way how brain defends itself: in AD this defence has only developed to over reaction: somewhat like too strong immune response causing allergy.

In an attempt to cure AD one can do three things (in collaboration with a professional since AD has strongly patient dependent profile).

1. Get rid of the brain inflammation.
2. Eliminate the sources of inflammation: both infection by microbes and sugar containing proteins.
3. Provide brain with the needed nutrients including metabolic energy, hormones, and trophic factors helping the regeneration of synapses.

This program requires nothing less than changing of the life style.

### 2.9.2 AD as suicidal behavior at neuronal level

The motivation for this post emerged as I started to read a chapter about how the new view about AD developed through the study of AD in Petri dishes, a completely new lab level approach initiated by Bredesen's group. Two big surprises were in store.



1. It was found that in AD the neurons perform a suicide instead of fighting against the disease! They just give up! This was something totally unexpected.
2. The researchers had an idea that there are receptors in brain stem, which could relate to neuro-degeneration. The idea was that when the receptors bind to corresponding ligands, the neuron dies. It would be kind of organized suicide. But this did not occur! Neurons die if the ligand is not present! A healthy neuron must have both the ligands and receptors. These ligands can be christened as neurotrophins since they support the growth of cell.

### 2.9.3 Translating the findings about AD to the language of TGD

It is fascinating to translate the findings of Bredesen's group to the language of TGD. This might even provide new insights to what is involved.

#### Some basic notions of TGD inspired biology

While reading, I realized that this fits nicely with the TGD based vision that magnetic body (MB) of the organism (biological body (BB)) or part of it takes care of BB, such as brain by receiving information as signals from brain and sending back control commands. Before continuing it is good to briefly summarize some key aspects of TGD view about biology and brain. There are several new notions.

1. The notion of MB distinguishes between TGD and Maxwellian (gauge theory) view about fields. In many-sheeted space-time one can say that physical object has field identity, field body. Given for instance a magnetic flux tube realized as topological field quantum -tubular 3-surface - one can tell, which physical system it emanates from. The double formed by organism and its environment is replaced with a triple formed by MB, BB, and environment, and this changes profoundly the view about possible disorders of organism.
2. Hierarchy of Planck constants  $h_{eff}/h = n$  making possible macroscopic quantum coherence in various scales is a key element of TGD inspired quantum biology. This hierarchy emerges as a prediction of adelic physics suggested to provide a unification of ordinary physics and of physics of cognition by introducing besides real number based physics also various p-adic physics serving as a correlate of cognition.  $h_{eff}/h = n$  hierarchy and p-adic length scale hypothesis define fractal hierarchies of length and time scales: this fractality means that the standard length scale reductionism breaks down and that interesting new effects emerge in all scales. I have been identifying these effects for more than two decades now: the information flux from web has been indispensable in this task. Living matter would be one of the most striking deviations from the naïve reductionism. Even molecular physics and chemistry fail to reduce to atomic physics as the reductionistic dogma dictates.

MB carries dark cyclotron condensates and dark photons with with non-standard value of  $h_{eff}/h = n$ . Cyclotron condensates and cyclotron radiation are crucial for the control of organism by its MB. The feed of metabolic energy generates cyclotron condensates.

3. The view about sensory perception and function of nerve pulse transmission differs from the standard view. Nerve pulse transition would not be communication between parts of CNS but building of communication line for dark photons making possible communications with maximal signal velocity [L87] [K86].
  - (a) This would allow generation of sensory mental images at sensory organs by an iteration involving virtual sensory input from brain to sensory organs. Pattern recognition would be realized as a build-up of an artwork representing standardized mental image as near as possible to the original sensory input.
  - (b) Neurotransmitters and all information molecules would be bridges needed to construct connected communication lines. Learning as formation of permanent synaptic connections would be generation of permanent bridges of this kind.

4. Cell membrane and perhaps also other structures serve as generalized Josephson junctions [K33]. The (generalized) Josephson radiation generated by nerve pulses would give rise to EEG (and perhaps also to its fractal counterparts) as communication of neural information from brain to MB via Josephson frequency modulation. The size scale of the layer of MB would be rather large, of the order  $1/f_c$ , of the order Earth size in alpha band ( $f_c \simeq 10$  Hz).

#### Disorders as problems in the communications between BB and MB and as problems at BB and MB

Both the failure of the communication and control links between magnetic body and problems at BB or MB can give rise to disorders/diseases. Many things can go wrong.

1. Magnetic flux tubes serve as kind of wave guides carrying signals consisting of dark photons. Telephone network gives an idea about the situation. The flux tube network would consist of permanently existing pieces, which can be connected to single connected communication line by attaching small bridges (relays) between disjoint flux tubes. This process is nothing but attachment of information molecule (say neurotrophin ligand) to the receptor and thus serving as a bridge.

If the connecting ligands are absent, the communication line does not exist and MB does not receive information from brain: MB cannot see its protege. Also the control of MB can fail if it involves this kind of bridges: MB becomes lame unable to help its protege.

This is of course not the only mechanism. There might be ligands, which are competing for binding but not serving as relays so that the connection would not be built. This turns out to be the case in AP. The dynamical equilibrium between genuine bridges (trophins) and fake bridges (antitrophins) determines how much communication between MB and brain takes place. When fake bridges dominate, one has fully developed AP. This picture seems to be very general and apply also to a wide variety of other diseases, in particular Mad Cow disease.

Could the blindness of MB with respect BB be the cause of A?! Could AD -and presumably many other diseases - be disorders in communications between BB and MB due to the broken communication lines? Does MB of brain as God of neurons purposefully reject some neurons? Sounds cruel but the limited metabolic resources could force to select between organism and individual neurons.

2. If MB is dynamical, some layers in its onion-like structure could even disappear. At the level of brain the structures of MB are indeed dynamical. The formation of mental image would involve the generation of connected quantum coherent flux tube network by the formation of bridges.

Nerve pulse patterns would give rise to this kind of structure with neurotransmitters giving rise to small bridges between pre- and post-synaptic neurons. The formation of amyloid plaques would destroy the synaptic connections and destroy the MBs is the scale of brain.

**Remark:** Watch-up network would serve as an analogy here.

3. The dark photons mediating the signal might fail to be generated at brain or at MB. Also depression involves brain inflammation. Depressive mood rather literally is characterized by a feeling of being rejected by God. MB has indeed forced to reject the patient if the signals from brain or to brain cannot propagate for some reason.

Cyclotron radiation by biologically important ions would be needed to generate the dark photons needed in communications to and control from MB. EEG would be basic example of this kind of communications, which are however expected to be present in several frequency scales. Control commands could come via genome along flux sheets traversing DNA strand.

Generalized Josephson radiation from neuronal membranes could mediate "sensory" information from brain to MB. The frequencies of generalized Josephson radiation are sums of differences  $f_{0,in} - f_{c,out}$  of cyclotron frequencies at the two sides of the neuronal membrane and genuine Josephson contribution  $\Delta f = ZeV/h_{eff}$  coding for the nerve pulse patterns representing information as frequency modulation.

At least the lack of Li and Mg are known to induce depression and suicide rates correlate with Li depletion. The cyclotron frequencies of  $Li_6$  resp.  $Li_7$  ions in the endogenous magnetic field  $B_{end} = .2$  explaining the findings of Blackmann are 50 Hz (radiation at this frequency has biological effects) resp. 42 Hz (near thalamocortical resonance frequency) suggests that communications to MB suffer from Li depletion. Mg has cyclotron frequency 25 Hz (flash of light induces a response in dog's EEG at 25 Hz frequency).

4. Also control can fail. It is also possible that cyclotron condensates at MB are not generated so that MB cannot generate the dark cyclotron radiation driving the oscillators at biological body representing the control commands. This could be due to the lack of metabolic energy feed from BB to MB.

### What AD actually is?

A further reading of the book taught more about what AD actually is.

1. It was found that peptide amyloid-beta ( $A\beta$ ) is toxic to neurons acting as anti-trophin competing with trophin making possible the well-fare of neuron. The interpretation is in terms of competition between real and fake bridges. Since metabolic resources are finite, antitrophin can have healthy effect in many situations.
2. Amyloids was originally seen as the cause of AD. There exists so called dependence receptor known as amyloid precursor protein (APP): one might say that it monitors the state of neuron. There exists molecular scissors (proteases), which can split APP to either 2 peptides or 4 peptides.

The members of peptide pair are inside and outside the cell membrane. They maintain the wellfare of the neuron. The 4 peptides divide two groups of 2 peptides inside outside of the membrane and include  $A\beta$ . Too high concentration of amyloid beta destroys synapses and leads to neuron death.

Dynamical equilibrium between these two kinds of peptides determines the fate of the neuron. If the equilibrium shifts to the side of 4 bad peptides increasing their concentration, there is a risk that AD develops.

3. What determines the equilibrium between these two kinds of peptides? APP is a receptor than can bind to kinds of ligands, let us call them good and bad. The good ligand is known as netrin-1. In this case APP splits into to peptides supporting neuronal well-fare. Netrin-1 is trophin.

**Remark:** Netrin comes from word "netr", which is sanskrit and means "one who guides". Netrin would indeed serve as a link to MB, which indeed guides!

The bad ligand is  $A\beta$ ! This leads to positive feedback. The higher the concentration of  $A\beta$  produced in splittings to 4 peptides is the faster the rate for the new similar splittings. This causes a catastrophe: an uncontrolled exponential growth of  $A\beta$  concentration analogous to cancer. Similar mechanisms appear also in cancer and Mad Cow disease. Peptides able to amplify their own concentration are known as prionic.

4. There are many causes of AP explaining why the usual single cause - single medication approaches to AD have failed. Bredesen's group as identified 36 independent causes of AD! One of these causes is APOE4. It was originally thought to reduce the clearance of amyloid from brain. This is true but it was also found to have much deeper role. It can affect gene expressing by binding to the promoter regions of DNA and preventing the transcription of genes coding for proteins promoting the well-fare of neuron. APOE4 is thus an active tool for inducing death of neuron.
5. Bredesen takes business organization in market economy as a metaphor. Brain must monitor whether the neurons are useful and whether metabolic and other resources are enough for survival. At older age these resources deplete. Brain must destroy the neutrons when there is shortage about nutrients, vitamins, hormones. Also neurons, which are inactive or somehow damage, must go.

### TGD view about AD

The interpretation of this picture in TGD framework should be now rather obvious.

1. The simplest view is that netrin serves as a genuine bridge to MB and  $A\beta$  as the fake bridge. The dominance of fake bridges means that connection to MB is lost.
2. Brain must survive and decides to kill the neurons or force them to perform suicide, and uses APOE4 as one particular tool to realize this. MB would be innocent, so to say.
3. Or could MB serve as Stalin actively promoting neuronal death by activating mechanisms leading to neuronal death? Could the connections via the flux sheets of MB of DNA making possible control of BB allow this: is the activation of APOE4 preventing transcription of important genes related to this. One could argue that MB affects only DNA via promoter regions and APOE4 generated by brain itself prevents this. MB would not be Stalin after all.
4. Irrespective of who did it, in TGD Universe there is a hierarchy of selves and layers of MB serving as "Gods" and it includes also us. We can change our life style and prevent Alzheimer and many other diseases if we act early enough. We can do good deeds - also to our our biological bodies! Perhaps this is easier!

**Remark:** This inspires the question whether same applies in capitalism/market economy, which is a fractal copy of biology at cell level in TGD Universe. We can transform biology to culture by bringing in ethics, values and moral.

### Why Alzheimer does not destroy some aspects of consciousness?

Some aspects of consciousness seem to survive Alzheimer. Alzheimer patient can understand singing and also express himself by singing (see <http://tinyurl.com/y73zzrq4>). Why?

1. Singing is conventionally associated with holistic aspects of consciousness whereas language corresponds to reductionistic, local, and linear representation of conscious experience. Holistic-reductionistic dichotomy is often associated with right-left dichotomy. One should be of course cautious with this identification and be happy with holistic-reductionistic dichotomy.
2. In any case, we know that left brain talks and right brain sings. Singing is a representation in terms of frequencies. It is 2-dimensional because also the pitch matters unlike in the case of speech. Everyone familiar with Fourier transform knows that frequency representation is holistic: Fourier amplitude carries information about the function in the entire domain of definition but not about details for low enough frequencies such as occur in singing (maybe the duration of duration of nerve pulse of order millisecond could serve as standard, could notes with pitch below kHz frequency be low frequencies?).
3. Why cognition does not survive in Alzheimer is easy to understand. Cognition is by definition about details: left brain is responsible for language and language indeed local, *linear(!)*, and reductionistic. Maybe 1-D neural strings and loops assignable to magnetic loops provide a realization of spoken and written language? Alzheimer would destroy synaptic connections and would split these strings. The disappearance of even single bridge in the loop/string splits the loop/string (into two): this is just 1-D topology. Communication line would be broken. Cognitive skills and language would be lost.
4. Why would the holistic aspects of consciousness survive in Alzheimer? Suppose that right brain involves 2-D net-work like structures instead of 1-D neural strings having much more connections and giving rise to quantum tensor network [L60] (see <http://tinyurl.com/y9kwnqfa>) as it would be fashionable to say. Quantum entanglement is very probably involved and would be actually responsible for the holistic and hologram-like aspects of neural activities known for a long time. It would not be surprising if brain waves with frequency spectrum below kHz would be important for this representation. EEG waves are almost by definition in the range 1-100 Hz.

What happens to 2-D networks in the destruction of synapses. Practically nothing! Quite a number of synaptic connections can disappear but this does not split the 2-D network into pieces as it splits 1-D string: 2-D topology! Communications take place and the structure can take care of itself. Holograms are not affected by the local splitting of the synaptic connections. The right brain would happily continue its singing!

Note that 2-D networks are also natural for the representation of sensory data as images and the language of images is different from the language of words: I have discussed the differences between these two different languages in [L84] (see <http://tinyurl.com/yb99u6u8>).

The natural question is whether could one approach to Alzheimer rely on activation of right brain: could art therapies such as music and visual arts help in Alzheimer?

### Questions about memory

AD also inspires questions about memory. Neuroscientists often identify memories as skills. There are however memories such as sensory memories, which can be induced in any-one by electrical stimulation of temporal lobes. Also dreams involve these memories. One can have spontaneous memory of some smell or suffer pain in non-existing leg. Some people often regarded as cognitively impaired might have sensory memories regularly: this could explain their amazing memory feats. Some people hear music all the time in their head: Tchaikovsky is one example of this.

I find it difficult to believe that sensory memories would reduce to strengthening of synaptic connections in the brain now: they are not learned skills. In TGD picture the new view about time leads forced by zero energy ontology (ZEO) leads to the idea that the perceptive field is 4-D causal diamond (CD, 2-D visualization helps to understand) and that sensory memories are mental images (sub-CDs) located near either boundary of CD. The remaining mental images inside CD would be represented symbolically so that it would make sense to speak about "sensory now" in 3-D sense. Cognitive impairment would mean a loss of the symbolic representations and sensory representations might replace it and make memory feats possible.

**Remark:** In ZEO one can even make the scifi sounding question whether the brains of geometric past still in good shape could be used? There are people who have lost most of their brains but still can cope with challenges of everyday life.

Could this view be tested? Could Alzheimer patients have long term memories about time when brain was still healthy? Could they have sensory memories about that time? This might be the case: my grandmother lost her cognitive skills during her last years but re-lived her youth very intensely: she had even strong intention of going to dance!

#### 2.9.4 Magnetite produced by traffic as a possible cause of Alzheimer disease

A rather unexpected partial explanation for Alzheimer's disease has been found: magnetite particles, which can be found in urban environments from exhaust gases containing breathing air [J81] (see this). I have written earlier about Alzheimer's disease from the TGD point of view [K81]. Magnetite particles seem to be found in the hippocampus of those with the disease, which is central to memory. Now it has been found that the exposure of mice to magnetite leads to a generation of Alzheimer disease. The overall important message to the decision makers is that the pollution caused by the traffic in urban environment could be an important cause of Alzheimer disease.

The brain needs metabolic energy. Hemoglobin is central to the supply of metabolic energy because it binds oxygen. Could it be thought that Alzheimer's is at least partially related to a lack of metabolic energy in the hippocampus? In the sequel I will consider this explanation in the TGD framework.

#### Short digression to TGD view of metabolism

Oxygen molecules  $O_2$  bind to iron atoms in hemoglobin (see this) that already have a valence bond with 5 nitrogen atoms and a bond is created where Fe has received 5 electrons and a sixth from oxygen molecule  $O_2$ . So Fe behaves the opposite of what you would expect and hemoglobin is very unusual chemically!

Phosphate  $O = PO_3$ , or more precisely phosphate ion  $O = P(O^-)_3$ , which also plays a central role in metabolism, also breaks the rules: instead of accepting 3 valence electrons, it gives up 5 electrons to oxygen atoms.

Could the TGD view of quantum biology help to understand what is involved. Dark protons created by the Pollack effect provide a basic control tool of quantum biochemistry in TGD. Could they be involved now. Consider first the so-called high energy phosphate bond, which is one of the mysteries of biochemistry.

1. Why the electrons in the valence bonds prefer to be close to P in the phosphate ion? For phosphate one would expect just the opposite. The negative charge of 3 oxygens could explain why electrons tend to be nearer to P.
2. The TGD based view of metabolism allows to consider a new physics explanation in which  $O = P(O^-)_3$  is actually a "dark" variant of neutral  $O = P(OH)_3$  in which 3 protons of OH have become dark (in the TGD sense) by Pollack effect, which has kicked 3 protons to monopole flux tubes of the gravitational magnetic body of phosphate to such a large distance that the resulting dark OH looks like  $OH^-$ , that is negatively charged. Charge separation between the biological body and magnetic body would have occurred. This requires metabolic energy basically provided by the solar radiation. One could see the dark phosphate as a temporary metabolic energy storage and the energy would be liberated when ATP transforms to ADP.

Could this kind of model apply also to the Fe binding with 5 N atoms in haemoglobin by valence bonds such that, contrary to naive expectations, electrons tend to be closer to Fe than N atoms? Can one imagine a mechanism giving an effective negative charge to the N atoms or the heme protein and to O-O?

1. In this case there are no protons as in the case of phosphate ions. The water environment however contains protons and pH as a negative logarithm of the proton concentration measures their concentration. pH=7 corresponds to pure water in which  $H^+$  and  $(OH)^-$  concentrations are the same. The hint comes from the fact that small pH, which corresponds to a high proton concentration, is known to be favourable for the binding of oxygen to the heme group.
2. Could dark protons be involved and what is the relationship between dark proton fraction and pH? Could pH measure the concentration of dark protons as I have asked?
3. Could the transformation of ordinary protons to dark protons at the gravitational MB of the heme protein induce a negative charge due to  $OH_-$  ions associated with the heme protein and could this favour the transfer of electrons towards Fe? Could the second O of O-O form a hydrogen bond with H such that the proton of the hydrogen bond becomes dark and makes O effectively negatively charged?

### What the effect of magnetite could be?

Magnetite particles, .5 micrometers in size, consist of  $Fe_3O_4$  molecules containing iron and oxygen. According to Wikipedia, magnetite appears as crystals and obeys the chemical formula  $Fe^{2+}(Fe^{3+})_2(O^{-2})_4$ . The electronic configuration is  $[Ar]3d^64s^2$  and 3 Fe ions have donated besides the s electrons also one electron to oxygen.

Could it happen that somehow the oxygen absorption capacity of hemoglobin would decrease, that the amount of hemoglobin would decrease, or that oxygen would bind to the magnetite molecules on the surface of the magnetite particle? For example, could you think that some of the  $O_2$  molecules bind to  $Fe_3O_4$  molecules instead of hemoglobin at the surface of the magnetite. Carbon monoxide is dangerous because it binds to the heme. Could it be that also the magnetite crystals do the same or rather could heme bind to them (thanks for Shamooun Ahmed for proposing this more reasonable looking option).

## Chapter 3

# Comments about the recent experiments by the group of Michael Persinger

### 3.1 Introduction

Michael Persinger's group reports (see <http://tinyurl.com/ycv7876g>) [J94, J95, J96] three very interesting experimental discoveries relating to EEG, magnetic fields, photon emissions from brain, and macroscopic quantum coherence.

In the first article (see <http://tinyurl.com/y7nbr496>) [J94] entitled *Congruence of Energies for Cerebral Photon Emissions, Quantitative EEG Activities and  $\sim 5$  nT Changes in the Proximal Geomagnetic Field Support Spin-based Hypothesis of Consciousness* correlations between cerebral photons emissions, EEG, and changes of the proximal geomagnetic field are reported. The findings provide support for the proposal of Hu and Wu [J120] that nerve pulse activity could induce spin flips of spin networks assignable to cell membrane motivated by the observation that the magnetic spin-spin interaction between protons at a distance of 10 nm (cell membrane thickness) corresponds to energies for which frequency is in EEG range.

In the second article (see <http://tinyurl.com/ycv531ye>) [J95] entitled *Demonstration of Entanglement of "Pure" Photon Emissions at Two Locations That Share Specific Configurations of Magnetic Fields: Implications for Translocation of Consciousness* the group reports an excess correlation between "pure" photon emissions at two locations separated by few meters that share specific correlations of frequency modulated magnetic fields. The photon emissions were from LEDs in the experiment consider. In an earlier similar experiment, which is also discussed, they were from chemical reactions occurring in solutions contained by cell cultures.

In the third article (see <http://tinyurl.com/ya4yb6bc>) [J96] entitled *Experimental Demonstration of Potential Entanglement of Brain Activity over 300 Km for Pairs of Subjects Sharing the Same Circular Rotating, Angular Accelerating Magnetic Fields: Verification by s-LORETA, QEEG Measurements* an excess correlation of brain activity of subject persons separated by 300 km and sharing the same circular rotating, angular accelerating magnetic fields is reported.

It turns out that the experiments provide support for several TGD inspired ideas about living matter: magnetic flux quanta as generators of macroscopic quantum entanglement, dark matter as a hierarchy of macroscopic quantum phases with large effective Planck constant, DNA-cell membrane system as a topological quantum computer with nucleotides and lipids connected by magnetic flux tubes with ends assignable to phosphate containing molecules, and the proposal that "dark" nuclei consisting of dark proton strings could provide a representation of the genetic code. The proposal of Hu and Wu [J120] translates into the assumption that lipids of the two layers of the cell membrane are accompanied by dark protons which arrange themselves as dark protonic strings defining representation for DNA sequences.

In the sequel I briefly explain my own interpretation of these experiments and their outcomes from TGD point of view and show that a nice interpretation of the findings emerges. Before going

into this it is however appropriate to summarize briefly those aspects of TGD-based view about living matter which are relevant for the interpretation of the experiments.

### 3.1.1 Key Aspects Of The TGD-Inspired Vision About Living Matter

The following are the key ingredients of TGD-inspired vision about living matter needed for our argument:

1. The notion of many-sheeted space-time is the first new element [?, K43]. Space-times are 4-D surfaces in 8-D space-time  $M^4 \times CP_2$  so that one has what might be called sub-manifold gravity. Any physical system corresponds to a space-time sheet characterizing its shape and size. The outer boundaries of macroscopic objects correspond to causal boundaries at which the signature of the induced metric of the space-time surface changes. Therefore space-time surfaces are topologically non-trivial in all scales and we directly perceive it. Space-time surfaces form a fractal hierarchy in the sense that subsystems of a system correspond to space-time sheets topologically condensed on it via the formation of wormhole contacts which are regions of space-time with an Euclidian signature of the induced metric.

Also the notion of classical field is topologized. Various classical fields are subject to what might be called topological field quantization. For instance, radiation fields decompose to topological light rays and magnetic field to magnetic flux quanta (flux tubes and flux sheets). Topological field quantization is of special importance in living matter and leads to the notion of field body and magnetic body as additional structural and functional parts of a living system.

2. p-Adic physics [K106] defines a further basic element. p-Adic number fields are proposed to serve as correlates for cognition in the sense that one can speak about p-adic space-time sheets as correlates for cognition and for intentions [K69, K126] The quantum jump transforming p-adic space-time sheet to a real one corresponds to a transformation of intention to action. The generation of thought in turn corresponds to an opposite of this transition. Zero energy ontology makes this picture internally consistent and no breaking of conservation laws is implied.

p-Adic length scale hypothesis [K70] states that p-adic primes near powers of 2 are of special physical significance and Mersenne primes  $M_n = 2^n - 1$  especially so. A possible explanation for the importance of these primes is that evolution corresponds to a gradually increasing complexity. The primes slightly below power of two are simple in the sense that all digits in their binary expansion are “1”s except possibly for some of the first ones, and are physically especially interesting because they should have emerged first if the number theoretical evolution proceeds from simple to more complex. Mersenne primes have only “1”s in their binary expansion so that they are the simplest possible primes and indeed seem to correspond to fundamental physical scales. This leads to quite powerful predictions in particle physics context.

In the scales of living matter a number theoretical miracle occurs: the length scale range from 10 nm (cell membrane thickness) to  $2.5 \mu\text{m}$  (size scale of cell nucleus) contains as many as four electron Compton scales  $L_e(k) = \sqrt{5}L(k)$  defined by Gaussian Mersennes  $M_{G,n} = (1+i)^n - 1$ : obviously they correspond to p-adic primes near  $p^k$ ,  $k = 151, 157, 163, 167$ .

3. The hierarchy of *effective* Planck constants [K37] coming as integer multiples  $\hbar_{eff} = n\hbar$  of the ordinary Planck constant was partially motivated by the findings of Blackman [J47] and others related to the unexpected effects of ELF em fields on vertebrate brain. These effects look quantal but this should not be possible since the cyclotron energies in the magnetic field  $.2 \times 10^{-4}$  T (2/5 times the nominal value of the Earth’s magnetic field  $B_E = .5 \times 10^{-4}$  T) are 10 orders of magnitude below the thermal threshold.

This led to the hypothesis about the value spectrum of Planck constants. The phases of ordinary matter with non-standard value of effective Planck constant are identified as dark matter. Later two different - possibly equivalent - reductions of the hierarchy to that for *effective* values of  $\hbar$  have emerged in TGD framework [K126].



One of the most speculative ideas related to the dark matter hierarchy is based on the observation that a simple model for dark proton implies that the states of dark proton are in 1-1 correspondence with DNA, RNA, tRNA, and amino-acids, and that there is a simple rule reproducing vertebrate genetic code [K65, K48]. Dark nuclei defined by sequences of dark protons would define the analogs of DNA sequences so that genetic code would not be a outcome of random bio-chemical selection but a basic element of particle physics, and biological systems would only define a secondary representation of the fundamental genetic code. This proposal has far reaching implications. Surprisingly, the findings of the first article [J94] supporting the hypothesis of Hu and Wu [J120] about proton spin networks combined with the dark DNA hypothesis lead to a concrete model for the proton spin networks as paired dark DNA sequences assignable to the two lipid layers of the cell membrane.

4. Magnetic flux tubes carrying dark matter take central role in TGD inspired quantum biology. The knotting and braiding of the flux tubes makes possible topological quantum computation and leads to the hypothesis that DNA and cell membrane connected by flux tubes form a topological quantum computer [K4]. Flux tubes can connect sub-systems of living organisms or even different organisms to form coherent structural and functional units. Indeed, the large value of  $\hbar_{eff}$  makes possible macroscopic quantum coherence. In particular, biomolecules can be connected by flux tubes to coherent structures. The reconnection of flux tubes plays a key role in the proposed model bio-chemical reactions and bio-catalysis. Important are also the phase transitions changing the value of Planck constant inducing in turn a change of the length of the flux tube identified as a quantal length scale depending of  $\hbar_{eff}$ . These phase transitions could be responsible for the phase transitions changing dramatically the density of matter in cellular interior (say sol-gel transition).

Cyclotron Bose-Einstein condensates at magnetic flux tubes are proposed to be a characteristic of living systems [K11]. Cyclotron frequencies are classical (no dependence on Planck constant) but cyclotron energies scale like  $\hbar_{eff}$  so that for a large enough value of the effective Planck constant cyclotron energies of dark photons are above thermal threshold, and can induce macroscopic quantum coherence. Dark photons decay to bunches of ordinary photons and an attractive hypothesis is that bio-photons result as decay products of dark photons.

The notion of magnetic body emerges naturally. Any physical system is accompanied by magnetic fields which in TGD Universe defines separate entity, which can be called magnetic body. Magnetic body is identified as an intentional agent using biological body as sensory receptor and motor instrument. Magnetic body has an onion like structure corresponding to the hierarchy of space-time sheets defining physical system, say biological body. The size of the magnetic body is much larger than that of biological body. 10 Hz frequency corresponds to a layer with size large than the size scale of Earth.

5. Zero energy ontology (ZEO) [K9] is a further basic element. In zero energy ontology physical states are zero energy states consisting of pairs of positive and negative energy states having opposite net quantum numbers and being localized to the opposite light-like boundaries of  $CD \times CP_2$ , where CD is the causal diamond identified as an intersection of future and past directed light-cones and defining a structure analogous to a double pyramid (a convenient shorthand for  $CD \times CP_2$  is simply CD).

The interpretation of zero energy states is as counterparts of pairs of initial and final states of physical events in positive energy ontology. CDs form a fractal hierarchy with CDs within CDs. The size scales of CDs come as integer multiples of  $CP_2$  size scale about  $10^4$  Planck lengths. One can interpret CD as an embedding space correlate for a “spotlight of consciousness” in the sense that the conscious experience of self associated with a given CD is about the region defined by CD. Space-time sheets within CD serve as correlates for selves at space-time level.

Also elementary particles are expected to be accompanied by CDs, and one especially important prediction is that the time scale of the CD associated with electron is .1 seconds, which corresponds to the fundamental 10 Hz bio-rhythm. All elementary particles correspond to macroscopic time scales and  $u$  and  $d$  quarks would correspond to time scales between 1 ms and .1 seconds.

### 3.1.2 Cell Membrane As Super-Conductor And A Model For Eeg

The proposal is that the cell membrane is accompanied by super-conducting dark magnetic flux tubes [K86]. Cooper pairs of electrons, protons, and biologically important fermionic ions would be the carriers of supra currents besides bosonic ions such as  $Ca^{++}$  and  $Mg^{++}$ . Note that the new exotic nuclear physics suggested by TGD allows to imagine that fermionic nuclei could appear as bosonic variants with essentially the same chemical properties [K65].

Josephson currents through cell membrane have frequency  $f = eV/\hbar_{eff}$  so that in this case the energy  $E = eV$  identifiable as the energy of electron or proton gained in traversing the cell membrane is a classical quantity whereas Josephson frequency is quantal [K86]. The situation is opposite to this for cyclotron frequencies and energies. Obviously, large values of  $\hbar_{eff}$  correspond to low Josephson frequencies. Soliton sequences associated with the Sine-Gordon equation governing the dynamics for small variations of membrane potential would represent ground states of axonal membranes mathematically, analogous to sequences of mathematical penduli rotating in phase. Nerve pulse generation would mean a perturbation in which one pendulum is kicked [K86].

There are two alternative models for the cell membrane as a Josephson junction [K11].

1. For the conservative option [K11] the cell membrane is a far-from-vacuum extremal and various charged particles experience only the electromagnetic field. The energy scale of excitations is determined by the electric voltage and is given by  $E = eV$ . Nerve pulse generation would be associated with this kind of membranes. Josephson radiation with harmonics of  $f = eV/\hbar_{eff}$  is one signature of super-conductivity.

One also ends up with an explanation of EEG in this framework [K33]. The function of EEG would be communication of sensory data from cell membrane to the magnetic body and control of biological body via flux sheets traversing through DNA, where genetic expression is activated by the control signals. EEG frequencies are linear combinations of harmonics of Josephson frequencies and of the increments of cyclotron frequencies. Cyclotron transitions can be also accompanied by a spin flip. This model allows one to identify EEG bands. The hierarchy of Planck constants suggest a generalization of EEG and its variants (say EKG) to a fractal hierarchy obtained by scaling EEG. For large enough values of  $\hbar$  cyclotron contributions to EEG energies would correspond to energies above thermal threshold as also Josephson frequency (Josephson energy  $E = eV_{thr}$ , where  $V_{thr}$  is the value of resting potential at which nerve pulse is generated is just at the thermal threshold). This would make possible the correlation of EEG with the brain state and also quantum biocontrol by using photons with EEG frequencies.

2. For the non-conservative option [K32] cell membrane is near-to vacuum extremal. The classical  $Z^0$  fields predicted by TGD dominate over em fields, and the voltage must be replaced by a combination of  $Z^0$  and em voltages. By assuming that the Weinberg angle is considerably smaller in this phase than in the standard phase the energies gained by various ions correspond to visible photons. This hypothesis allows one to understand the frequencies for which photoreceptors - which do not directly generate nerve pulses - are most sensitive. Near-vacuum extremal property obviously implies high sensitivity to perturbations making the sensory receptor optimal.

An interesting possibility is that the far-from-, respectively near-to-vacuum extremal options are realized for the neurons of left *resp.* right hemisphere. This option finds support from the observation of Persinger *et al* [J94] that visible photon emissions are mostly from the right hemisphere. Another possibility is that glial cells as cells which do not generate nerve pulses correspond to near-to vacuum extremals. The identifications do not exclude each other.

### 3.1.3 Learning To Apply The Notion Of Induced Field

The geometrization of classical gauge fields and gravitational fields relying on the induction of spinor connection of  $CP_2$  and  $M^4 \times CP_2$  metric to the space-time surface is one of the key ideas of TGD and it is useful to get more concrete understanding of the induced fields since this notion will be applied in the sequel.

### The basic objection and its resolution

The basic objection against the induced fields is that they reduce the dynamics to that of only 4 field like variables since the 8 embedding space coordinates take the role of field variables and 4 of them are eliminated by general coordinate invariance as field variables. Besides this preferred extremals of Kähler action represent space-time surfaces carrying very restricted kind of patterns of induced gauge fields analogous to Bohr orbits.

Many-sheeted space-time however saves the situation. Each system creates its own field body represented in terms of topological field quanta. If these field bodies have common  $M^4$  projection, a test particle topologically condenses to each of these field body (touches each of them), and the effects of these fields sum up although fields do not interfere as they would do in ordinary field theory.

### How could one generate dark photons with large $\hbar$ ?

The observation which led to the proposal of the effective hierarchy of Planck constants, was that microwaves with frequency of  $f_h$  modulated by ELF frequency  $f_l$  induce in vertebrate brain effects which could be understood in terms of cyclotron frequencies assignable to quantal cyclotron transitions in an endogenous magnetic field  $B_{end} = .2$  Gauss for which cyclotron frequency was equal to ELF frequency:  $f_c = f_l$ . These effects are possible only if the cyclotron energy is above thermal energy, and this led to the proposal about the hierarchy of Planck constants.

The key question is how the modulation by ELF frequency could generate dark photons with large  $\hbar_{eff}$ . A possible answer to this question comes from another question. Topological field quantization forces one to ask what is exactly implied by the amplitude modulation of fields.

The simplest modulation corresponds to a multiplication of rapidly oscillating field with a slowly varying oscillating amplitude so that amplitudes with frequencies  $f_h \pm f_l$  result (“h” and “l” refer to “high” and “low”). The natural thing to do is to develop the two amplitudes with frequencies  $f_h \pm f_l$  in Fourier series in time interval  $T = 1/f_l$ . All harmonics of  $f_l$  appear and coefficients of the expansion are proportional to  $1/(f_h - (n \pm 1)f_l)$ . Maximal amplitudes correspond to  $f_h \simeq (n \pm 1)f_l$ . This suggests that when this almost-resonant condition is satisfied the generation of dark photons with frequency  $f_l$  and energy  $\hbar_{eff}f_l$ , with  $\hbar_{eff} \simeq f_h/f_l$ , can take place at a considerable rate. If this argument is correct, one could generate dark photons with given  $\hbar_{eff}$  by using modulation satisfying the condition  $f_h/f_l = \hbar_{eff}$ .

In the case of ELF em fields interacting with brain this is not enough since microwave photons have energies below the thermal threshold  $E_{th}$ . Bio-systems however contain photons with energy above thermal threshold - say bio-photons with frequencies  $f$  in visible range or infrared Josephson photons generated by cell membrane Josephson currents; the fields associated with MEs (“massless extremals”, topological light rays) accompanying these many-photon states can be modulated by the ELF modulated microwaves. Since one can say that a modulation of modulation is also a modulation, the outcome is modulation  $(f, f_{ELF})$  producing dark photons with  $\hbar_{eff} \simeq f/f_{ELF}$  with energies about  $E_{th}$ .

This mechanism would explain the “scaling law of homeopathy” [K48] stating that fields with low frequencies  $f_l$  are somehow transformed to fields with high frequencies  $f_h$  and vice versa. The proposal has been that large  $\hbar_{eff}$  photons with  $\hbar_{eff} \simeq f_h/f_l$  decay to ordinary photons or vice versa. This transformation has quite concrete description:  $\hbar_{eff} = n$  photons correspond to  $n$ -furcations of space-time surface made possible by the non-determinism of Kähler action. All  $n$ -sheets of the  $n$ -furcation would be present and each of them would carry photon with frequency  $f_l$  and total energy would be  $\hbar_{eff}f_l = f_h$ .

### How to describe time-varying magnetic fields?

The topological flux quantization for static magnetic fields is easy to understand. The description of time varying magnetic fields in terms of flux quanta is however a non-trivial exercise in thinking in terms of topological field quanta.

Flux quantization implies that the magnetic dipole field decomposes into closed flux tubes with a straight part inside dipole and a portion outside the dipole carrying return flux in roughly opposite direction also arranged to flux tubes.

The basic assumption is that the flux tube structure of dipole field is not lost but is only re-arranged as the dipole field oscillates. As the dipole strength decreases the flux tubes along field lines outside the dipole contract so that eventually the closed flux tubes of dipole field degenerate to those of wormhole magnetic fields [K128] restricted inside the dipole and consisting of parallel flux tube space-time sheets with same  $M^4$  projection and carrying opposite magnetic field strength and having distance of order  $CP_2$  length along  $CP_2$  direction. A charged particle topologically condensing at both sheets experiences the sum of the magnetic fields, which vanishes. As the sign of dipole changes, the flux tubes in the interior of dipole begin to move to the exterior of the dipole. In operational sense this dynamics is approximated well by Maxwell's theory or vice versa.

How are the electric fields associated with the time-varying magnetic fields predicted by Faraday law represented? These fields are rotational with flux lines rotating around the magnetic field. In Maxwell's theory one would have single vortex like structure. In TGD this vortex-like structure decomposes into smaller vortices assignable to individual flux tubes just like the rotational flow of super-fluid decomposes into smaller vortices satisfying quantization condition analogous to the quantization of the magnetic flux.

Also the geometro-dynamics for the flux quanta of electric field is possible and in this case magnetic fields induced by time dependent electric fields are assignable to flux quanta. Cell membrane is a good example of this kind of situation. Quite generally, the geometro-dynamics of topological field quanta together with the possibility to have varying overlapping  $M^4$  projections allows to reproduce the smooth dynamics of Maxwell fields.

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> [L30].

## 3.2 First Article

The first article has the title *Congruence of Energies for Cerebral Photon Emissions, Quantitative EEG Activities and  $\sim 5$  nT Changes in the Proximal Geomagnetic Field Support Spin-based Hypothesis of Consciousness*, which already summarizes the findings.

### 3.2.1 Findings

In the article (see <http://tinyurl.com/y7nbnr496>) [J94] Persinger's group reports simultaneous changes in photon emissions, EEG activity, and alterations of proximal geomagnetic field when a person sitting in dark is imagining white light or not.

According to the article's abstract,

the hypothesis by Hu & Wu that networks of nuclear spins in neural membranes could be modulated by action potentials was explored by measurements of the quantitative changes in photon emissions, electroencephalographic activity, and alterations in the proximal geomagnetic field during successive periods when a subject sitting in the dark imagined white light or did not. During brief periods of imagining white light the power density of photon emissions from the right hemisphere was about  $10^{-11}$  Wm $^{-2}$  that was congruent with magnetic energy within the volume associated with a diminishment of  $\sim 7$  nT as predicted by the dipole-dipole coupling relation across the neuronal cell membrane. Spectral analyses showed maxima in power from electroencephalographic activity within the parahippocampal region and photon emissions from the right hemisphere with shared phase modulations equivalent to about 20 ms. Beat frequencies (6 Hz) between peak power in photon (17 Hz) and brain (11 Hz) amplitude fluctuations during imagining light were equivalent to energy differences within the visible wavelength that were identical to the intrinsic 8 Hz rhythmic variations of neurons within the parahippocampal gyrus. Several quantitative solutions strongly suggested that spin energies can accommodate the interactions between protons, electrons, and photons and the action potentials associated with intention, consciousness, and entanglement.

The authors interpret the results in terms of entanglement identified as enhanced correlations. Entanglement in this sense does not correspond to quantum entanglement. To my opinion

(quantum) coherence would be a more standard manner to interpret the findings. Quantum coherence of course also makes possible quantum entanglement.

Spin flips, whose importance for consciousness has been emphasized by Hu and Wu [J121], would occur between spin triplet and singlet states of pairs of protons belonging to the spin network. The basic finding is that the energy changes are accompanied by changes in EEG power.

Note that spin flips are possible also for cyclotron states proposed to be important for consciousness in TGD approach. In the case of electron the change of the energy in spin flip is in excellent approximation the same as in the transition  $n \rightarrow n \pm 1$  of cyclotron state characterized by integer  $n$  (radial wave functions of electron in constant magnetic field correspond to those of harmonic oscillator). For ions the Lande factor  $g$  characterizes the effective nuclear angular momentum and appears in the spin flip energy and also now the frequencies involved are in EEG range.

The correlation of photon emissions with imagination of white light supports the hypothesis that EEG photons are responsible for communications to and control of biological body by magnetic body.

### 3.2.2 TGD Inspired Interpretation Of The Findings

What has been observed is correlation between EEG, emission of visible photons, and weakening of Earth's magnetic field with the change of magnetic energy equal to the energy of radiated photons. There is also evidence that spin flip transitions for protons are involved.

#### What is the origin of the visible photons?

The basic question concerns the origin of the visible photons.

1. An attractive general hypothesis is that the visible photons result in the transformation of dark EEG photons to ordinary visible photons. In TGD based model EEG (and its predicted fractal variants) correspond to dark photons with large *effective* value of  $\hbar$  - call it  $\hbar_{eff}$  - and energy  $E = \hbar_{eff} f$  in infrared or visible range and perhaps even in UV. Also bio-photons would result from these large  $\hbar$  "dark" photons as they decay to bunches of ordinary photons. The wavelengths of dark photons with given energy are scaled by  $\hbar_{eff}/\hbar$  predicted to be integer. The transformation of EEG photons to ordinary visible photons could explain the correlation between EEG and visible photon emission reported by Persinger's group. This kind of process would generate also bio-photons.
2. The mechanism providing energy for dark photons (in particular EEG photons) would provide it also for the visible photons. According to the authors, the energy would come from the Earth's magnetic field which I as inhabitant of many-sheeted space-time take liberty to translate to "measured magnetic field". What is interesting is that magnetic body would serve as a provided of metabolic energy. It is interesting to notice that in TGD based cosmology matter is created from the dark energy identified as Kähler magnetic energy assignable to magnetic flux tubes.
3. Authors conclude that the energy liberated per action potential is  $E = eV_{rest}$ . In TGD framework it could correspond to either a photon of Josephson radiation or the energy liberated when an electron traverses the cell membrane. What is troublesome is that this energy corresponds to IR photon just above thermal threshold rather than visible photon. The non-conservative model for the cell membrane mentioned above (applying to photo-receptor cells at least) could explain why visible photons rather than infrared photons with energy  $E = eV_{rest}$  correspond to photons of the Josephson radiation.
4. The model based on the observation of Hu and Wu [J120] suggesting that action potentials affect a spin network of protons (possibly at opposite ends of lipid of two lipid layers making cell membrane) looks like a totally different explanation from what would come first in mind in TGD framework. Could the spin network proposal of Hu and Wu be integrated to the picture of living matter provided by TGD? This is the question to be considered next.

### The spin network hypothesis of Hu and Wu from TGD point of view

The hypothesis of Hu and Wu (see <http://tinyurl.com/yb5emq27>) [J120] states that nuclear spin networks of nuclei associated with the cell membrane are relevant for consciousness in the sense that action potential induces modulations of the coupling parameters describing the magnetic interaction between neighboring spins of the spin network.

1. A direct calculation using the value of proton magnetic moment gives that the magnetic field created by proton at distance defined by cell membrane thickness of 10 nm is 3 nT. There are also other factors involved, and the estimate of Hu is that the field is about 5 nT.
2. The crucial observation is that the classical spin-spin interaction energy for two protons at distance  $d = 10$  nm defined by cell membrane thickness and given by  $E_{s-s} = -\mu \cdot B$ , where  $B$  is the dipole field created by proton, corresponds to a frequency of the order  $10^{-14}$  eV and thus is in EEG range. This can be seen by a direct calculation by assuming that proton creates a dipole field with Lande factor of proton.

The frequencies assignable to the energies of neighboring interacting proton spins at distance  $d$  are in EEG range also when the effects of the environment are taken into account. For instance, the Hamiltonian for a rotationally symmetric nearest neighbor spin-spin interaction characterized in terms of so called J-factor, predicts in the case of protons frequency differences  $\Delta E$  between singlet and triplet states varying in the range 5-25 Hz.

For heavier nuclei these interaction energies scale down like  $1/A^2$ ,  $A$  the mass number, so that a naïve conclusion would be that the frequencies tend to be below 5 Hz scale. Proton would therefore be in a completely unique position. That EEG frequencies result in case of proton suggest that cell membrane thickness is not 10 nm by a pure accident (not that p-adic length scale hypothesis fixes assigns it to the p-adic length scale  $L(k = 151)$ , where  $k = 151$  characterize Gaussian Mersenne prime.

The fact that the frequencies for energy differences of singlets and triplets are in EEG range is highly relevant also from TGD point of view since this energy range makes it possible for EEG frequencies to induce spin flips.

1. In TGD framework fermionic spin and fermion numbers in various modes of second quantized induced spinor field (1 or 0) are predicted to serve as correlates for Boolean cognition (see <http://tinyurl.com/y73smj9v>) [K25] so that there are good reasons to expect that also spin flips are important. One might even think that protonic and even nuclear spins could be utilized to build Boolean representations.
2. The basic objection against the proposal of Hu and Wu is same as that against the findings of Blackman and others: quantum coherence is not possible since the energy differences corresponding to (say) frequency of 5 Hz is about 12 orders of magnitude below thermal threshold. From the basic relation  $E = h_{eff} f$  it is clear that the objection can be circumvented for large values of effective Planck constant, which can take raise the energies involved to those of IR or perhaps even visible photons.
3. Authors conclude that the energy emitted per single action potential is  $E = eV_{rest}$  which corresponds to IR photon just at the thermal threshold. It is however visible photons which are emitted. Why not photons with the Josephson energy  $E = eV_{rest}$  just at the thermal threshold?

If the photons would result when electron or proton traverses cell membrane and liberates potential energy as a photon or if the emitted IR photon could be interpreted as a photon of Josephson radiation this would be the case. TGD allows also to imagine that the cell membranes in question correspond to the non-conservative option for the model of cell membrane as Josephson junction for which  $V_{rest}$  contains  $Z^0$  potential as a dominating contribution and gives rise to Josephson photons with energies in visible range.

If one takes the proposal of Hu and Wu seriously, the visible photons would have different origin, and one must perhaps give up the assumption that the estimate of authors forces the identification of basic energy quantum emitted in the process considered as  $E = eV_{rest}$ .

Authors state that the energy associated with visible photon emission should be equivalent to the energy emitted in the emission of photons. What can one conclude from this?

1. An attractive possibility would be “dark” spin network formed by spin-coupled protons, whose members are associated with the lipids of the two lipid layers with lipids. The number of the lipids per cell membrane would be roughly  $N_l = r^2/d^2$ , with lipids thickness estimated to be  $d \sim .1$  nm. For  $r \sim 10^{-4}$  m corresponding to a relatively large neuron this would give  $N_l = 10^{14}$ .

This number would give also the maximum number of spin pairs participating in phase transition and an estimate for the value of  $\hbar_{eff}$  from  $N_l \Delta E_{s-s} = E_{ph}$  as

$$N_l = \frac{E_{ph}}{E_{s-s}} = \frac{f_{ph}}{f_{s-s}} .$$

Suppose that all dipoles make a simultaneous spin flip with energy change  $\Delta E = \hbar f$ ,  $f_{s-s} = 5$  Hz generating an energy of  $E_{ph} = 1\text{eV}$  corresponding to a frequency of  $2.4 \times 10^{14}$  Hz. This requires  $N_l \sim .5 \times 10^{14}$ . It is encouraging that the rough estimates are consistent with each other.

2. That all protonic spin pairs make a simultaneous spin flip between singlet and triplet states of neighboring pairs looks like a phase transition. This suggests strongly macroscopic quantum coherence. What looks extremely strange is that a single visible photon should be emitted in the process since the entire magnetized region would behave like single spin! In standard physics this is not possible. TGD however leads to a possible realization of this kind of process as a mechanism of psychokinesis (see <http://tinyurl.com/yckq32pv>) [L23].

The hierarchy of effective Planck constants could resolve the paradox. If one has  $\hbar_{eff}/\hbar \simeq E_{ph}/\Delta E \simeq .5 \times 10^{14}$ , the emitted photon would be large  $\hbar$  dark photon with frequency 5 Hz and the energy of visible photon and geometrically would corresponds to a  $n$ -furcation of space-time with  $n = \hbar_{eff}/\hbar$  sheets each carrying single 5 Hz photon. Each dipole pair emits ELF photon but they combine to single dark ELF photon with the energy of single photon.

It seems that it is not natural to assign the photon emission to cyclotron transitions ionic cyclotron B-E condensates or to the transitions associated with the cell membrane Josephson junctions. Also the model based on the observation of Hu and Wu is very attractive. This does not add a completely new element to TGD. One can find a nice connection with one of the TGD inspired basic ideas about genetic code, namely the dark realization of genetic code as sequences of dark protons.

1. About 7 years ago I constructed a model for dark nuclei identifying them as strings of dark nucleons [K65, K48]. The model of dark nucleon yielded a compete surprise: the states of the nucleon were in 1-1 correspondence with DNA, RNA, tRNA, and amino-acids and vertebrate genetic code could be understood in a simple manner. This led to the vision that dark proton sequences allow a virtual world realization of genetic code making possible a kind of R&D department developing and testing various genetic alternatives. The genetic discoveries are however useful only if they can be used. This requires a generalization of transcription process allowing to transcribe DNA and RNA and perhaps even tRNA, and amino-acids to their dark counterparts and vice versa. This requires that dark nucleon sequences have same size scale as ordinary DNA, RNA, and amino-acids and that they could accompany the biomolecules.

This fixes the size scale of dark proton to be of the order of the volume defined by the length  $L$  corresponding to single nucleotide in nucleotide sequence. The value of Planck constant would be of the order  $\hbar_{eff}/\hbar \sim L/r_p \simeq 2.3 \times 10^5$ ,  $r_p = \hbar/m_p \simeq 1.3 \times 10^{-15}$  m and  $L \simeq .3$  nm.

2. At the same time I also constructed a model of DNA and cell membrane acting as a topological quantum computer [K4]. DNA nucleotides would be connected to lipids of the inner lipid layer of the cell membrane by magnetic flux tubes, whose braiding would define the topological quantum computer programs. The braids would continue from the outer lipid layers to

the membranes of other cells and in this manner bind the cells to a kind of network. The strands could have at their ends molecules containing phosphates to make possible transfer of metabolic energy to the system.

3. Dark protons could be generated in the ionization of OH group to  $\text{OH}^-$  as proton drops to dark space-time sheet and possibly becomes a part of dark proton sequences.
  - (a) The basic process would be formation of dark water in this manner and the rich spectrum of anomalies of water could be understood in terms of temperature dependence fraction of dark protons [K32].
  - (b) OH groups are also associated with the hydrophilic ends of lipids such as fatty acids (see <http://tinyurl.com/cqq2nd9>), glycerolipids, and phospholipids, which are the basic structural element of cell membranes. In phospholipids OH is associated with phosphate. In the DNA strand the phosphates contain  $\text{O}^-$  identifiable as  $\text{OH}^-$  resulting when proton of H drops to dark space-time sheet and possibly becomes part of dark proton sequence.
  - (c) Also carbohydrates, in particular sugars, which are basic building brick of metabolism and defined the sugar backbone of DNA and RNA, contain a large number of OH groups. The model of DNA as topological quantum computer led to a proposal that magnetic flux tubes have OH or  $\text{OH}^-$  groups as their ends. These observations would allow magnetic flux tubes have dark protons at either or both ends. According to the earlier proposal [K4] magnetic flux tubes to have OH and O = at their ends. Earlier picture need not to be modified if the cell membrane carries dark double DNA strand connected to the ordinary DNA double strand inside nucleus. Similar connections would be natural also between DNA and amino-acids and their dark counterparts possibly associated with the cell membrane and reconnection of the color magnetic flux tubes could allow to build and manipulate these connections.
4. This would predict that single DNA codon, which corresponds to a length of .33 nm along DNA strand is connected to single lipid by magnetic flux tube or three color magnetic flux tubes to corresponding proton consisting of 3 quarks. This seems to be consistent with the width of single lipid in lipid bilayer if one takes seriously the illustration of the Wikipedia article (see <http://tinyurl.com/yahmx3s7>). Note that in the earlier model single nucleotide was assumed to be connected by a magnetic flux tube to *single lipid*.
5. A further natural working hypothesis is that the proton pairs assignable to the  $\text{OH}^-$  groups at the hydrophilic ends of opposite lipid layers can also be connected by triplets of (color) magnetic flux tubes giving rise to the dipole-dipole interaction. This connection need not be permanent and could disappear or appear by the reconnection of the magnetic flux tubes. This could correspond to the transition to singlet state for proton pairs and would require energy. The working hypothesis of [K4] indeed is that during topological quantum computation the connection is split so that the cell is isolated from external world. The connection would be restored as the computation halts. Photon emission would therefore be seen as a signature of topological quantum computation.

The fact that the proton cyclotron frequency 300 Hz in  $B_{\text{end}} = .2$  Gauss is the only cyclotron frequency above EEG range, one can ask whether biologically important dark ions form cyclotron Bose-Einstein condensates (possibly also Cooper pairs if fermions), dark protons form a cell membrane spin network, and dark electrons arrange to dark Cooper pairs making cell membrane a super-conductor. This would provide a unified picture about the role of various particle in TGD inspired vision about living matter.

### Correlation of photon emissions with the weakening of the Earth's magnetic field

Authors say *During brief periods of imagining white light the power density of photon emissions from the right hemisphere was about  $10^{-11} \text{ Wm}^{-2}$  that was congruent with magnetic energy within the volume associated with a diminishment of  $\sim 7 \text{ nT}$  as predicted by the dipole-dipole coupling relation across the neuronal cell membrane.*



The experiment is to some extent a replication of earlier experiment of [J83] in which it was observed that visible photon emissions mainly from the right hemisphere is accompanied by a weakening of the horizontal component of the Earth's magnetic field. Decreases over 10 to 15 s of 15 nT and 5 nT at 0.25 m and 1 m from the right side of the head of the subject person were associated with the same magnitude of energy ( $10^{-11}$  J) that was associated with the net increase in photon emissions during that period. This energy - assuming each action potential is associated with energy of  $eV_{rest} = 1.9 \times 10^{-20}$  J - would be the equivalent of the activity of about 1 billion neurons.

1. If I have understood correctly, the weakening of the magnetic field outside the head of the subject person would be due to magnetic energy change associated with the spin flips taking place in the cell membrane and absorbing the needed energy from this magnetic field. This would obviously represent a new kind of metabolic activity: magnetic field would provide the needed metabolic energy instead of ATP-ADP process. That magnetic body could directly use its magnetic energy to control biological processes, would mean quite a dramatic modification of the usual view about metabolism.
2. The nuclear magnetization disappears for a moment in a transition from spin triplet to spin singlet state, which then spontaneously decay to triplet state again. The excitation of singlet state requires energy so that the magnetic field outside should weaken if it pays the energy bill. The contribution of magnetic dipoles to the horizontal magnetic field component measured outside the head of the subject person disappears and if the direction of dipole magnetization correlates with the direction of the magnetic field the strength of the magnetic field is reduced. The correlation would guarantee that the magnetic fields from different pairs of dipoles do not interfere to zero. Some kind of ordering of the orientations of neurons perhaps induced by the layered structure of cortex and of the almost collinearity of the myelinated axons of white matter is required.
3. Spin-flip transition from triplet to singlet state would change the contribution of magnetic dipoles to the net magnetic field and thus affect the net magnetic field experienced by a test particle. Could this explain the reduction of  $B_E$  by factor about  $1.8 \times 10^{-4}$ ? At distance of order .1 meter the dipole field created by proton is very small: by a factor  $10^{-21}$  weaker than the 9 nT field created at distance of  $d = 10$  nm. The fields of neurons each containing a contribution of about  $10^{14}$  protons sum up and the estimate is that there are  $10^9$  active neurons. The resulting net factor of  $10^{23}$  could make possible reduction by 9 nT.
4. Triplet-to-singlet spin flip transition taking its energy from the magnetic field is the interpretation suggested by the experiments. The return to the ground state would liberate this energy as large  $\hbar_{eff}$  quanta with energies of visible photons transforming later to ordinary visible photons. Therefore the radiated energy could indeed be magnetic energy also in TGD. Of course, also metabolism might drive particles directly to the excited cyclotron states and is expected provide the energy needed to regenerate the magnetic fields since the energy of visible photons is lost.
5. In TGD Universe the correlation of the photon emission with changes (about 7 nT) in the measured magnetic field identified as the Earth's magnetic field  $B_E$  having nominal value of  $.5 \times 10^{-4}$  T does not force to assign dark photons with the magnetic flux tubes of the Earth's magnetic field.
  - (a) One can of question the assignment of 7 nT weakening to  $B_E$  as a Maxwellian description not applying in TGD framework. The changes of the horizontal component of the magnetic field are detected outside the head of the subject person is it possible to assign this change to any particular magnetic field? How to distinguish between magnetic fields associated with different space-time sheets? TGD predicts that test particles "feel" their sum if these magnetic space-time sheet have projection in the same region of Minkowski space.  
The possibility to move the flux tubes in such a way that only the flux quanta of one particular component of the many-sheeted magnetic field contribute to the projection,

would allow to analyze the field into these components. Note that un Maxwell's theory this is not possible. The change in the measured magnetic field could be induced by a flux tube carrying 7 nT field assignable to the proton spin network and having a projection to the same  $M^4$  volume as a flux tube of the Earth's magnetic field or the endogenous magnetic field has. Therefore it might not be easy to distinguish between changes of  $B_E$  and  $B_{end}$ .

- (b) The experimental findings of Blackman *et al* [J47] about the effects of ELF frequencies on vertebrate brain however encourages an interpretation in terms of cyclotron frequencies for magnetic field in "dark" endogenous magnetic field  $B_{end} \simeq 2B_E/5$  (this predicts that  $Ca^{++}$  cyclotron frequency is 15 Hz, which is not far from 17 Hz). It is of course possible that the flux tubes of the Earth's magnetic field thicken inside the brain so that the strength of the magnetic field is reduced accordingly.

### Can one understand the ELF frequencies involved?

Authors state: *Spectral analyses showed maxima in power from electroencephalographic activity within the parahippocampal region and photon emissions from the right hemisphere with shared phase modulations equivalent to about 20 ms.*

The time scale of 20 ms appears also in the experiments of articles 2 and 3 in which rotating and frequency modulated magnetic fields were applied. This time scale corresponds to 50 Hz frequency, which has been found to have biological effects [J170]. The cyclotron frequency of Lithium (bosonic ion) for  $B_{end} = .2$  Gauss equals to 50.1 Hz (see the appendix of [K20] at <http://tinyurl.com/y75k72xe>).

Authors continue: *Beat frequencies (6 Hz) between peak power in photon (17 Hz) and brain (11 Hz) amplitude fluctuations during imagining light were equivalent to energy differences within the visible wavelength that were identical to the intrinsic 8 Hz rhythmic variations of neurons within the parahippocampal gyrus.*

Can one understand the ELF frequencies involved? In TGD framework (see <http://tinyurl.com/y96stvwg>) [K20] cyclotron states of electrons, protons, and of ions are possible [K20].

1.  $Ca^{++}$  is one important bosonic ion able to form cyclotron Bose-Einstein condensates and the 17 Hz frequency for the power of photon fluctuations could correspond to  $f(Ca^{++}) = 15$  Hz: note that the strength of the endogenous magnetic field is expected to be under homeostatic control and thus vary in some range.
2. 11 Hz frequency is perhaps too far from alpha frequency 10 Hz but rather near to cyclotron frequency 11.4 Hz for  $Mn^{++}$  or 10.8 Hz of  $Fe^{++}$  in the field  $B_{end} = .2$  Gauss (see the appendix of [K20] at <http://tinyurl.com/y75k72xe>).
3. The superposition of effects on test charges caused by MEs associated with 17 Hz and 11 Hz frequencies would give 6 Hz beat frequency. Note that  $K^+$  and  $Cl^-$  (fermionic ions) have cyclotron frequencies 7.5 Hz and 8.5 Hz and their Cooper pairs might relate to parahippocampal 8 Hz frequency.

## 3.3 Second Article

Second article has the title *Demonstration of Entanglement of "Pure" Photon Emissions at Two Locations That Share Specific Configurations of Magnetic Fields: Implications for Translocation of Consciousness.*

In the article [J95] (see <http://tinyurl.com/ycv531ye>) the group reports an excess correlation between "pure" photon emissions at two locations separated by few meters that share specific correlations of frequency modulated magnetic fields. The photon emissions were from chemical reactions.

According to the article's abstract,

The experimental demonstration of non-locality for photon emissions has become relevant because bio-photons are coupled to conscious activity and cognition. The experimental condition that produces doubling of photon emissions from two loci during

simultaneous chemical reactions when exposed to a sequence of circular rotating magnetic fields with differential phase and group angular velocities was applied to photons from LEDs (light-emitting diodes). A significant but weaker enhancement of photon emissions as measured by photomultiplier tubes occurred when the two LEDs were activated simultaneously within two loci separated by several meters. The effect suggests that under optimal conditions photons emitted from two, magnetic field congruent, loci become macroscopically entangled and that the two loci display properties of a single space. Implications for the transposition of consciousness over large distances are considered.

What was observed was enhanced visible photon emission from LEDs subject to the same magnetic stimulation as the cell culture dishes (neurons) in the earlier experiment [J60]. The size of the effect was however smaller. If the effect is real, the presence of organic matter (the cell culture dishes) is not absolutely necessary for the effect although it enhances it. The conclusion of the authors is that photons are carriers of consciousness. TGD inspired interpretation is that the experiment provides support for the identification of magnetic flux tubes as generators of macroscopic quantum coherence.

### 3.3.1 Experimental Arrangement And Results

The article describes first earlier similar experiment [J60] using instead of LEDs chemical reactions occurring in cell culture dishes (neurons) and leading to a doubling of photon emissions serving as a signature for coherence - or entanglement as authors express it. LEDs were motivated by the hypothesis that photon field can be equated with consciousness, and to test this the cell culture dishes were replaced with LEDs. A weaker but significant enhancement of LED emissions is indeed reported.

In the following I shall consider mostly the earlier experiment (see <http://tinyurl.com/yc5wsaww>) [J60] involving cell culture dishes which is identical to the recent one except for the mentioned replacement.

1. The distance between the cell culture dishes was a few meters as was also the distance of the solenoids from the sample located circularly around it. If I have understood correctly, the circular arrangements of solenoids were in parallel planes around the cell culture dishes (neurons) and the solenoids were directed radially to the dishes: otherwise it would not be possible to achieve a rotating magnetic field.
2. Each set of eight solenoids in circular arrangement around the cell culture dish received identical patterns of piecewise constant magnetic fields generated by potentials having 8 different values: the duration of single constant piece was 1 ms. Each solenoid created a magnetic field, whose lines emanating from the end of the solenoid were directed to the center of the cell culture dish.
3. Figure 1 of [J95] (see <http://tinyurl.com/yc5wsaww>) describes the shapes of the AD (accelerating angular velocity, decreasing "phase" modulation) and DI (decelerating angular velocity, increasing "phase" modulation). AD configuration was represented for 8 minutes and followed by DI configuration induced the effect and it occurred immediately after the initiation of DI phase.

Consider now a more detailed description of the AD and DI phases of magnetic stimulation.

1. During AD phase the accelerated rotation of the magnetic field was achieved by creating a magnetic pulse of duration 20, 18, 16, ...,  $T_n = 20 - 2n, \dots$  ms to subsequent solenoids so that only single solenoid contributed to the net magnetic field at any moment. This series was repeated for every rotation of  $2\pi$ . During AD phase the frequency modulation was slowed down meaning the frequency decreased and also this process was same for every rotation of  $2\pi$ . The optimal duration of AD phase was about 4-5 minutes.
2. During DI phase decelerated rotation was achieved by in increasing the subsequent durations by 2 ms so that a series of pulses with durations 18, 20, 22, ...,  $T_n = 20 + 2n, \dots$  ms was obtained. During this period frequency modulation was increased.

3. What “frequency modulation of phase” precisely means? Pictures of AD and DI temporal patterns of voltages (equivalently magnetic fields) fed to the solenoids inducing a series of values of magnetic field are given in **Fig. 2** of [J95] (see <http://tinyurl.com/yc5wsaww>).

A more detailed description can be found from the earlier article by Persinger’s group [J60]. The voltage range  $[-5\text{ V}, 5\text{ V}]$  was discretized to 8 pieces and the possible discretized voltages in this range are represented by 8 bits. The bit patterns were selected so that they were “physiologically patterned”. The value of the magnetic field inside solenoid for  $n$ : th bit was proportional to  $V_n$ . The duration of each voltage was 1 ms - basic frequency of brain synchrony.

During AD pattern a) with decreasing frequency and during DI pattern b) with increasing frequency was used. The numbers of points which composed each pattern were 859 (duration was 859 ms) for AD and 230 (duration of 230 ms) for DI. Only a part of the pattern could be represented since the duration of single  $2\pi$  rotation was 104 ms, which corresponds to 10 Hz, a fundamental bio-rhythm (Unless there was scaling of the bit duration).

4. Within the center of the 8-solenoid configuration the value of the magnetic field averages to  $1\text{ }\mu\text{T}$ . A natural assumption that this magnetic field contributes to the net effective value of the endogenous magnetic field  $B_{end}$  inducing small variations of  $B_{end}$  in turn modulating cyclotron frequencies.

The modulated cyclotron frequency should be higher than frequency of modulation and thus higher than 1 kHz. For  $B_{end}$  this leaves only electron with cyclotron frequency  $f_c = 6 \times 10^5$  Hz under consideration. The effect would be on electron Cooper pairs in the case of cell culture dishes or electrons in the case of LEDs. Electrons are indeed essential also for the function of LED.

5. The frequencies  $f_n = 1/T_n$  defined by the durations of magnetic field vary during AD phase between 50 Hz and 157 Hz. During DI phase the frequencies vary between 50 Hz and 30 Hz. In [J170] it is reported that 50 Hz frequencies have biological effects. As already noticed, 50.1 Hz corresponds to cyclotron frequency for Lithium (bosonic ion) for  $B_{end} = .2$  Gauss.

### 3.3.2 Reconnection Of Magnetic Flux Tubes As A Mechanism Generating Macroscopic Quantum Coherence

A doubling of the rate of emissions of visible photons immediately after the AD phase in the earlier experiment [J60] and weaker enhancement in the recent experiment using LEDs instead of cell culture dishes, is interpreted as a signature of entanglement. Quantum coherence is perhaps a more appropriate manner to express the findings of the two experiments although quantum coherence makes possible also quantum entanglement. To my opinion the experiments provide support for the basic prediction of TGD inspired quantum biology that magnetic flux tubes are generators of macroscopic quantum coherence.

What seems necessary is that some flux tubes emanating from the solenoids must reconnect to form flux tubes connecting the two cell culture dishes or LEDs: reconnection is indeed one of the fundamental processes in TGD inspired theory of living matter. Without reconnection the flux tubes of the two magnetic fields remain disjoint and cannot induce macroscopic quantum coherence. The reconnection can occur only if the temporal and spatial patterns of the rotating and modulated magnetic fields are identical. These flux tube connections would induce quantum coherence by effectively binding the two systems to single system.

The doubling of the photon emission rate in the earlier experiment involving cell culture can be understood by the well-known rule that in incoherent emission the total rate is  $N$  times the individual rate, and in coherent emission  $N^2$  times the individual rate: now  $N$  equals to 2. Also destructive interference becomes possible when the summed amplitudes are in opposite phases. This would reduce the rate below the predicted based on incoherence.

Also the enhancement of the photon emission rate from LEDs in a similar arrangement supports the view that macroscopic quantum coherence generated by the magnetic field patterns is relevant and implies that the amplitudes describing the emission of photons from the two LEDs add coherently with some probability so that constructive or possibly also destructive interference occurs. To make this statement more precise, one would need a detailed quantum model for LEDs.

### 3.3.3 Why AD Followed By DI Is Needed To Induce Enhanced Photon Emissions?

Why should AD period followed by DI period be most effective in inducing photon emissions? Why the flux quanta (flux tubes) do not induce any effects, when the angular velocity is constant and frequency is absent (constant magnetic field)?

1. Accelerated rotation during AD period corresponds at quantum level to an application of magnetic flux tubes from directions  $\phi_n = n \times 2\pi/8$  such that the duration of the pulse is reduced in discrete steps. The process should generate frequencies coming as harmonics of  $f_n = 1/T_n$ . The patterns of magnetic field consisting of periods of constant magnetic field lasting 1 ms and fixed for AD and DI to be “physiologically patterned” determines the Fourier decomposition. The duration of 1 ms brings in harmonics of kHz resonance frequency.
2. The variation of the duration of the magnetic field makes it possible to scan a wide range of resonance frequencies of the cell culture. The process would be like tuning a radio. At special frequencies resonant coupling to the frequency of magnetic field and to the frequency defined by the duration of magnetic field becomes possible and enhanced dark photon emissions take place. If the fundamental frequency were not varied, the effect would occur only for very special pulse durations.
3. Why the visible photons were observed only during the beginning of DI phase? If the emitted photons were dark having very long wave length but energy of visible photon, they would not have been detected during AD phase. The decay of dark photons after the beginning of DI phase to bunches of ordinary photons could explain the observed enhanced emissions of visible photons.

### 3.3.4 Why The Magnetic Pulses From A Given Direction Arrived With Frequency Of 10 Hz?

The magnetic pulses arriving from a given direction to the cell culture dish/LED came with a frequency of 10 Hz. That a fundamental biorhythm is in question, cannot be an accident. In TGD framework 10 Hz frequency corresponds to the secondary p-adic time scale assignable to electron and defines the size scale of causal diamond assigned with electron. This conforms with the assumption that electronic Cooper pairs are fundamental for consciousness serving also as carriers of super-current through cell membrane. In fact, all elementary particles correspond in zero energy ontology to macroscopic time scales via the secondary p-adic time scales associated with them and for quarks the time scales correspond to frequencies of order 10 ms.

## 3.4 Third Article

Third article has the title *Experimental Demonstration of Potential Entanglement of Brain Activity over 300 Km for Pairs of Subjects Sharing the Same Circular Rotating, Angular Accelerating Magnetic Fields: Verification by s-LORETA, QEEG Measurements*.

In the third article (see <http://tinyurl.com/ya4yb6bc>) [J96] the group reports excess correlation of brain activity of individual subjects separated by 300 km and sharing the same circular rotating, angular accelerating magnetic fields.

According to the article’s abstract,

in order to test the presence of excess correlation, or entanglement, pairs of subjects separated by 300 km were either exposed or not exposed to specific configurations of circular magnetic fields with changing angular velocities that dissociated the phase and group components. When one person in the pair was exposed to sound pulses but not to light flash frequencies within the classical electroencephalographic band, there were discrete changes in power within the cerebral space of the other person even though they were not aware of the stimulus times and separated by 300 km. The intra-cerebral changes that only occurred if the magnetic fields were activated around the two cerebrums simultaneously were discrete and involved about single, punctate volumes of

about 0.13 cc (125 mm<sup>3</sup>). The potential energy from the applied magnetic field within this volume was calculated to be about  $6 \times 10^{-14}$  J and with an average brain power frequency of 10 Hz would result in  $6 \times 10^{-13}$  W. Assuming  $\pi \cdot 10^{-2}$  m<sup>2</sup> for the surface area of the cerebrum, this is equivalent to  $\sim 2 \cdot 10^{-11}$  Wm<sup>-2</sup>. This power density is the same order of magnitude as that associated with photon emission during cognition. Given the average of  $6 \times 10^6$  neurons per 125 mm<sup>3</sup>, the induced energy is equivalent to about  $10^{-20}$  J per neuron. This value can be considered a quantum of universal energy and would be congruent with a condition that could promote non-locality.

### 3.4.1 Experimental Arrangement And Results

If I have understood correctly, the experimental arrangement was roughly following.

1. Two individual subjects were involved. The second subject was 300 km away. The other subject received stimuli at various frequencies of sound or flashes of light while the first person was unaware of these stimuli. Both members of the pair were exposed to a rotating, circular magnetic field whose frequency modulation would vary with rotation angle. This guarantees that the phase and group velocities of the magnetic field varied and were different.
2. It seems safe to assume that the magnetic field pattern used to stimulate brains of subject persons was identical with that applied in the second experiment.

Authors report a correlation between individual subjects in the sense that there were discrete changes in EEG power within the cerebral space of the second person even if he/she was not aware of the stimulus. The effect occurred only if the phase and group velocities assignable to the magnetic field were different. Authors interpret this as entanglement identified as excess correlation if the fields were activated around cerebrum simultaneously and were discrete and involved about single punctuate volumes of about 125 mm<sup>3</sup>. Entanglement in this sense need not correspond to quantum entanglement although it could make it possible.

Authors introduce what they call quantum universal energy  $E = 10^{-20}$  J, and estimate the that this is the induced energy per neuron transferred from the magnetic field to energy of EEG. In particle physicist's units this gives  $E = 6.24 \times 10^{-2}$  eV. This would naturally correspond to energy gained by electron or proton in the resting potential  $E_{rest}$ , which is above  $E_{min} = 6.15 \times 10^{-2}$  eV. Note that threshold potential for nerve pulse generation corresponds to energy  $E_{thr} = 5.5 \times 10^{-2}$  eV. On the other hand, also the first experiment and predecessor of the second experiment involved visible photon emissions which suggests that also visible photons were emitted and they came from the transitions of the proton spin network associated with cell membrane proposed by Wu and Hu [J120].

### 3.4.2 TGD Based Interpretation

TGD interpretation should rely on the notion of magnetic body and a model for neuronal membrane as a super-conductor - at least electronic but possibly also ionic super-conductor), cyclotron Bose-Einstein condensed of biologically important ions, and the spin network of dark protons associated with the cell membrane discussed in TGD based model for the outcome of the experiment described in the first article.

1. The flux tubes of the rotating magnetic field would connect the subject persons into a single coherent unit reacting to the stimuli posed to second subject like a single unit. TGD assigns to the magnetic bodies large effective value of Planck constant so that photons with energies of order  $E$  would correspond to much longer wavelengths essential for the coherence in scales of the order of a few wave lengths.
2. The wave length  $\lambda = 300$  km could correspond to the Planck constant  $\hbar_{eff} \simeq \lambda/\lambda_0 = 1.5 \times 10^{10} \times \hbar$ , where one has  $\lambda_0 = c/E\hbar \simeq 20$   $\mu$ m is the wavelength of photon with "quantum universal energy". This energy is in IR region just around thermal threshold. The corresponding period and frequency are  $T = c/\lambda = 1$  ms and  $f = 1$  kHz, which correspond to fundamental time scales for cell membrane with 1 ms defining the time scale of nerve pulse

and 1 kHz defining an important resonance frequency in brain associated with the generation of coherence. Probably this is not an accident. The authors indeed mention that the effect is maximal at distance of 300 km.

Concerning the detailed interpretation of the experiment there are several options. First, TGD suggests two alternative models for cell membrane as Josephson junction involving currents of electron Cooper pairs and possibly also bosonic ions or Cooper pairs of fermionic ions. For the conservative option the cell membrane would be far-from- vacuum extremal carrying strong induced Kähler field. For the non-conservative option the cell membrane would be near-to-vacuum extremal making it maximally sensitive to sensory input. Secondly, the universal quantum suggests emission of dark IR photons, whereas the emission of visible photons associated with cognition suggests visible photons.

1. The “quantum universal energy”  $E = eV_{rest} = 6.24 \times 10^{-2}$  eV would naturally correspond to the energy gained by electron or proton in a membrane potential slightly above the threshold potential. Also the conservative option for cell membrane as Josephson junction would predict Josephson radiation emitted at multiples of Josephson frequency  $E = eV_{rest}$  or  $E = eE_{thr}$ .
2. The non-conservative option for the cell membrane as Josephson junction predicts that the emitted photons have visible energies. This option might be realized for photoreceptors in retina, which react to the sensory stimulus by variation of membrane potential instead of nerve pulse. The correlation of cognition with the emission of visible photons also allows one to consider the possibility that some neurons are near-to-vacuum extremals (also glial cells as cells which do not generate nerve pulses could be such). Since visible photon emissions are mostly from the right hemisphere, one can ask whether the emissions from the left hemisphere are in IR region and those from right hemisphere in visible region and whether the different ground states of neurons as far-from- respectively near-to- vacuum extremals could distinguish between right and left hemisphere.
3. How does the spin network model based on dark proton strings relate to this? Since the photons have biological functions, the energies of all kinds of EEG photons should be in the same region of spectrum: visible or IR for a given hemisphere. For near-to-vacuum extremals the argument of Hu and Wu would be modified by replacing ordinary magnetic field with a combination of  $Z^0$  magnetic field and ordinary magnetic field. This would imply that the energy scale would increase just as it does when  $Z^0$  electric field dominates over em electric field. Therefore also the photons emitted by spin network at the right hemisphere would be dark EEG photons with energies of visible photons.
4. An alternative interpretation encouraged by the photon emission associated with cognition is that  $\lambda_0$  corresponds to the energy of visible photon resulting in the transformation of dark ELF photon produced in the triplet-to-singlet transition of proton pair associated with the cell membrane as described in the interpretation of the first experiment. For a photon with energy 1.77 eV at the red end of visible spectrum this would give  $\hbar_{eff} = 4.3 \times 10^{11}$ . Interestingly, Cyril Smith [J43] reports on the basis of his own experimentation that the transformation of low energy photons to high energy photons and vice versa takes place for frequency ratio  $f_h/f_l = 2 \times 10^{11}$ : the interpretation would be also in this case in terms of  $\hbar_{eff}$  [K48].

### 3.5 Conclusions

The results of the experiments of Persinger *et al* can be understood in the framework of TGD and the findings allow to develop a more precise view about the role of dark electrons, protons, and ions in TGD inspired quantum biology.

1. The identification of the magnetic flux quanta connecting two systems as generators of macroscopic quantum coherence finds experimental support.

2. The proposal of Hu and Wu about proton spin networks associated with cell membrane has a TGD counterpart in terms of dark proton strings allowing interpretation as dark DNA. The spin-paired protons are assigned to the hydro-philic ends of the two lipids in the layers of the cell membrane and the dark proton strings define an analog of DNA double strand. The model of Wu and Hu is subject to the same objections as the model for cyclotron Bose-Einstein condensates and is circumvented by introducing the hierarchy of effective Planck constants.
3. The fact that photon emissions are detected only from the right hemisphere suggests that both options for the cell membrane as Josephson junction are realized: far-from-vacuum extremal option for the neurons of the left hemisphere with emissions in infrared and near-to vacuum extremal for the neurons of the right hemisphere.

To sum up, the resulting framework allows an overall view about the roles of both dark electrons, dark protons, and dark ions in quantum biology according to TGD.



## Chapter 4

# Emotions as sensory percepts about the state of magnetic body?

### 4.1 Introduction

What emotions are? How emotions are created? How are they represented: in brains, at body, or perhaps somewhere else? One can consider these questions from the point of view of neuroscience, endocrinology, and quantum physics. Emotions can be divided to lower level emotions accompanied by intention/need/desire (hunger is accompanied by the need to eat) and thus distinguishing them from sensory qualia whereas higher level emotions like catharsis and the experience of beauty not accompanied by any desire. What does this division correspond to?

TGD inspired answer to the questions is following.

1. Emotions are sensory percepts about the state of magnetic body (MB). Also sensory-motor loop generalizes: various glands excreting hormones to blood stream and binding to receptors give rise to the analog of motor output. Neural transmitters binding to receptors serve as bridges allowing to build connected networks of neurons from existing building bricks. They are accompanied by flux tube networks giving rise to tensor networks [L60] as quantum coherent entangled structures serving as correlates of mental images, and allowing classical signalling with light velocity using dark photons. In a similar way hormones would give rise to active networks of ordinary cells accompanied by tensor networks. Nervous system gives information about the state of these networks to brain and hypothalamus serves as the analog of motor cortex sending hormones controlling the excretion of hormones at lower level glands.
2. Emotions are sensory percepts about the state of magnetic body (MB) rather than those of biological body (BB). Also sensory-motor loop generalizes: various glands excreting hormones to blood stream and binding to receptors give rise to the analog of motor output.

Consider first neuronal level. Neural transmitters binding to receptors serve as bridges allowing to build connected networks of neurons from existing building bricks (flux tubes associated with axons in the case of nervous system) and accompanied by flux tube networks giving rise to tensor networks as quantum coherent structures serving as correlates of mental images and allowing classical signalling with light velocity using dark photons. These tensor networks represent our mental images only if they correspond to our sub-selves [L100].

In a similar way hormones would give rise to tensor networks of ordinary cells accompanied by flux tube networks giving rise to quantum coherent structures, tensor networks serving as correlates of emotional mental images. Nervous system mediates information about the state of these networks to brain. Hypothalamus serves as analog of motor cortex excreting hormones controlling the excretion of hormones at lower level glands.

3. The hierarchy of Planck constants defines a hierarchy of dark matters and  $h_{eff} = n \times h$  defines a kind of IQ. The levels of MB corresponding to large/small values of  $n$  would correspond to higher/lower emotions.

MB decomposes to two basic parts: the part in the scale of BB and formed by networks having cells and larger structures as nodes (forming a fractal hierarchy) and the part in the scales larger than BB.

1. In the scales of BB (short scales) the dynamics involves topological dynamics of the flux tube network and sensory percepts can be accompanied by conscious-to-us desire to change the state of MB and thus of BB and could be seen as intentions induced by the comparison between what happened and what were the expectations. The outcome would be state function reduction replacing the behavioral pattern with a new one giving better hopes for achieving the goal. In zero energy ontology (ZEO) behavioral pattern is represented as quantum superposition of 4-D MBs so that time aspect is naturally involved with emotions.
2. In the scales larger than that of BB (long scales) the change the topology is not easy and the dynamics involves oscillations of MB - analogs of Alfven waves - and analogs of ordinary motor actions changing the shape of flux tubes but leaving its topology unaffected (these actions might represent or serve as templates for ordinary motor actions in body scale [K108]).

Alfven waves with cyclotron frequencies and generalized Josephson frequencies assignable to cell membrane as Josephson junction [K86, K33] would be involved. The size scale of particular onion-like layer of MB corresponds to the wavelength scale for cyclotron frequencies and is proportional to  $\hbar_{eff}/h = n$  for dark photons. For instance, alpha band in EEG corresponds to the scale of Earth but the energy scale of dark photons is that of bio-photons.

The TGD inspired model of music harmony [L31] gives as a side product a model of genetic code predicting correctly the numbers of codons coding for aminoacids for vertebrate code. The model allows to see sensory percepts about the dynamics in large scales as analog of music experience. The notes of 3-chords of the harmony correspond to light as dark photons and frequencies defining the notes of the chord: cyclotron radiation and generalized Josephson radiation from cell membrane would represent examples of dark light. Music expresses and creates emotions and music harmonies would correspond to various emotional states/moods realized at the level of DNA and its dark counterpart (dark nuclei represented as dark proton sequences). MB would be like a music instrument with flux tubes serving as strings. It is difficult to assign any specific desire to large scale sensory percepts about MB and the interpretation as higher emotions - or rather feelings - makes sense.

## 4.2 Background

### 4.2.1 Some background from evolution

It is good to list some basic data from evolution of nervous system (see <http://tinyurl.com/yabt4fhy>) first.

- Bacteria have no nervous system but already they are capable of simple sensory perceptions. Bacteria can move to the direction where the concentration of nutrients increases so that they probably perceive the concentration of nutrients. The feelings of hunger and satiety are perhaps the most primitive emotional states, one can think that these emotions/feelings were possessed also by bacteria. The need to get food is associated with hunger and it seems that the lower emotions induce desire/intention leading to goal directed behavior.
- Ladder-like nervous system is a primitive nervous system possessed by invertebrates and has at its end a bulge - ganglion - representing primitive brain. Anthropods, which include insects, belong to this class of animals.
- Brainstem and cerebellum developed from the ganglion and gave rise to what is called lizard brain. Brain stem controls the functioning of heart, lungs, stomach and other organs and cerebellum controls motor activities. Since the cortex allowing to decompose visual field into objects is missing, vision must be very primitive - including however detection of motion and distance for the target of attention. Maybe there is just the target of attention instead of the decomposition of the perceptive field into objects. Olfaction, hearing, and vision work together to identify the target of attention.

- Chordata (see <http://tinyurl.com/63af3ag>) consist of urochordata and cephalochordata preceding vertebrates.

**Remark:** Vertebrates have EEG, which must be a significant difference. In TGD framework scaled up variants of EEG are in principle with higher frequency ranges are possible with similar structure and correspond to smaller value of  $h_{eff}/h = n$ .

- Limbic system (see <http://tinyurl.com/ny2e8ff>) defines what is known as emotional brain. It contains hypothalamus as an analog for the highest motor areas in cortex. Hormone excretion is the tool of control. Using this tool hypothalamus controls the hormone excretion of lower level glands in brain and body in turn controlling the state of body. Hormone levels correlate strongly with emotions [J46].
- At the top is cortex containing sensory, motor and associative regions.

#### 4.2.2 Some background from neuroscience and endocrinology

Also some data bits in neuroscience and endocrinology dealing with the endocrine system, its diseases, and its specific secretions known as hormones are in order. Endocrine system forms only part of cell signalling (see <http://tinyurl.com/yckwaaob>). One can classify the signalling according to the range of signals. Intracrine signals stay in target cells, autocrine signals affect the cell itself or of nearby cells via receptors. Juxtacrine signals affect adjacent (touching) cells. Paracrine signals target cells in the vicinity of the cell: nerve pulses correspond to this kind of signalling. Endocrine signals target distance cells and hormones reaching their target via blood stream serve as signal molecules.

**Remark:** In TGD framework the term “signal molecule” is misleading. Signal molecules bound to receptors would only serve as bridges/relays giving rise to networks in which dark photon signals would propagate and make possible classical communications. Also quantum entangled structures - tensor networks - would be formed.

1. Limbic brain (see <http://tinyurl.com/ny2e8ff>) would be the neural part for the system behind emotions and serve as the analog of cortex participating the neural processing related to emotions. Neural information would arrive from body to brain via nervous system and the analog of motor response from limbic brain would be based on endocrine system using hormones as a control tool (<http://tinyurl.com/l2pstuv>) .
2. Endocrine system (see <http://tinyurl.com/l2pstuv>) involves several feedback loops via hypothalamus and pituitary. Hypothalamus plays a role analogous to that of the highest motor areas in cortex. Emotions are expressed via excretion of hormones by hypothalamus (see <http://tinyurl.com/hdt5t8g>) and the hormones from hypothalamus control the excretion of hormones by lower level glands. Besides hypothalamus also pituitary gland and pineal gland are brain glands.

The four most important glands outside brain are pancreas, ovaries/testes, thyroid gland, parathyroid gland, and adrenal glands: together with 3 brain glands this makes altogether 7 glands. Interestingly, this happens to be the number of chakras in the Eastern medicine. Besides this there are many other hormone secreting organs. The so called diffuse endocrine system involves hormone emitting cells heart muscle and epithelial cells in gut. Immune system excretes hormone and also skin can be regarded as a gland.

3. Hormones (<http://tinyurl.com/znk4tzn>) are used to communications between organs and tissues for physiological regulation and behavioral activities. Hormones have diverse chemical structures, most of which belong to 3 classes: eicosanoids, steroids, and amino acid/protein derivatives (amines, peptides, and proteins).

All vertebrates possess hypothalamus (see <http://tinyurl.com/hdt5t8g>). Hypothalamus is located below thalamus and serves as a link between neural system and endocrine system and regulates certain metabolic processes and other activities of the autonomic nervous system. Hypothalamus synthesizes and releases neural hormones in turn stimulating or inhibiting the secretion of pituitary hormones in turn controlling the secretion of hormones in lower level glands.

Hypothalamus controls body temperature, hunger, important aspects of parenting and attachment behaviors, fatigue, sleep and circadian rhythms. Hypothalamus consists of several nuclei. Hypothalamic-pituitary-adrenal axis is a complex set of direct influences and feedback between hypothalamus, pituitary and adrenal glands located in kidneys. Delta waves (in EEG) with frequencies in the range (.5,4) Hz - usually thought to arise either in cortex or thalamus - controls excretion of neural hormones from hypothalamus.

**Remark:** In TGD framework delta waves would be associated to the control by MB. Note that delta waves do not correlate directly with the contents of consciousness.

Endocrine system controls physiology and there are good reasons to think that at least some hormones are closely related to the control of simple emotions such as satiety, pleasure, hunger, fatigue, fear, aggression, and rage. Not all emotions involved need to be conscious to us. For instance, at the neural side autonomous part of the neural system is unconscious to us.

**Remark:** TGD inspired theory of consciousness [L100] predicts self hierarchy. The sub-selves of self give rise to mental images of self. Sub-sub-...-selves contribute a diffuse background to the experience of self. Emotions could correspond to this kind of background.

The book “Molecules of emotion” by Candace Pert [J46] gives a nice representation about peptides as molecules of emotions. Dopamine is one peptide acting both as both neural transmitter and hormone and positive emotions accompany its excretion.

### 4.2.3 What emotions are and how do they emerge?

#### Basic facts about emotions

One learns from Wikipedia (see <http://tinyurl.com/7ml7vcs>) that there is almost endless variety of theories of emotion. For instance, in Scherer’s components processing model of emotion, five crucial elements of emotion are said to exist:

- Cognitive appraisal: provides an evaluation of events and objects.
- Bodily symptoms: the physiological component of emotional experience.
- Action tendencies: a motivational component for the preparation and direction of motor responses.
- Expression: facial and vocal expression almost always accompanies an emotional state to communicate reaction and intention of actions.
- Feelings: the subjective experience of emotional state once it has occurred.

This definition of emotion includes as its aspects cognitive processing (neural feedback), physiological correlates (hormone excretion), action tendencies (intentions/needs/desires/drives), bodily expression of emotion, and feeling. This classification assigns physiological activation patterns to all emotions (what about “higher” emotions?). Feeling forms only one aspect of emotion.

It has been also proposed that there are 6 basic emotions: anger, disgust, fear, happiness, sadness and surprise. One can wonder why pleasure and psychological pain are not counted as basic emotions: maybe they are associated with happiness and sadness. Neither hunger and satiety are included: since hunger induces goal directed behavior, it would seem natural to count it as emotion rather than sensory experience. It seems possible to assign to emotions positive/negative coloring, which would allow to see them as pairs analogous to pairs of color and complementary color.

Personally I would call emotions inducing desires primitive emotions perhaps possessed already by the simplest organisms - even those without a nervous system. Certainly I would not try to reduce higher level emotions such as experience of beauty to these primitive emotions.

One can also distinguish emotions using as a criterion the time scale involved: feelings, moods, temperament, personality describe these time scales in increasing order.

1. Primitive emotions represent information in a very concise form. Just a single bit represented as emotional coloring of experience as positive or negative is enough and if it is

negative/positive it induces an intention to change/continue the behavior. A very complex unconscious information processing can give rise to this bit and intuition and emotional intellect could summarize the outcome of this kind of processing.

**Remark:** In TGD framework this unconscious information processing could be assigned to the levels of self hierarchy below sub-selves identified as mental images.

2. It seems that simple emotions induce the need or desire to do something, an intention. This would naturally relate to the comparison of the expected state to the perceived one. If the result is not expected, the desire to change something is created: hunger  $\rightarrow$  need to eat. Computer scientist would tend to see us as collection of behavioral programs (habits and routines) and emotional coloring would suggest how to change the routine to possibly achieve the desired result.
3. Low level emotions are holistic meaning that the physiological correlates cannot be localized in particular body part. One might however argue that a person fallen in love localizes this feeling with heart. Also hunger (if counted as emotion rather than sensory experience) can be localized to stomach. In any case, emotions as mental images would be holistic and physiologically assignable to a rather large part of body. One can argue that higher level emotions such as feeling of beauty cannot be localized to body.
4. There are also experiences what one might call higher level emotions and they perhaps relate to emotional intellect and intuition. They can be created in by many ways: say by art: catharsis - experience of beauty - or by meditation - experience of bliss. It is difficult to associated this kind experiences with particular physiological events. Interestingly these emotions do not seem to induce any desire or intention.

Music creates this kind of emotions. Simplest emotions are feeling of joy and sadness correlating with the harmony of music but in general music harmony defies characterization in terms of language and in terms of emotions of real life. To my opinion this correlation is a valuable guide line as one tries to understand correlates of emotions and feelings.

### Are emotions percepts or analogs of motor actions?

Concerning the generation of emotions there has been debate between proponents of two alternative visions.

1. Brain expresses emotions using body as a tool so that emotions (e-motion) would be analogous to motor activities. The problem is that emotions are not intentional actions and one cannot control them. The explanation could be that the activities generating emotions are unconscious to us. This argument might make sense: we have autonomic nervous system too.

**Remark:** In TGD framework self hierarchy could solve the problem. An action unconscious would be conscious at some lower level of the self hierarchy. Emotions would be our perceptions about what has happened at lower levels of self hierarchy and the outcome would be statistical.

This view is supported by the existence of endocrine system. Glands excreting hormones would generate the emotions as analogs of motor actions. Hormones diffuse via blood circulation and induce emotional expression. Hormones serve as molecules of emotion and information. Hypothalamus plays the role of the highest motor area controlling by hormones the hormone expression of lower glands.

Hypothalamus, pituitary, and pineal gland are brain glands. The glands in body can also control emotions. In particular, heart muscles and epithelial cells in gut could independently express emotions by emitting hormones. Reflex action serves as an analogy for this.

2. Philosopher James proposed an alternative interpretation: body produces emotions and brain perceives them: this would explain why emotions are not under volitional control. This interpretation as such has been show to be wrong by an experiment in which the generation of physiological correlate of emotion was prevented in gut: the emotion was however felt.

It is however true that there is neural feedback giving information about the physiological state.

Candace Pert proposes in her book [J46] a compromise between these views. There is the analog of sensory-motor loop involved and one cannot actually say that emotion would be associated with brain or with body: it is assignable to both of them.

**Remark:** Quite recent observation (see <http://tinyurl.com/pzfhw9d>) is that so called vagus nerve traverses all organs and couples nervous system, endocrine system, and immune system together. In TGD picture this nerve would build bridges between neurons of these systems and couple them to single quantum coherent system and allows communications with dark light between these organs.

### 4.3 TGD based interpretation for emotions

In TGD framework the interpretation of the transmitters involved (such as hormones) would not be as signal but as a tool creating the channels making signals propagating with light velocity (dark photons transforming to ordinary photons identified as bio-photons) and giving rise to quantum coherent active networks of cells (tensor networks) giving rise to conscious entities at some level of self hierarchy and possibly our mental images as sub-selves.

Signal molecules bound to receptors would act as small bridges connecting existing pieces of network to larger networks. These pieces would be flux tubes associated with axons in the case of nerve pulse transmission and neurotransmitters would give rise to the bridges. Synchronous neuronal firing would be a signature of the connected flux tube network. In [L87] and [L85] TGD inspired view about nervous system is discussed. This view has a natural generalization to the case of other signalling systems.

The dynamics for the topology (reconnections, braiding) of MB would induce the dynamics of biomolecules, cells and larger structures at the nodes of the fractal network.

#### 4.3.1 Basic notions of TGD inspired quantum biology

It is good to list the basic notions of TGD inspired biology once again. They are magnetic body (MB), dark matter as  $h_{eff} = n \times h$  phases of ordinary matter with  $n$  having non-standard value having first principle description in terms of adelic physics [L98], and zero energy ontology (ZEO).

1. The basic distinction between TGD and Maxwell's electrodynamics and gauge theories is that every system as field identity in TGD Universe as separate space-time sheets, topological field quanta correspond to magnetic flux sheets or tubes and also to electric field has topological quanta. This follows from the notion of induced gauge field. In Maxwell's theory fields of different systems interfere, in TGD they correspond to separate space-time sheets but particle experiences the sum of the forces caused by them since it touches these space-time sheets.

This forces the replacement organism + environment  $\rightarrow$  magnetic body (MB) + organism + environment. MB receives sensory input from biological body (BB) and controls BB. Sensory input to MB can be in terms of generalized Josephson radiation from cell membrane acting as generalized Josephson junction and coding nerve pulse patterns to frequency modulations. The control by MB can be realized in terms of cyclotron radiation to DNA (accompanied by what I call dark DNA [L52]).

2. The hierarchy  $h_{eff} = n \times h$ ,  $n = 1, 2, 3, \dots$  of Planck constants gives rise to a hierarchy of dark matters.  $h_{eff} = n \times h$  labels the onion like layers of MB. The size scale of give layer is by uncertainty principle of order of cyclotron wavelength  $\lambda \propto m/eB$  and thus proportional to particle mass  $m$ . The value of Planck constant determines the hierarchy level:  $n$  measures the complexity of the algebraic extension associated with the dynamics as dimension of extension of rationals involved with the dynamics at basic level, and serves as a kind of IQ. Evolution corresponds to a gradual and unavoidable increase of  $h_{eff}/h = n$  in statistical sense.

- (a) At the atomic level the value of  $n$  seems to be  $n = 6$  rather than  $n = 1$  [L92, L62]. For valence bonds the value of  $n$  is already larger and increases along the rows of the

periodic table being largest for the molecules containing atoms towards the right end of the period: biologically important atoms C, N, O, S, P are examples associated with valence bonds with large  $n$ .

- (b) For protons at hydrogen bonds the value of  $n$  is much higher than for electrons of valence bonds and the generation of hydrogen bonds could be seen as a crucial aspect of bio-chemistry. Metabolic energy is measured as the difference of the energy of bond for ordinary value of  $\hbar_{eff}$  from the real one and one can say that metabolic energy provides for the system ability to increase its negentropy. Metabolic energy increases  $\hbar_{eff}$  resources: this is why we must eat.
- (c) An important additional hypothesis generalizes the notion of gravitational Planck constant due to Nottale [E1]. The hypothesis [?, K78] states that at the flux tubes mediating gravitational interactions (propagation of gravitons) one has

$$\hbar_{eff} = n\hbar = \hbar_{gr} = \frac{GMm}{v_0} ,$$

where  $M$  and  $m$  are the masses associated with the ends of the flux tube and  $v_0 < c$  has dimensions of velocity. This formula holds true if  $Mm/v_0$  exceeds Planck mass squared and implies that the coupling parameter  $GMm$  in perturbation series is replaced with  $v_0/c < 1$  so that one achieves convergence.

For large values of  $M$  the value of  $\hbar_{gr}$  can be very large, which means that long range gravitational interaction can give rise to systems with very high cognitive resources. This hypothesis generalizes also to other interactions in rather obvious manner and the phase transition increasing the value of  $\hbar_{eff}$  leads to dark phase in which perturbation theory converges (the value of the coupling strength  $\alpha \propto 1/\hbar_{eff}$  is reduced).

The value of  $M$  depends on the state of the network defined by the flux tubes mediating gravitational interaction. At the limit of ordinary quantum gravity  $M$  would be mass of elementary particle. There is however entire dynamical fractal hierarchy of gravitational flux tubes completely analogous to those postulated flux tube hierarchies in neural system and in endocrine system. For instance, the fountain effect of superfluidity could correspond to a situation involving large value of  $\hbar_{gr}$ . In living matter the mass of large neuron is of order Planck mass and defines kind of critical mass in the sense that gravitational interaction between two large neurons could correspond to  $\hbar_{gr}$ .

3. Zero energy ontology (ZEO) essential for TGD inspired theory of consciousness is the third basic notion. In ZEO quantum states have as classical correlates 4-D space-time surfaces rather than time=constant snapshots of time evolution as in standard physics. They can be identified as preferred extremals of action principle analogous to Bohr orbits. Following biologists and neuroscientists one could speak about the generalization of the notion of behavioral pattern or biological function. Computer scientist talks about programs.

The act of free will is analogous to a replacement of a deterministic program with a new one in ZEO. ZEO is actually forced by the acceptance of the fact that we have free will which must be consistent with the determinism of field equations. At quantum level, classical program as preferred extremal is replaced with a quantum superposition of classical programs, which in some resolution cannot be distinguished from each other.

System must have sensory percepts about the state of MB. If the percept is not consistent with the expectation, the perception is accompanied by negative emotional coloring.

### 4.3.2 Sensory perceptions as artworks

TGD view about neural system differs in several aspects from that of neuroscience.

1. Sensory organs are assumed to serve as carriers of sensory percepts: qualia [K44] are not associated with sensory areas but with sensory organs [L84, L87]. ZEO providing a new view about time and memory allows to solve the basic objection related to phantom limb phenomenon: pain in phantom limb would be sensory memory and realized as 4-D sensory percept having contributions from geometric past.

2. The distinction between experienced time - identified as a sequence of small state function reduction identifiable as analogs of weak measurements (generalized Zeno effect) - and geometric time identifiable as distance between the tips of causal diamond (CD) is essential for understanding this view about memory [K9].
3. 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 standardized 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 dark photon signals propagating with maximal signal velocity between brain and sensory organs are suggestive [L87]. Dark photons decay to ordinary photons in energy conserving manner and identifiable as bio-photons and having energy spectrum in visible and UV range [K14, K23].
4. 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  $\hbar_{eff}/\hbar = n$ ) transforming to biophotons in an energy conserving manner. 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.
5. This picture leads to a concrete proposal [L84, L87] about the roles of DMT and pineal gland concerning imagination and dreams and hallucinations. Pineal gland would indeed serve as third eye (it serves quite concretely as an eye in some lower organisms) but receives dark photon radiation from MB. This give rise to imagined sensory percepts. DMT attaching to the receptors can lead to continuation of flux tubes down to sensory organs and this in turn would generate sensory percepts identifiable as dreams, hallucinations, psychedelic experiences, mystic experience, even encounters with extraterrestrial life-forms.

### 4.3.3 Emotions as sensory percepts about the state of MB

The model of emotions relies on the identification of sensations as sensory percepts about the state of magnetic body so that the same mechanisms would be involved. In particular, the percepts at the level of brain would involve iterative fourth-and-back signalling using dark photons building emotions as standardized mental images.

Consider first the view about sensory perceptions and motor actions.

1. One can argue that ordinary sensory percepts are basically observations about the state of BB. For instance, retina is part of body affected by the incoming light signal. Nerve pulses from sensory organs generate transmitters, which produce bridges connecting existing flux tubes to connected flux tube networks assignable to networks of active neurons. The activity manifests as synchronous firing. This makes possible communications with light-velocity and quantum entanglement for the network possible so that it become tensor network [L60]. These network give rise to sensory mental images representing objects of the external world.

**Remark:** Cortex is essential for this process: this would mean that organisms without cortex should not be able to decompose perceptive field to objects. Is midbrain able to achieve targeted attention to some feature of perceptive field and how much does the information processing in retina contribute? Note that frogs have no cortex and are able to perceive only the motion of the target and presumably also its distance.

2. Motor action can be seen as a response to sensory percept. In ZEO motor action has interpretation as time reversed sensory perception mathematically. This is suggested by Libet's classical discovery [J31] that the decision to perform motor action is preceded by neural activity in brain. TGD based interpretation is that the decision induces a classical signal



proceeding to geometric past or that it replaces superposition of space-time surfaces with a new one so that the “average” geometric past changes.

This view generalizes to emotions.

1. Emotions would be seen as sensory percepts about the state of MB rather than that of BB. For the part of MB inside BB the topology of MB is under continual change and lower level emotions would characterize the state of this part of MB. Not all these emotions need be conscious to us and this might relate to diffuse de-localized character of emotions. The most important contribution to the bodily emotion would come from the dynamical pattern for the topology of MB regarded as 4-D object in ZEO.

Also now emotional mental images would be assignable to MB and would naturally be artworks involving forth-and-back signalling with light-velocity.

2. Hormones as molecules of emotion excreted to blood flow as an analog of motor response would replace neural transmitters and serve as bridges allowing to build networks of cells and possibly larger structures. Hormones would serve as tools for changing the topology of the network in body length scales and the topology would depend on the distribution of hormones. One would have the analog of sensory-motor loop involving feedback in terms of neural signals.

Hypothalamus would serve in the role of motor area in cortex and control other glands by excreting hormones controlling their hormone excretion. The neural input to brain and eventually to limbic brain would lead to the hormonal response of hypothalamus and other glands. Also MB would control the response.

As already noticed, delta waves in frequency range  $[.5, 4]$  Hz (not correlating directly with our conscious experience) are involved with the control the excretion of hormones from hypothalamus. Neuroscientist would assign these waves to cortex and thalamus, In TGD framework these waves would come from appropriate layer of MB but could have also brain counterparts since the interaction between MB and BB requires resonance and therefore same frequencies [L110].

3. The connected networks of cells - or more precisely, their 4-D time evolutions as space-time surfaces analogous to Bohr orbits - would give rise to emotional mental images. The 4-D nature of basic objects could explain why emotions involve temporal aspect. Their size scale of networks would be typically rather large so that emotions or more precisely feelings associated with them would be holistic and would not allow localization to any part of body. In smaller scales they would be probably unconscious to us: this could provide an alternative explanation for the diffuse nature of emotions. Besides transmitters and hormones there are also other information molecules responsible for the generation of tensor networks inside cell and in the vicinity of cells.
4. There are also sensory percepts from the part of MB outside BB. There are no nodes defined by cells or larger structures of organism and the dynamics could involve motions of biological body perhaps representing this dynamics as a template or mimicry.

**Remark:** Since the magnetic bodies of organisms can have sizes of order Earth size and even larger different organisms - in particular those of the same species - could appear as nodes of flux tube network. This might related to the findings of Sheldrake [L18, I76] about species learning [L54].

Also oscillations of this part of MB - analogs of Alfven waves (see <http://tinyurl.com/7ekxqt2>) propagating with light velocity and analogous to oscillations of strings in the case of flux tubes - should contribute to sensory percepts about MB. EEG and its possibly existing fractal counterparts at higher frequency scales have natural identification as the analogs of Alfven waves and cyclotron frequencies are favoured frequencies in the control of gene expression by MB as also their differences modulated by nerve pulse patterns in the case of communication of sensory data from cell membrane to MB [K86]. These oscillations could correspond to higher emotions since these parts of MB have the largest values of  $h_{eff}/h = n$ .

In feelings generated by music time is indeed essentially involved and one can say that these experiences are non-local in time.

It would seem that emotions, which do not involve any obvious goal or desire - such as happiness or sadness - correspond to higher level emotions assignable to the part of MB outside MB. Note that the parasympathetic part of autonomic system - rest-and-digest mood - involves also goals/needs/desires such as sexual arousal, salivation, lacrimation, urination, digestion, and defecation so that these emotions do not correspond to “higher” ones. The sympathetic part - fight-or-flight mood - obviously involves desires and goals.

**Remark:** One of the basic paradoxes related to time is how it possible to become conscious of entire music piece in single moment as for instance Mozart did. The explanation relies on the distinction between subjective time and geometric time.

The idea the part of MB with the scale of BB stores emotional memories raises interesting questions. Could also immune system involve flux tube network? Could the meridian system of Chinese medicine (see <http://tinyurl.com/cwggkw>) be a flux tube network having acupuncture points as nodes. Is this network rather static and based solely on signalling with dark photons? The reports that heart transplants can transfer the memories of the donor to the receiver conform with the proposed vision. The claim that eating meat causes violent nightmares is supported also by my own experiences.

#### 4.3.4 Emotions and information

It is known that emotions correlate strongly with information although emotions and rational thinking are often seen as diametrically opposite to each other. One however speaks of intuitive feelings and emotional intelligence is now a generally accepted notion.

1. Negentropy is a measure for the amount of conscious information having no counterpart in standard physics, where one can define only ensemble entropy and entanglement entropy. Entanglement negentropy is defined in p-adic sectors of the adele and although it obeys generalization of Shannon formula it can have positive values unlike the negative of the ordinary Shannon entropy.

**Remark:** Adelic physics [L98] [L97] fuses real number based physics for sensory experiences (physics of matter) and various p-adic physics as physics of cognition to single structure.

2. The values of  $h_{eff}/h = n$  for given system is bound to increase in statistical sense since there exists infinite number of extensions with dimension higher than given extension and only finite number of them with dimension smaller. The increase of  $n$  does not imply increase of negentropy: it only gives prerequisites for generating larger negentropy and the system can decide whether to do this.
3. Metabolic energy feed provides system with molecules having valence bonds with values of  $n$  larger than for atoms. Hydrogen bonds and their generalization have even larger  $n$ . To gravitational flux tubes one can assign even larger  $n$ . Reality as zero energy state wants to understand itself and this leads to an increase of its negentropy in statistical sense and at the same time makes reality algebraically more complex giving rise to evolution in this manner. Note that metabolic energy does not generate negentropy as I have claimed earlier - it only makes possible to generate negentropy.

Emotions - at least those assigned to BB in the proposed model - have positive/negative coloring. What could be the interpretation of this bit.

1. Could this bit tell whether the state function reduction meaning a replacement of zero energy states as a kind of behavioral pattern with new one led to increase or decrease of negentropy?
2. Or could the color of emotion tell whether the state function reduction led to the increase or decrease of  $n$  characterizing the ability to generate negentropy.

### 4.3.5 “Higher” emotions and music

Music expresses emotions and also create higher level emotions. As all art, it also induces experience of beauty. Since  $h_{eff}/h = n$  serves as a kind of IQ in the evolutionary hierarchy, there are good reasons to expect that the emotions/feelings induced by music and other art forms are assignable to MB.

The dynamics of MB involves oscillations characterized by frequencies and in EEG frequencies are of key importance for the part of MB outside biological body. The communications from cell membrane to MB involve modulation of EEG frequencies identified as generalized Josephson frequencies by nerve pulse patterns [K86] and would define a coding of sensory data to higher level emotions. The control signals from MB via DNA inducing gene expression would use dark photons at cyclotron frequencies to control BB.

#### Model for music harmonies and genetic code

For few years ago I ended up with a model of music harmonies leading also to a model of genetic code as a side product [L31].

1. The idea was that the 12-note scale could allow mapping to a closed path (octave equivalence) going through all vertices of icosahedron having 12 vertices and not intersecting itself. Also the idea that the triangles defining the faces of the icosahedron have interpretation as 3-chords defining the notion of harmony for a given chord deserves study. The paths in question are known as Hamiltonian cycles and there are 1024 of them [A7]. These paths can be classified topologically by the numbers of triangles containing 0, 1, or 2 edges belonging to the cycle representing the scale. Each topology corresponds to particular notion of harmony and there are several topological equivalence classes.
2. In the article [L36] I introduced the notion of Hamiltonian cycle as a mathematical model for musical harmony and also proposed a connection with biology: motivations came from two observations. The number of icosahedral vertices is 12 and corresponds to the number of notes in 12-note system and the number of triangular faces of icosahedron is 20, the number of amino-acids. This led to a group theoretical model of vertebrate genetic code and replacement of icosahedron with tetra-icosahedron to explain also the 21st and 22nd amino-acid and solve the problem of simplest model due to the fact that the required Hamilton's cycle does not exist. The outcome was the notion of bio-harmony.
3. All icosahedral Hamilton cycles with symmetries ( $Z_6, Z_4, Z_2^{rot}$  and  $Z_2^{refl}$ ) turned out to define harmonies consistent with the genetic code. In particular, it turned out that the symmetries of the Hamiltonian cycles allow to predict the basic numbers of the genetic code and its extension to include also 21st and 22nd amino-acids Pyl and Sec: there are actually two alternative codes - maybe DNA and its conjugate are talking different dialects! One also ends up with a proposal for what harmony is leading to non-trivial predictions both at DNA and amino-acid level.
4. The conjecture is that DNA codons correspond to 3-chords perhaps realized in terms of dark photons - music of light - or even ordinary sound. 256 different bio-harmonies are predicted and these harmonies would give additional degrees of freedom not reducing to biochemistry. Music expresses and creates emotions and a natural conjecture is that these bio-harmonies are correlates of emotions/moods at bio-molecular level serving as building bricks of more complex moods. Representations of codons as chords with frequencies realized as those of dark photons and also sound is what suggests itself naturally. This together with adelic physics involving hierarchy of algebraic extensions of rationals would explain the mysterious looking connection between rational numbers defined by ratios of frequencies with emotions.
5. In fact, also the emotions generated by other art forms could be realized using music of dark light. Dark photons in various wavelength ranges and correspond to various values of  $h_{eff}$  would correspond to various sensory qualia and are represented at pineal gland (“third eye”) as imagined sensory percepts [L87]. They can be transformed to real sensory percepts at sensory organs by using DMT molecules as bridges allowing the propagation of dark

photons (or the bio-photons resulting in their energy conserving transformation to ordinary photons) to sensory organs, where they generate genuine sensory experience identified as dream, psychedelic experience, hallucination, etc...

### How to realize emotions as music of genes concretely?

How to realize the music of genes represented as sequences of 3-chords of dark light as a communication tool between dark and ordinary DNA/RNA and possibly even dark and ordinary variants of tRNA and amino-acids?

1. Communication between ordinary and dark matter levels must be possible. This is guaranteed if the transition energy spectra at different levels of  $h_{eff}/h = n$  hierarchy contain common transition energies so that a resonant interaction by exchange of dark photons becomes possible. This condition is extremely demanding and could explain why basic bio-molecules are selected amongst numerous alternatives [L110] - this is indeed one of the hen-egg problems of pre-biotic evolution.
2. A hypothesis worth of studying is that the cyclotron transition energies of both ordinary DNA and RNA nucleotides and their dark variants represented as dark proton sequences are same [L110]. Cyclotron transition energies should cover several octaves and the natural proposal is that magnetic field strength associated with the flux tube codes for the notes. In music experience roughly 10 octaves are needed corresponding to the range of audible sounds.
3. The cyclotron frequencies of DNA nucleotides A, T, C, G are very nearly the same and near 1 Hz for  $B = B_{end} = .2$  Gauss since their masses do not differ much. Since the nucleotides are negatively charged, also the cyclotron energies for codons and codon sequences are around 1 Hz.  $h_{eff} = h_{gr}$  hypothesis states that the cyclotron energies of DNA are in the energy range of bio-photons in visible and UV.

There should be correspondences between a) the 64 ordinary DNA codons and allowed 3-chords and b) 64 dark variants of DNA codons and allowed 3-chords. These correspondences fix that between ordinary and dark codons. One would have triality.

1. To realize music of genes one the value of  $B$  must have values in a range of several octaves. The magnetic field strengths  $B$  associated with the flux tubes accompanying DNA strand should have a spectrum given by 12-note scale. Both 64 dark DNA codons and  $4^3 = 64$  ordinary DNA codons should correspond to  $20 + 20 + 20 + 4 = 64$  allowed 3-chords formed from the notes of 12-note scale.
2. Dark codons correspond to entangled states of 3 dark protons. The positions of dark protons are different so that ermutations of the positions of dark protons are involved. The invariance of 3-chord under permutations of notes would correspond to fermionic statistics. These permutations are lifted to braidings if dark protons are connected by flux tubes to some other system, for instance ordinary DNA.

If the dark protons are ordered linearly along flux tube, it would seem that these these positions correspond to those of ordinary code letters. This does not make sense. If the letters of codon are connected to the dark protons by flux tubes, the permutations of dark codons induce braiding of the flux tubes but do not affect the order of the letters of the ordinary codon. Braiding would become an essential part of the correspondence between ordinary and dark codons.

3. One should understand the correspondence of dark codons with the allowed 3-chords of a given harmony and also with the ordinary DNA codons. Bio-harmony is defined as a composite of 3 harmonies with 20 allowed 3-chords and having symmetries  $Z_6$ ,  $Z_4$ , and  $Z_2$  and of tetrahedral harmony with 4 chords. Tetrahedron can be regarded as disjoint object or attached to DNA, and this gives two variants of code.

How could these the icos-tetra-hedral Hamilton cycles relate to the physical realization of dark proton triplets? Each icosahedral cycle should give rise to 20 dark proton triplets. Why

the icosahedral geometry with Hamiltonian cycle should make itself manifest in the quantum physics of dark proton triplet?

4. Could icosahedral geometry quite concretely correspond to a tensor network? The vertices of the icosahedron would be connected by a sequence of flux tubes connecting nearest neighbors to form a Hamiltonian cycle. Dark proton triplets would quite concretely be localized at the triangular faces of the icosahedron.

Braided triplet of flux tubes would emerge from the vertices of an icosahedral triangle defining 3-chord and would connect it to the nucleotides of the corresponding ordinary DNA codon. Magnetic field strengths at these flux tubes would correspond to the notes of 12-note scale as defined by the Hamiltonian cycle in question. The permutations of the dark proton states at the vertices of the triangle would induce braidings of the flux tube triplet actually defining minimal braid in topological quantum computation (sic!) The braiding accompanying the states of 3 dark protons would make the correspondence with ordinary ordered DNA codons possible.

Note that each dark proton triplet could be also connected (without braiding) to its conjugate dark proton triplet by a triplet of flux tubes so that one would obtain closed flux loops and one could speak of knots instead of braids.

**Remark:** Braiding brings strongly in mind the many TGD inspired proposals for DNA as topological quantum computer [K4, K119]: maybe DNA as topological quantum computer could be (also?) realized in this manner.

What physical objects could the 20 vertices of icosahedron correspond to? Hydrogen bonded water clusters give rise to both tetrahedral and icosahedral structures. Could one associate dark proton triplets to the dark parts of these structures? Could one try to experimentally identify possible sequence of icosahedral water molecule clusters with vertices connected by hydrogen bonds associated with the DNA sequence? If the hydrogen bonds correspond to flux loops as suggested, they can be rather long (proportional to  $h_{eff}/h = n$ ) so that even distant water molecules can become hydrogen bonds and one could have a fractal hierarchy of icosahedra.

5. Resonance condition suggests that at the level of ordinary DNA double strand the cyclotron energies of dark protons associated with the hydrogen bonds connecting DNA nucleotides correspond to those of flux tube triplets connecting ordinary and dark DNA codons. The magnetic field strengths associated with the dark flux tubes accompanying hydrogen bonds would correspond to those associated with the triangles of icosahedral triangle. This would make possible communication between the two dark sectors by dark-photon triplets as music of genes.

This leaves unanswered questions.

1. Why the  $20+20+20=60$  3-chords from 3 harmonies with different icosahedral symmetries ( $Z_6, Z_4, Z_2$ ) and 4 chords from tetrahedral harmony would combine to form single bio-harmony with 64 chords? This requires the presence of 3 Hamiltonian cycles with different symmetries. Why all three different symmetry types for DNA and RNA? Could the 20 amino-acids correspond to single symmetry type? Could tRNA codons correspond to two symmetry types?
2. How the 3-chords of dark photons could be played? 3-chord should be a collective effect affecting both dark and ordinary codon by inducing emission of 3-photon state like - like playing a chord by string instrument. The notes of the light chord need not emerge simultaneously but as arpeggios. Could there be a pulse travelling along the Hamiltonian cycle and picking all the cyclotron notes at the vertices containing dark proton and sending a cyclotron signal along flux tubes to ordinary DNA codon. This pulse would travel along dark DNA and play the music defined by dark DNA sequence.

### 4.3.6 Support for the view that information molecules serve as bridges in flux tube networks

I have discussed information molecules from TGD point of view for for the first time about two decades ago [K74]. It was amusing to find that this discussion highlighting the interpretational problems related to information molecules is still very topical. These strange findings give direct support for the view that information molecules serve as bridges making possible the formation of networks of cells interpreted in terms of flux tube networks in TGD framework. For this reason I glue below the earlier discussion followed by the recent comments.

*Central nervous system (CNS), endocrine system and immune system are three basic systems involved with bio-control and -communication. The work of Candace Pert and other neuroscientists has led to a general notion of information molecule described in popular manner by Candace Pert [J46]. Neural transmitters and modulators associated with CNS are only special cases of information molecules. Also neuropeptides and various hormones are involved. It has become clear that emotions are closely related with the activity of information molecules and that both brain, endocrine system and immune system communicate intensively with each other. One could regard even brain as a big gland. Of course, one could also consider various glands and organs as mini-brains.*

*The interactions of the information molecules involve the formation of receptor-information molecule complex either at cell surface or in the cell plasma inside cell. Receptor-information molecule complex inside cell can move to genome and induce gene transcription. In case that the complex is formed at the surface of cell, second messenger action is involved. One can also speak about N:th messenger action. There are many poorly understood aspects related to the mechanisms of information molecule action [I54].*

- 1. There are only few second messenger pathways and relatively few receptors but large number of different functions. This phenomenon is known as pleiotropy or multi-functionality. For instance, given second messenger causes different effects depending on the hormone that activated it (the phenomenon is somewhat analogous to the phenomenon in which message can be understood in several ways depending on the state of receiver). At purely chemical level the problem is how second messenger knows what hormone activated it? In steroid action the complex formed by information molecule and receptor in turn activates some gene. Now the question is: How the activated RNA polymerase knows which gene has to be activated? Pleiotropy appears also at level of hormones. Same hormone can have multiple effects and the border between hormone, neuropeptide or even neurotransmitter is unclear. For instance, hormone which by definition transmits long distance communications, can have effects in nearby cells and thus acts like a neuropeptide. How hormone knows what function it must perform? Also drugs and treatments can have different effects and side effects.*
- 2. There is also functional redundancy: the same function is performed by several second messenger molecules. For instance, glucagon, growth hormone, adrenaline and corticosteroids elevate glucose levels. This suggests that there is deeper level of communication involved and that second messenger molecules are more like computer passwords than subprogram calls. Now the question is: What these subprogram calls do correspond physically?*
- 3. Biological functions can be initiated also in non-chemical manner. The phenomena of healing by touch and the effects of meditation and biofeedback are examples of biological self-organization processes are initiated in non-chemical manner. Even other treatments like massage, acupuncture or meditation can decrease or inhibit pain. These observations suggest that chemical level is not the deepest level involved with biological functions and the question is: What is this deeper control level?*

*Simple lock and key mechanism cannot provide answer to the questions raised above. Rather, computer password might provide better metaphor for the second messenger action whereas receptor-information molecule complex would effectively generate sub-program call perhaps carried by the second messenger molecule or possibly broadcasted. It seems that information molecules act more like signs or symbols rather than being purely chemical agents. These symbols are interpreted by cell level intelligences and the interpretation depends on context.*

The mysterious looking finding is that the cell activated by information molecules somehow knows, which information molecule did the activation. This can be understood if the information molecule attached to the receptor serves as a bridge so that the cell becomes part of a flux tube network to which information molecule characterizes. The recent interpretation is in terms of a generation of a flux tube network. Information molecule characterizes the network which is formed. The information storage capacity of these networks - allowing quantum entanglement - is exponentially large than that of state of the nodes: hence the naïve AI based idea about copying consciousness to diskette by assigning a bit to each neuron is extremely unrealistic.

#### 4.3.7 Getting memories by eating those who already have them

While writing this article I learned about extremely interesting findings. I have already earlier written about the finding that both pieces of a split planaria inherit the memories (identified as learned skills or conditionings) of the original planaria [K82]. One possibility is that the bodies rather than brains of the planaria carry the memories. Second possibility is that the splitting of planaria involves the replication of its magnetic body carrying at least some of the memories. The news at this time was that planaria get the memories of planaria that they have eaten!

To begin with, one must carefully distinguish between genuine memories and memories as behavioral patterns (conditionings, skills).

1. Cognitive memories as behavioral patterns are assumed to be due to the strengthening of synaptic contacts (long term potentiation (LPT, see <http://tinyurl.com/yafzovyk>) giving rise to nerve circuits, which are active or easily activated.

In TGD framework activation means formation of a flux tube network giving rise to quantum entangled state with neurons at the nodes: neural activity generates transmitters serving as bridges between flux tubes associated with axons and create flux tube network carrying a conscious mental image. A quantum coherent entangled tensor network is formed and also classical communications using dark photons are possible in this state. These neurons are firing synchronously. Nerve pulses would not be signals between neurons but would induce communications to magnetic body in scales even larger than body.

2. Genuine memories - say episodal memories - would in TGD (zero energy ontology, ZEO) correspond to neural activities in geometric past: kind of seeing in time direction. These are typically verbal memories but also sensory memories are possible and can be induced by electric stimulation of brain.

Consider now the experiments discussed in the popular article “*Somewhere in the brain is a storage device for memories*” (see <http://tinyurl.com/y8ejpcho>). They all relate to the identification of memory as a behavioral pattern induced by conditioning and are therefore emotional memories.

1. In one experiment sea slugs learned to avoid painful stimulus. This led to a generation of synaptic contacts between neurons involving increased synaptic strength - long term potentiation (LPT). Then some drug was used to destroy the LPT. The problem was that the lost contacts were not those formed when the memory was formed!
2. In second experiment mice were used. A conditioned fear (LPT) was induced in mice and again the generation of synaptic contacts was observed. Then the contacts - long term potentiation - was destroyed completely. Memories as conditioned fear however remained!

It was an amusing accident to learn about this just when I was building a model for emotions as sensory percepts about the state of magnetic body (MB) fundamental in TGD inspired quantum biology.

1. In the recent case the memories are definitely emotional memories and in TGD framework they would be naturally at the level of body and generated as mental images associated with large numbers of ordinary cells appearing as nodes of quantum entangled flux tube networks giving rise to tensor networks [L60]. Hormones would be the tool to generate and modify these networks.
2. Emotional memories would be represented by the conditioning and analog of LPT at the level of body rather than at the level of brain! Hormones like also other information molecules would act as relays connecting existing pieces of network to larger ones! The neural activity would be involved only with the generation of memories and induce hypothalamus to generate the fear network using the hormones controlling hormonal activities of lower level glands.
3. The model could also explain the finding that in the splitting of flatworm the both new flatworms inherit the memories and that even non-trained flatworms eating trained flatworms get their memories (defined as behavioral patterns involving emotional conditioning).

### 4.3.8 How brain selectively remembers new places?

Emotions are involved with memory storage and memory recall. Limbic brain, in particular hippocampus, plays a key role in these processes but what really happens is not really understood. The notion of memory has two basic meanings. Memory can mean learned skills and emotional conditionings: one can argue that memory is not correct word in this case. Long term potentiation (LPT) strengthening synaptic contacts is known to be the key mechanism in the formation of memories in this sense. Memory can also mean memory recall: what happens in genuine memory is not understood and it is difficult to understand episodal memories in terms of conditioning and synaptic contacts.

In TGD framework one might say that LPT makes possible generation of cognitive (emotional) mental images as quantum entangled flux tube networks and also signalling using dark photons between neutrons (cells) of the network. In TGD framework memory recall means seeing in time direction making possible to retrieve information about the mental images in the geometric past and even to re-experience them.

There was a very interesting link in Minding Brain (see <http://tinyurl.com/y8w2zyus>) related to the storage of new memories. The title of the popular article (see <http://tinyurl.com/yap3dzuk>) is “*How brain selectively remembers new places?*”. The research article by the research group led by Nobelist Susumu Tonegava is published in PNAS [J104] (see <http://tinyurl.com/yak262hu>). The following represents TGD based view about what might happen.

1. In TGD framework brain/body corresponds to 4-D geometric object classically - a space-time surface with complex topology (zero energy ontology, ZEO). Brain and biological body are accompanied by magnetic body (MB) defining a topological time evolution of flux tube network having neurons (and also body cells) as its nodes and it is MB, which seems to be of fundamental significance [L87, L116] (see <http://tinyurl.com/y8mpo7mb>) and <http://tinyurl.com/ydhxen4g>). Memories are located in 4-D brain (body) for the first time to the time-place, where they were formed, later successful memory recalls form new copies of them.
2. To remember is to see in time direction to geometric past. The signal sent from hippocampus backwards in geometric time scatters back in standard time direction: this is nothing but seeing in 4 dimensions. 4-D memory storage means that there is practically no limitations on memory storage since new storage capacity is created all the geometric time! Making careful distinction between experienced and geometric times allows to both avoid paradoxes and solve the paradoxes of existing theory.

**Remark:** Also the possibility of quantum entanglement also increases exponentially the memory storage capacity (and destroys the dreams of AI aficionados about copying human consciousness as bits telling whether neuron fires or not to a computer file!).



3. Brain is able to detect whether the sensory percept - say completely new place - is indeed new. Brain acts as novelty detector. This requires scanning of 4-D brain to see whether there are sensory percepts in geometric past, which share common features with the recent sensory percept. This requires high level conceptualization so that perceptive field is decomposed to objects with some attributes. If common objects are not found, the percept is regarded as something new. In this case a new symbolic memory representation about perceptive field is formed.
4. This strongly suggests that the signal sent from hippocampus scatters back from brain of past and is then compared with the recent sensory percept. If they the signals are very similar - this might give rise to some kind of resonance - the experience is "I have seen this before". The information provided by the already existing memory is utilized. If not then sensory percept is regarded as new and memory representation is formed.

Where is this new memory representation constructed?

1. The article suggests that locus coeruleus (LC) and area CA3 of hippocampus are involved. It was found that the modulation of CA3 by LC is was involved in the formation of new memory: if the modulation was prevented, no new memory was formed and the mice behaved next day as if the place were still new.
2. In ZEO the new memory would correspond to a collection of activated neurons in LC and CA3 accompanied by connected flux tube structure represented the new mental image as a quantum entangled structure - tensor network. This kind of mental images would have formed for some period of time in the brain of the mice and given rise to a 4-D representation of new place to be read later by sending signals backwards in geometric time.

## 4.4 The experiments of Masaru Emoto with emotional imprinting of water

Sini Kunnas sent a link to a video telling about experiments of Masaru Emoto (see <http://tinyurl.com/pqy57jj>) with water, which is at criticality with respect to freezing and then frozen. Emoto reports is that words expressing emotions are transmitted to water: positive emotions tend to generate beautiful crystal structures and negative emotions ugly ones. Also music and even pictures are claimed to have similar effects. Emoto has also carried out similar experiments with rice in water. Rice subjected to words began to ferment and water subject to words expressing negative emotions began to rotten.

**Remark:** Fermentation is a metabolic process consuming sugar in absence of oxygen. Metabolism is a basic signature of life so that at least in this aspect the water+rice system would become alive. The words expressing positive emotions or even music would serve as a signal "waking up" the system.

One could define genuine skeptic as a person who challenges existing beliefs and pseudo-skeptic (PS in the sequel) as a person challenging - usually denying - everything challenging the mainstream beliefs. The reception of the claims of Emoto is a representative example about the extremely hostile reactions of PSs as aggressive watchdogs of materialistic science towards anything that challenges their belief system. The psychology behind this attitude is same as behind religious and political fanaticism.

I must emphasize that I see myself as a thinker and regard myself as a skeptic in the old-fashioned sense of the word challenging the prevailing world view rather than phenomena challenging the prevailing world view. I do not want to be classified as believer or non-believer. The fact is that if TGD inspired theory of consciousness and quantum biology describes reality, a revolution in the world view is unavoidable. Therefore it is natural to consider the working hypothesis that the effects are real and see what the TGD based explanation for them could be.

The Wikipedia article about Masaru Emoto (see <http://tinyurl.com/pqy57jj>) provides a good summary of the experiments of Emoto and provides a lot of links so that I will give here only a brief sketch. According to the article Emoto believed that water was a "blueprint for our reality" and that emotional "energies" and "vibrations" could change the physical structure of

water. The water crystallization experiments of Emoto consisted of exposing water in glasses to different words, pictures or music, and then freezing and examining the aesthetic properties of the resulting crystals with microscopic photography. Emoto made the claim that water exposed to positive speech and thoughts would result in visually “pleasing” crystals being formed when that water was frozen, and that negative intention would yield “ugly” crystal formations.

In 2008, Emoto and collaborators published an article titled “Double-Blind Test of the Effects of Distant Intention on Water Crystal Formation” about his about experiments with water in the Journal of Scientific Exploration, a peer reviewed scientific journal of the Society for Scientific Explorations (see <http://tinyurl.com/y99ko12e>). The work was performed by Masaru Emoto and Takashige Kizu of Emoto’s own IHM General Institute, along with Dean Radin and Nancy Lund of the Institute of Noetic Sciences, which is on Stephen Barrett’s Quackwatch (see <http://tinyurl.com/y99ko12e>) blacklist of questionable organizations. PSs are the modern jesuits and for jesuits the end justifies the means.

Emoto has also carried experiments with rice samples in water. There are 3 samples. First sample “hears” words with positive emotional meaning, second sample words with negative emotional meaning, and the third sample serving as a control sample. Emoto reports (see <https://youtu.be/Wc-ZmvxfBxE>) that the rice subjected to words with positive emotional content began to ferment whereas water subject to words expressing negative emotions began to rotten. The control sample also began to rotten but not so fast.

In the sequel I will consider the working hypothesis that the effects are real, and develop an explanation based on TGD inspired quantum biology [K110, K82, K81]. The basic ingredients of the model are following: magnetic body (MB) carrying dark matter as  $h_{eff}/h = n$  phases of ordinary matter; communications between MB and biological body (BB) using dark photons able to transform to ordinary photons identifiable as bio-photons; the special properties of water explained in TGD framework by assuming dark component of water implying that criticality for freezing involves also quantum criticality, and the realization of genetic code and counterparts of the basic bio-molecules as dark proton sequences and as 3-chords consisting of light or sound providing a universal language allowing universal manner to express emotions in terms of bio-harmony realized as music of light or sound. The entanglement of water sample and the subject person (with MBs included) realized as flux tube connections would give rise to a larger conscious entity expressing emotions via language realized in terms of basic biomolecules in a universal manner by utilizing genetic code realized in terms of both dark proton sequences and music of light of light and sound.

#### 4.4.1 The reception of the findings of Emoto

The findings of Emoto challenge the materialistic world view and have received both genuine criticism and “criticism”.

##### Criticism and “criticism”

Commentators have criticized Emoto for insufficient experimental controls and for not sharing enough details of his approach with the scientific community. Prof. emeritus William A. Tiller, a researcher featured in the documentary “*What The Bleep Do We Know?*”, states that experiments of Emoto fall short of proof, since they do not control for other factors in the supercooling of water. It is easy to agree that scientific proof is not in question. William Tiller claims that supercooling of water involved with the experiments might have delicate effects difficult to control.

**Remark:** Supercooling of water makes it critical system, even quantum critical and in TGD Universe, and this makes it ideal target of remote mental interactions.

A lot of experiments are needed: in particular, the possible dependence on the person who utters the words with emotional content, deserves to be studied. Just taking randomly chosen group of people and control system might not be enough to achieve a significant effect. Situation could be similar to that in the recent double slit experiments of Radin [L83] (see <http://tinyurl.com/y72b87p7>), in which subject person tries to intentionally affect the interference pattern for light travelling through slits. The effect is clear in the case of experienced meditators. That very few of us are not concert pianists, cannot be used to argue that there are no concert pianists.

There is also the authoritative “criticism”, which carefully avoids stating anything about contents of the work and directs the efforts on rhetoric tricks. These “criticisms” do not deserve serious attention except as perfect examples of the empty rhetorics so typical for PSs. The following examples are citations from the Wikipedia article (see <http://tinyurl.com/pqy57jj>).

Emoto has been criticized for designing his experiments in ways that leave them prone to manipulation or human error influencing the findings. Biochemist and Director of Microscopy at University College Cork William Reville wrote, “*It is very unlikely that there is any reality behind claims of Emoto.*”. Reville noted the lack of scientific publication and pointed out that anyone who could demonstrate such a phenomenon would become immediately famous and probably wealthy.

**Remark:** The absence of scientific publication (in respected journal of course) often reflects the fact that PSs have reached their goal to prevent publishing anything challenging their beliefs. I have experienced this myself during four decades very concretely. At nineties it became even impossible to get anything into arXiv.

Writing about Emoto’s ideas in the Skeptical Inquirer, physician Harriet A. Hall concluded that it was “*hard to see how anyone could mistake it for science*”. Commenting on Emoto’s ideas about clearing water polluted by algae, biologist Tyler Volk stated, “*What he is saying has nothing to do with science as I know it.*” Stephen Kiesling wrote in Spirituality & Health Magazine, “*Perhaps Emoto is an evangelist who values the message of his images more than the particulars of science; nevertheless, this spiritual teacher might focus his future practice less on gratitude and more on honesty.*”.

Needless to restate that these comment say nothing about contents.

### Emoto is not the only victim of pseudo-skepticism

The criticism of the experiments of Emoto mostly reflects the prevailing materialistic dogmas, which do not allow these effects so that depending on the authority Emoto is concluded to be mad, charlatan, or evangelist. The rage of PSs is really frightening and demonstrates how powerful effects ideology can have.

Emoto shares the fate of experimenters studying water memory and homeopathy. “Homeopathy” is indeed a word making skeptic growl and drool: one can hardly imagine a more impressive demonstration of words on water than this! An almost- Nobelist Benveniste was labelled as swindler as he announced about experiments providing support for water memory and homeopathy. Magician Randi - Randi again(!) - participated the investigation of the mind-police of science, in which Benveniste and laboratory staff was treated like criminals unless otherwise proven.

There is a lot of support about the representation of water memory as extremely low frequencies (ELF) of radiation associated with water [I25, I26]. These ELF frequencies can be stored electronically and they produce the same effects as the bio-active chemical, whose presence induced these frequencies in water. These facts PSs simply neglect because they do not fit the belief system of PSs dating back to 18th century. At the age of IT the idea about the existence of representations of bio-active molecules as frequency patterns able to induce the biological effects of molecules without the presence of molecules should not raise aggressions.

Few years ago HIV Nobelist Montagnier did experiments giving support for water memory and the procedure involved a part very similar to that used in preparing homeopathic remedies [I36] [L15]. In TGD framework these frequencies would correspond to cyclotron frequencies assignable to MBs of molecules, and immune system is proposed to have emerged from the ability of water to mimic the magnetic bodies of invader molecules and learning to recognize them [K48]. This interpretation could mean a breakthrough in biology but unfortunately the time is not mature for this yet.

Remote mental interactions/paranormal phenomena [K110] belong also to the pariah phenomena having no place in materialistic world and people having the courage to challenge this view are labelled as science criminals by PSs.

### Analyzing the mindset of PS

People calling themselves skeptics are rarely skeptics in the original meaning of the word but believers, even fanatic believers. The basic un-challengeable belief is materialism stating that consciousness is only an epiphenomenon - illusion as David Dennett puts it without explaining what he means with the claim that consciousness does not exist but is only one particular phenomenon of consciousness - namely illusion. There is no free will and there are no genuine intentional actions. Moral and ethics are illusions. And certainly, human can have no intentional effects on water since even genuine intentional effects on our own body are impossible. This leads to the notion of objectivity as PS understands it.

This notion of objectivity implies that the outcome of given experiment cannot depend on who carries it or on who the subject persons are. If this turns out to not be the case, the experiment is not well-done and experimenter can be ridiculed. Water is dead matter for PS, even the PS himself should be dead matter if the materialistic logic is taken to its bitter end. I dare guess that most PSs privately believe - without even realizing that this is the case - that their intentions genuinely affect the sack of water with some chemicals that is called their body. It is extremely difficult pretend that one is not conscious when one is conscious.

The conclusion of the PS is that the outcome of Emoto's experiments with water and rice cannot depend at all on the person who utters the words expressing positive or negative emotions. PS calls this assumption objectivity but is actually only an assumption that there is no such thing as intentional free will and that we live in a deterministic world of billiard balls. This view is known to be wrong: quantum entanglement has been verified for cell sized system in macroscopic scales and quantum world is non-deterministic - mentioning this fact is carefully avoided in text books. PSs also unashamedly put under the rug hundreds of anomalies related to the physics of water.

If human intention and emotion can have effects on water, the first question is whether the intention and emotion of some humans these effects are stronger. Belief moves mountains and since Emoto believes that intention can have effects, it would be only natural that the effects are stronger. If this is true, one cannot demand the repeatability of the experiment anymore. In paranormal research the experimenter effect is well-known - some experimenters are more successful than others without being charlatans - as also in medicine. This is the case always when living systems are involved. There is another amusing example demonstrating the shallowness of the thinking of PSs: PSs love to say that the effects of healing practices produce nothing but placebo effects without realizing that placebo effect as such is a fascinating mind-over-matter effect begging for explanation!

Of course, if Emoto believed that the emotions have effects on water, his desire to prove this belief might have produced these effects - not by cheating but by intentional rather than emotional imprinting based on remote mental interactions affecting water. The words as such need not have caused the effect. This would represent an example of remote mental interactions. Note however that also music and even pictures were reported to have effects on water and it is not easy to explain this as experimenter effect.

An amusing "experiment" on rice was carried out by a hard-nosed skeptic Carry Poppy (see <http://tinyurl.com/y8g9jgal>). The extremely nasty tone of the article reveals the hatred of Poppy towards Emoto and people challenging the materialist world view. The outcome of the "experiment" carried by Poppy was of course negative. Perhaps not surprising, the outcome would express faithfully the real intention and desire of the experimenter!

#### 4.4.2 TGD based model for Emoto's findings

In TGD based view the notion of magnetic body (MB) is central [K82, K81]. MB carries dark phases of matter identified as phases of ordinary matter with  $h_{eff}/h = n$  making possible macroscopic quantum coherence explaining the coherence of living matter not understandable in the biochemistry based approach. The interactions between MB and biological body (BB) are essential remote mental interactions based on signalling using dark photons. Therefore the basic mechanisms of quantum biology would be also mechanisms of remote mental interactions - only the target would be non-standard. We are mostly water and it would not be surprising if these mechanisms would allow intentional and emotional imprinting of also water outside our body and

in quantum critical state.

### Basic ingredients of the model

In TGD universe water is very special substance in that it contains both ordinary water and its dark variant. What makes it dark is that dark magnetic flux tubes representing long hydrogen bonds are present for some portion of water [L121] (see <http://tinyurl.com/y8fvwbp9>): the length of bonds scales as  $n$  or perhaps even  $n^2$ . The presence of these flux tubes makes any liquid phase a network like structure and one ends up with a model explaining an anomaly of thermodynamics of liquids at criticality known already in Maxwell's time. This leads to a model explaining the numerous anomalies of water in terms of the dark matter.

For instance, the dark part of water with non-standard Planck constant transforms to ordinary water in freezing. As a consequence, a large amount of energy is liberated. This explains why water has anomalously large latent heat of fusion. One can also understand why the volume of water increases in freezing and decreases in heating in the interval 0-4 °C. The anomalies of water are largest at physiological temperature  $T_{phys} \sim 37$  °C suggesting that the dark portion of water is largest at  $T_{phys}$ . Dark fraction of water would be essential for life.

Dark protons sequences at flux tubes representing genetic code and the analogs of basic biomolecules are realized in water. Pollack effect [L34] (see <http://tinyurl.com/oyhstc2>) requiring feed of energy - as IR radiation for instance - generates so called exclusion zones (EZs), which are negatively charged regions. A fraction of protons from water must go somewhere and the TGD inspired proposal [L34] (see <http://tinyurl.com/gwasd8o>) is that the protons transform to dark protons at magnetic flux tubes. The dark variants of particles quite generally have higher energies than ordinary ones and energy feed provides the needed metabolic energy go make the protons dark. In the case of homeopathy and water memory mechanical agitation creates provides the metabolic energy and would generate EZs accompanied by dark proton sequences at flux tubes [K48].

Remote expression of emotions as crystal patterns - emotional imprinting - is required and communication requires a code so that receiver and sender have same interpretation for the signal. Genetic code would provide the fundamental code making possible universal meanings. TGD leads to two basic proposals predicting the numbers of DNA codons coding for given AA rather successfully.

1. The first proposal [L52] relies on TGD view about dark matter as  $h_{eff}/h = n$  phases of ordinary matter [K37, ?, K78] motivated by adelic physics extending physics to include also the correlates of cognition [L98, L97] (see <http://tinyurl.com/ycbhse5c> and <http://tinyurl.com/ybzkfevz>). The empirical motivation comes from several sources, in particular from the findings of Pollack.

Dark genetic code would be realized in terms of dark proton sequences at flux tubes- dark nuclei. The model predicts dark counterparts of DNA, mRNA, tRNA, and AA as dark proton sequences which codons identifiable as dark proton triplets. Bio-chemistry would emerge as a shadow of the much simpler dynamics of dark matter at flux tubes and genetic code would be induced by dark code code.

2. Second model of genetic code emerged accidentally from a geometric model of music harmony [L31, L120] (see <http://tinyurl.com/yad4tqw1> and <http://tinyurl.com/yd8d8x6j>) involving icosahedral (12 vertices-12-note scale and 20 faces-number of AAs) and tetrahedral geometries leading to the proposal that DNA codons and possibly also AAs correspond to 3-chords defining the harmony and obtained as unions of 20+20+20 3-chords associated with icosahedral 20-chord harmonies with symmetries  $Z_6$ ,  $Z_4$ ,  $Z_2$  plus tetrahedral 4-chord harmony. There is large number of these harmonies bringing in additional degrees of freedom.

**Remark:** This model has obviously analogies with the notion of wave genome introduced by Peter Gariaev [I29, I30, I49].

Since music both expresses and creates emotions, the proposal is that these harmonies assigning additional hidden degrees of freedom to the MBs of dark variants of DNA, RNA, etc... serve as correlates of emotions also at the molecular level. This emotional context could also give rise to context dependence of the code if several harmonies are realizable chemically.

Taking seriously TGD inspired theory of consciousness [L100] (see <http://tinyurl.com/ycxm2tpd>) and model of emotions [L116] (see <http://tinyurl.com/ydhxen4g>), one might say that the details of the code might depend slightly on the “emotional” state of DNA, RNA, and possibly other molecules.

### TGD based mechanism for emotional imprinting

One must not forget that as a passionate researcher Emoto probably had very intimate relationship with water! As we all have with one particular water volume, which we call our body! I can intend raising my hand and it raises. Also my emotions are expressed in this personal bag of water containing also some fraction of biomolecules. I doubt that even the most fanatic PS would not try to tell me that I am performing a sleight of hand as I do this. But they should do this in order to take their materialistic logic to its bitter end.

One can perhaps say that Emoto extended his body by fusing with the MB of water, which in turn controls the ordinary part of water just like it controls our own body. The reports of experiences about extension of body are not unheard in the spiritual practices. Not even in everyday life. If you touch ground with a stick, you experience the touch as if the stick were part of your body. Could the stick really become part of your body in some sense?

What could be the precise mechanism for emotional imprinting (as analog of intentional imprinting that Tiller talks about [J180])?

1. The basic vision is that living matter is a quantum critical system making it extremely sensitive to perturbations (actually TGD Universe is quantum critical in well-defined sense [L122] (see <http://tinyurl.com/yakz11lk>). This makes biological system an ideal sensor and motor instrument. In particular, intentions can affect body water at quantum criticality optimally. At quantum criticality phases with several values of Planck constant  $h_{eff}/h = n$  are present and correspond to dark matter which is the key player in TGD inspired model of living systems. As already noticed, the dark portion of water would be maximal at physiological temperature.
2. In the system studied by Emoto the subject person and water must form an entangled quantum critical system. Water - or rather, the MB of water - must have part of it in  $h_{eff}/h = n$  dark phase becoming in certain sense part of subject person. Magnetic flux tubes connecting subject person to a sample of water (or of rice and water) and carrying dark matter would serve as correlates of attention.

What might be called loving attention would provide metabolic energy to the target and might be essential element in generating the dark phase giving rise to the beautiful crystal patterns.  $h_{eff}/h = n$  can be seen as kind of universal IQ: the more the system contains subsystems with large  $n$ , the higher its ability to generate conscious information, negentropy, is.

Therefore choosing randomly a subject person who just says a word with positive or negative meaning but without emotion might not be enough to reproduce Emotos findings. It is also quite possible that the outcome of the experiment is a realization of subject person's intention/desire to have the desired effect. This would not however reduce the profound implications of the findings of Emoto if they are true.

3. Thanks to the presence of dark portion of water, super-cooled water is quantum critical system in TGD Universe. In supercooling the temperature can become considerably lower than in the usual freezing and means that also the dark portion of water stays dark. This dark portion would react to the intentions of subject person. The crystal structures would serve as kind of photograph is of the representations of mental images of the system subject person + dark portion of water.

**Remark:** Water normally freezes at 273.15 K (0 °C), but it can be supercooled at standard pressure down to its crystal homogeneous nucleation at almost 224.8 K.

What about the effects of music and even visual pictures on water? Also these effects are in principle possible and would rely on universal representation of emotions in living matter

at molecular and maybe even at higher levels. Since music represents and creates emotions, the natural assumption is that the collection of allowed 3-chords express emotions both at the molecular level and at the level of MB.

1. The resonant interaction by 3-chords made of photons is possible between any pair formed by taking given member to be either DNA, RNA, tRNA or its dark variant. Dark counterparts of AAs would couple resonantly to the frequencies defined as sums of the frequencies of 3-chords. These dark variants of bio-molecules are present also in water if TGD based explanation of Pollack effect is correct. One actually ends up to a model for prebiotic evolution involving dark nuclei made from dark proton sequences in an essential manner [L110, L120](see <http://tinyurl.com/yalny39x> and <http://tinyurl.com/yd5t82gq>).
2. The frequencies of visible light are rather high for the ordinary value of Planck constant. The original motivation for the hierarchy of Planck constants was the finding that ELF em fields have quantal effects on living matter [J47]. This led to a proposal in which bio-photons at visible and UV frequencies are dark photons at ELF frequencies transformed to ordinary photons [K14]. Also the reverse transformation taking ordinary photons to dark photons is possible so that dark matter - dark variants of AAs responding resonantly to single frequency - at the flux tubes can “see”.
3. The effect of words expressing positive emotions would initiate metabolism based on fermentation. The spoken words must serve as encouraging of dis-encouraging control signal just as music of light. The meaning of the words should be same for the subject person and the system rice + water. This can be the case if the systems entangle to single system via flux tube bridges.

This relates interestingly to the theory of Russian biologist Peter Gariaev based on the assumption that genes define a language in rather concrete sense [I73, I48, I43]. I have developed these ideas from TGD point of view in [L120] (see <http://tinyurl.com/yd5t82gq>): dark variants of genes identified as dark proton sequences - essentially dark variants of nuclei - define a universal language.

4. In the model the 3-chords in question are made of light. In the case of music as we understand it they would be made of sound. In living matter sounds can be transformed to em oscillations by piezo-electric effect. The resulting em oscillations would be accompanied by both ordinary and dark photons, and both the 3-chords and melody of the music would couple to dark dark proton triplets at flux tubes serving as counterparts of DNA, RNA, tRNA, and AAs. If the same mechanism is involved with Emoto’s experiments, the sounds should transform to light or they should induce at flux tubes vibrations - dark phonons - at the same frequencies that realize the representation of biomolecules and their dark variants as 3-chords.

**Remark:** In TGD Universe physical state as a collection of particles is replaced with a network of flux tubes having particles at its nodes [L60] (see <http://tinyurl.com/y9kwnqfa>). Therefore sound as vibrations of the length of flux tube accompanied by fermionic string connecting pair of nodes becomes fundamental excitation rather than something emerging only at condensed matter physics.

Ugly crystals are assigned with negative emotions and emotions are assigned with harmonies. Harmonies - also those, which are sad (consider only passions of Bach) - are however usually thought of as something beautiful. Can negative emotions really correspond to any bio-harmonies characterized by symmetries. In a discussion with Sini Kunnas I realized that also the notion of disharmony could make sense. There are indeed 6 Hamiltonian cycles without any symmetries [A7, A12, A5]. I neglected them in the model of harmony because they would represent which one might call disharmony. Could one of the contributing 3 Hamiltonian cycles in bio-harmony correspond to this kind of dis-harmony and bring in 20 3-chords without any symmetries? If so the relationship between geometry and aesthetics would become very concrete. The alternative view would be that there are several harmonies realized simultaneously and thi creates disharmony.

## 4.5 Updated view about the rice experiments of Masaru Emoto

Masaru Emoto has carried out extremely interesting experiments with water at the critical point against freezing. Emoto reports that words expressing emotions are transmitted to water: positive emotions tend to generate beautiful crystal structures and negative emotions ugly ones. Also music and even pictures are claimed to have similar effects. Emoto has also carried out similar experiments with rice in water. Rice subjected to words began to ferment and water subject to words expressing negative emotions began to rot.

### 4.5.1 Emoto's findings

The Wikipedia article about Masaru Emoto (see <http://tinyurl.com/pqy57jj>) provides a good summary of the experiments of Emoto and provides a lot of links so that I will give here only a brief sketch. Emoto believed that water was a “blueprint for our reality” and that emotional “energies” and “vibrations” could change the physical structure of water. The water crystallization experiments of Emoto consisted of exposing water in glasses to different words, pictures or music, and then freezing and examining the aesthetic properties of the resulting crystals with microscopic photography. Emoto made the claim that water exposed to positive speech and thoughts would result in visually “pleasing” crystals being formed when that water was frozen, and that negative intention would yield “ugly” crystal formations.

In 2008, Emoto and collaborators published an article titled “Double-Blind Test of the Effects of Distant Intention on Water Crystal Formation” about his about experiments with water in the *Journal of Scientific Exploration*, a peer reviewed scientific journal of the Society for Scientific Explorations (see <http://tinyurl.com/ycsnu2oc>). The work was performed by Masaru Emoto and Takashige Kizu of Emoto's own IHM General Institute, along with Dean Radin and Nancy Lund of the Institute of Noetic Sciences, which is on Stephen Barrett's Quackwatch (see <http://tinyurl.com/y99ko12e>) blacklist of questionable organizations. PSs are the modern jesuits and for jesuits the end justifies the means.

Emoto has also carried experiments with rice samples in water. There are 3 samples. First sample “hears” words with positive emotional meaning, second sample words with negative emotional meaning, and the third sample serving as a control sample. Emoto reports (see <https://youtu.be/Wc-ZmvxfBxE>) that the rice subjected to words with positive emotional content began to ferment whereas water subject to words expressing negative emotions began to rot. The control sample also began to rot but not so fast.

### But has anyone replicated the experiments of Emoto?

Has anyone replicated the experiments of Masaru Emoto? This was the question posed to me by Alain Jutras on FB. In the research community very few people want to get a label of crackpot by trying to do something like this. The experiments are however simple and ordinary laymen can do the replication (for a successful replication see this).

When we are talking about Emoto's experiment we make head on collision with physicalism, which identifies as the core of scientific thinking the belief that consciousness has no causal effects so that our desires and intentions cannot have any effects on anything. Giving up this belief would of course pose strong challenges for experimentation: how can we know the desires of the experimenter have not affected the outcome of the experiment? For the skeptic, also free will is an illusion (this implies that also moral and ethics are illusory but usually even the most hardfore skeptics avoids saying this aloud). Some extremists believe that even consciousness is an illusion.

Just for fun I looked at some URLs on the web and found that the typical reaction was that it does not matter whether Emoto's experiments can be replicated or not. Emoto must be a crackpot of fraud. This is idiotism in the veil of scientific thinking and I have learned during years that it is useless to argue with an idiot.

There are of course numerous phenomena suggesting remote mental interactions, where skeptics are forced to give up logical thinking.



1. For instance, in medical experiments, a placebo can produce the same effect as real medicine. For skeptics this shows that the idea about the mind-matter interaction is deadly wrong. Skeptic does not (want to) realize the very placebo effect proves that mind can affect matter!
2. The so-called experimenter effect is well-known and well-documented and is an example of the effect of the desires of experiment on the results (very probably) involving no fraud. In the development of a new medicine the test results can be phantastic but when the tests are repeated years later there is no effect. The reason could be that the interest of experimenters has already faded, and their desire to get nice results has vanished. The nice results were the outcome of desire, which is just the remote mental interaction!
3. Some experimenters get fantastic results from tests of some paranormal effect but it turns out that the results cannot be replicated. The very fact that this could well be the case without fraud shows the existence of remote mental interactions but skeptics manage to not notice this in their arguments. And of course, there is always the easy explanation: an experimenter is a swindler or crackpot or something like that. The researchers of paranormal phenomena are martyrs of modern science!
4. Water memory and homeopathy is a further example: Nobel level scientists have demonstrated it but have been labelled either swindlers or fools. The attitudes to "cold fusion" is a further example of anti-intellectualism in the veil of scientism.
5. The final example is skeptic himself: at least outside the academic environment he believes that he has command of his actions over his body. Why should he have this belief if it is a mere illusion? This question skeptic manages to unask.

The Emoto experiments are especially vulnerable against the attacks of skeptics. First of all, the experimenter must be able to take seriously the idea that the system studied can have emotions, he must be able to perceive the emotional state of the system and be even able to affect it.

The attempt to affect water at freezing point or the rice in a water bottle requires remote mental interaction: one might say that at the level of conscious experience one must be able to fuse with the water. This kind of ability, emotional intelligence, probably requires an empathetic personality and also a long period to develop since developing a deep emotional relationship with a rice bottle is not a one-night stand. If a skeptic (usually not a very empathetic person) tries to replicate the experiments, he probably fails since he wants to fail and because for him the rice is dead matter (as also other people and skeptic himself, if he thinks completely logically).

There is no way to prove to skeptics that these effects are real since in his world view these effects are impossible. Therefore I think that there is only one way to proceed. A new view of fundamental physics based on good philosophy respecting internal logical consistency, consistent with existing physics, solving the anomalies of the existing physics, and predicting a lot of new phenomena is the only way to proceed. Even skeptics must eventually bow to the power of logic.

This theory must explain what consciousness and life are and must provide an elegant identification for emotions as a universal panpsychic phenomenon appearing already at DNA level. This theory must explain emotional intelligence as the ability to sense the emotional state of another system and explain how emotions are expressed, transferred and induced. If this kind of theory exists, there are hopes that human kind eventually gains the ability to study consciousness instead of denying it.

### TGD view of the findings

In the sequel I will consider the working hypothesis that the effects are real, and develop an explanation based on TGD inspired quantum biology [K110, K82, K81]. I have developed a model for the findings of Emoto already earlier [L116] [L126] but the updated version of the model involves new elements related to the progress of TGD.

I will also ask new questions. How emotions are communicated at the fundamental level and how a conscious entity can perceive the emotional state of another conscious entity and possibly affect it? What does emotional intelligence mean? How could one assign a measure of conscious

emotional information to the emotional state? How certain sounds or gestures with emotional contents or even pictures can induce emotional response at the fundamental DNA level?

The basic ingredients of the model are following: magnetic body (MB) carrying dark matter as  $h_{eff}/h = n$  phases of ordinary matter; communications between MB and biological body (BB) using dark photons able to transform to ordinary photons identifiable as bio-photons; the special properties of water explained in TGD framework by assuming dark component of water implying that criticality for freezing involves also quantum criticality; the special properties of water at the quantum criticality for Pollack effect at physiological temperature, and the realization of genetic code and counterparts of the basic bio-molecules as dark proton sequences and as 3-chords consisting of light or sound providing a universal language allowing universal manner to express emotions in terms of bio-harmony realized as music of light or sound.

The entanglement of water sample and the subject person (with MBs included) realized as flux tube connections would give rise to a larger conscious entity expressing emotions via language realized in terms of basic biomolecules in a universal manner by utilizing genetic code realized in terms of both dark proton sequences and music of light of light and sound.

### 4.5.2 Bioharmony and the genetic code

The notions of genetic code and bioharmony have evolved gradually during years. The following gives a brief summary of the basic ideas.

#### Basic ideas of bioharmony

1. The notion of bioharmony is based on the observation that 12-note-scale could correspond to a Hamilton cycle at an icosahedron containing 12 vertices [L31, L140, L170, L192, L212]. The scale would correspond to a Hamilton cycle going through all the vertices just once. Quint cycle is a very attractive identification for the representation of the scale in the sense that neighboring points of the icosahedron correspond to scaling of frequency by factor  $3/2$  and so that octave equivalence characterizing musical perception gives 12-note scale spanning a single octave.
2. For a given Hamilton cycle, the 20 faces of the icosahedron define 3-chords proposed to correspond to an icosahedral harmony. One obtains a large number of different Hamilton cycles characterized by a symmetry group which is either  $Z_6$ ,  $Z_3$  or  $Z_2$ , which can be generated by reflection or a rotation by  $\pi$ . There are also 6 Hamilton cycles with trivial symmetries ( $Z_1$ ). Hamilton cycles without any symmetries have an interpretation as disharmonies.
3. The surprising finding was that the 3 icosahedral 20-chord harmonies: the unique  $Z_6$  harmony,  $Z_4$  harmonies and considerable larger number of  $Z_2$  harmonies give rise to a partial representation of the genetic code in the sense that the orbits of these symmetry groups correspond to amino acids. The number of triangles at a given orbit  $Z_n$  is the same as the number of DNAs coding the corresponding amino acid.

4 codons from 64 codons are however missing. These are obtained by adding a tetrahedral Hamilton cycle with 4 chords and 4 vertices. The conclusion is that genetic code and music harmony might be deeply related.

4. Icosa tetrahedral hyperbolic tessellation [L212] emerges as a unique hyperbolic tessellation involving 3 Platonic solids tetrahedron, octahedron and icosahedron. The proposal is that it could provide a universal representation of the genetic code and associated bioharmony, which is not restricted to biology but applies to all kinds of systems in all scales. One could say that the tessellation is induced (projected) to the 3-surface at hyperbolic space  $H^3$  (light-cone proper time constant surface in  $M^4$  and defines a genetic code for almost any system.

The 3 Hamilton cycles as representations of 12-note scale give  $20+20+20=60$  chords and the tetrahedral Hamilton cycle gives 4 chords. These 64 chords would correspond to genetic codons represented as faces of icosahedron and tetrahedron.

### The quantum realization of bioharmony

How to realize bio-harmonies physically if the TGD view of dark matter residing at monopole flux tubes and controlling biomatter is assumed?

1. Dark genome at the magnetic monopole flux tubes paired with DNA and realized in terms of dark protons. Dark 3-proton triplets would represent the 3-chords of the icosahedral bioharmony. Chords would be assignable to cells of a unique hyperbolic icosahedral tessellation containing icosahedron, octahedron and tetrahedron as basic units. These three Platonic solids have triangular faces so that they can be glued together.

The icosahedral tessellation of  $H^3$  would induce a tessellation of the 3-surface  $X^3 = X^4 \cap H^3 \times CP_2$ , where  $X^4 \subset H^3 \times CP_2$  denotes the space-time surface [L212]. The octahedrons belonging to the tessellation would have naturally a passive role since all faces could be regarded as either icosahedral or tetrahedral. Codons would be realized in terms of dark proton triplets assigned to vertices of the triangular faces of the tessellation.

2. Dark photon triplets as cyclotron frequency triplets, 3-chords, induce transitions between the states of dark proton sequences. Differences of cyclotron frequency triplets would correspond to dark photon triplets which can induce transitions between dark proton triplets. This realization came rather recently and it is still somewhat unclear whether the chords correspond to the differences of the triplets or to triplets. Also pairs of frequencies and even a single frequency can induce transitions in which 2 or only one frequency of the chord changes.
3. TGD leads also to a speculative generalization of genes. Not only dark codons would be possible but also sequences of dark codons forming dark 3N-protons behave as quantum units, dark genes. They can emit and absorb dark 3N-photons inducing transitions between dark genes as 3N resonances.

For a given bioharmony, the dark codons and dark genes would effectively serve as addresses and given dark 3N-photon could induce transitions only between dark genes for which its 3N cyclotron frequencies would correspond to differences of the cyclotron frequencies.

Also partial resonance is enough and even a single dark photon can induce transition between two dark genes. Several transitions are possible if only a single dark proton makes a cyclotron transition. It is also possible that the transformed dark gene belongs to a different bioharmony.

This leads to a view of how dark genes control ordinary genes.

1. Dark biomatter as  $h_{eff} = nh_0$  phases at magnetic monopole flux tubes of the magnetic body (MB) of the system should act as a boss receiving information from the ordinary biomatter controlling it. This strongly suggests that the dark and ordinary information molecules, in particular genes are paired and form helical structures. A rather detailed view of this idea was developed in [L212].
2. The control and communication between dark and ordinary genes would involve the transformation of dark photons to ordinary photons, possibly identifiable as bio-photons, or vice versa. This applies also to the communications of dark and ordinary counterparts of the other information molecules and would be essential in the processes like transcription and translation. Dark 3N-photons as quantum coherent units could decay to 3N ordinary photons. The communication would involve energy resonance but not frequency resonance since  $h_{eff}$  changes. A full 3N-resonance is not needed.
3. The resonance condition requires that the dark cyclotron energies and corresponding transition energies assignable to ordinary DNA are identical. The frequency increases since  $h_{eff}$  decreases. The transitions of ordinary information molecules need not be cyclotron transitions but can correspond to ordinary chemical transitions. This gives a strong constraint to the values of  $h_{eff}$ . This poses strong constraints on both the ordinary and dark information molecules and could have led to a selection of the DNA, RNA and tRNA codons and amino-acids.

4. The original long held belief was dark genes as sequences if 6 bits are identical with the ordinary genes. There is actually no need to assume this. Both the bioharmony and bits can be dynamical. Even the bioharmonies of the dark codons can be dynamical and the dark bioharmony should be consistent with the transition energy spectrum of the ordinary genetic codons only during their mutual communications. 3N-photons of dark genes or their substructures should induce transitions of ordinary genes in order to make control possible. Dark genes pairing with DNA would make the DNA a cognitive unit consisting of units of 6 bits, an intelligent entity. It would also have emotions and perhaps also emotional intelligence due to the existence of several bio-harmonies.

#### *1. About the symmetries of dark codons*

Before continuing one must consider the symmetries of the bioharmony.

1. An open question is whether the dark 3-chords related by a permutations of vertices should be identified or not. If they are regarded as different, there are  $(3!=6)$  non-equivalent chords). If a full permutation invariance is allowed, it does not make sense to speak of permutations of the vertices of F and the transitions inducing changes of the 3-chord would not be possible since they could correspond to vanishing energy change of cyclotron energy.
2. In the case of ordinary DNA the order of nucleotides matters and one has  $3!$  different orderings. Now however the codons are quantum entangled units of 3 dark protons so that the situation is not so simple. If the cyclotron frequency spectra assignable to the vertices are not identical then one can say that dark protons are ordered. In this case either of these options is relevant.
3. An interesting possibility is that the 3-chords related by cyclic permutations are equivalent. There would be only 2 non-equivalent 3-chords with different total cyclotron energies and they would have opposite orientations which might be interpreted in terms of parity violation. This would double the number of physically realizable chords and the problem associated with the physical realization of the codons is that the number of codons is by a factor  $1/2$  too small for the simplest proposals.
4. If a full permutation invariance is allowed it does not make sense to speak of permutations of the vertices of F and the transitions inducing changes of the the 3-chord would not be possible since they could correspond to vanishing energy change of cyclotron energy. If only cyclic invariance is assumed, one can reach 2 vertices/notes from a fixed vertex/note of F by a reflection which permutes the vertices and changes the total cyclotron energy.

#### *2. Does the notion of bioharmony relate to the ordinary notion of harmony*

It would be nice to have a contact with the ordinary notion of harmony in which the numbers of chords are small and the 12-note scale is replaced by the 8-note scale or 5-note scale and one has minor and major scales or fusion of them to a scale containing 9 notes.

At the fundamental level music should induce transitions between the codons of a bioharmony so that it is natural to study the transitions changing the dark codons. Consider now the possible transitions changing the 3-chord represented as 3-proton state and induced by one or more dark photons.

1. For a given icosahedral triangular face F and given bioharmony, one can consider the neighboring faces of F, which have either 3, 2, 1 common vertices reachable by a transition induced by keeping the face/3-chord fixed, keeping one edge (2 notes) fixed, or keeping 1 vertex/note fixed. If there are no common vertices, the initial and final chords have no common frequencies. Also these transitions are possible.
2. For transitions leaving a single edge E/note pair fixed, there are 3 faces/3-chords reached by reflection with respect to E. One could call them inner faces/chords. There are 6 faces/chords reached by keeping a single vertex/note fixed: these faces/chords could be called outer chords.

The total number of faces/chords reached by edge and face preserving transitions is  $6+3=9=10-1$ , where 10 is half of the number of faces of the icosahedron. If the orientation of the face matters, 10 faces are reached. The faces belonging to the complement of these 10 faces require the change of all frequencies.

The inner  $3+1=4$  faces define 4 3-chords and 6 outer faces define 6 3-chords: 10 chords altogether making  $1/2$  of all 3-chords. Could they be regarded as simpler sub-harmonies of the 64 chord harmony?

3. The Hamiltonian cycle has 12 vertices and 3 of them must belong to the complement of the reachable region and should define a triangle by the reflection symmetry of the icosahedron. One would have dual sub-harmonies. Could they somehow relate to the minor and major scales? Or could they relate to DNA strand and conjugate strand? The outer faces contain 6 vertices, which do not belong to F so that the reachable region contains  $6+3=9$  vertices. Could this have something to do with the 8-note scale which has actually only 7 notes by octave equivalence. The minor scale has two additional notes since the scale  $(AHCDEF\sharp F\sharp A)$  differs from its reversal  $AGFEDCHA$ : this would make 9 notes/vertices. For a given base note the number of notes of minor and major scale is 9.
4. From a given vertex of F, one can reach  $3+1$  outer vertices and 2 vertices of F if reflection symmetry is not true. Could the pairs formed by the fixed vertex of F and these vertices define 6 notes which define allowed changes of notes for a melody. Interestingly, the 8-note scale  $(C,D,E,F,G,A,H)$  allows 6 non-trivial intervals  $(\{(C,D), (C,E), (C,F), (C,G), (C,A), (C,H)\})$ .

### 4.5.3 The interpretation of bioharmonies in the framework of the TGD inspired theory of consciousness

The key idea is that music expresses and generates emotions. Harmony dictates the emotional tone of music and this suggests that bioharmonies are correlates for emotions and that emotions are realized already at the molecular level.

#### Empirical support for the notion of bioharmonies as correlates for emotions

There is empirical support for the idea that bio-harmonies correlate with emotions.

1. RNA seems to represent and transfer emotions [J70] (see <http://tinyurl.com/y92w39gs>) [L116]. RNA from the brain of a snail conditioned by a painful stimulus is transferred to the preparation made from neurons of sea slug. Neuron preparation in the Petri dish reacts to the conditioning stimuli as if it were itself conditioned.
2. Somehow RNA is able to transfer emotions. The TGD inspired proposal [L31, L209, L110, L170, L113] [L116] is that dark DNA and RNA represent emotions as sequences of 3-chords made of dark photons of dark RNA form 3N-dark photons behaving like a single quantum coherent unit. The representation of the genetic code would rely on icoso-tetrahedral representation in which the 3-chords would correspond to triangular faces of icosahedron and tetrahedron to which 3-chords are assigned.
3. The first proposal was that the induction of emotions could take place by 3N-resonant cyclotron absorption of dark 3N-photons by dark genes represented as sequences of 3N dark proton triplets at monopole flux tubes of MB. Also the absorption of dark photon singlet or doublet by a dark codon is enough to induce transition between dark codons and therefore between dark genes. This would "wake-up" the dark gene and induce emotional response.

#### Emotions are expressed and emotional expression induces emotions

Assume that emotions reduce to the DNA level or at least, that they are realized at DNA and biomolecular level. One can pose several questions. What are emotions? How are they expressed? How does emotional expression induce emotions? How are emotions perceived?

1. The universality and uniqueness of the hyperbolic tetra icosahedral tessellation suggests that the notions of bioharmony and moods are universal and can be defined at the level of DNA and other bio-molecules and could even generalize to even larger structures by inducing the icosahedron-tetrahedron structure to the 3-surface associated with the structure.
2. Moods at the bio-molecular level would correspond to bio-harmonies realized in terms of dark genes represented as sequences of dark codons representable as dark proton triplets. The dark genes would be dynamical unlike the ordinary genes and dark bioharmony would only correspond to the transition energies of DNA only during control and communications. Dark genes would therefore represent intelligence in both cognitive (bit) sense and emotional sense.
3. The basic idea is that music induces emotions and expresses them. How this would be realized at the level of bioharmonies. The first guess is that the emotional state is represented by 3N-chords defining a bioharmony and identified as dark proton triplets, dark genetic codons. The original proposal was that dark photon triplets define another representation of the dark code. This would not be the case: dark photon frequency triplets could correspond to differences of the frequency triplets assignable to dark proton triplets. With this interpretation the notes and chords of music would correspond to the differences of chords and notes for the bio-harmonies.

This interpretation also allows us to consider temporal patterns of dark codons defining a sequence of 3-chords as a kind of music piece. The dark 3N-photon triplets and also dark photon singlets and doublets induce cyclotron transitions between these triplets if the bio-harmonies of the sender and receiver are the same. Otherwise only some chords induce transitions or only some notes of a given chord. One can even consider transition of entire dark genes by using dark 3N-photons.

4. Systems A and B with the same bioharmony, have the same emotional state, can be in emotional resonance. Transitions between different chords induced by dark photon triplets generated by codon A induce transitions of codon B producing temporal sequences of 3-chords, music pieces!
5. The resonance can be also partial so that all notes of the dark codon are not affected. For instance sequence of notes can induce transitions between chords if the two chords belong to the same 20-codon bioharmony. This is the case always for the codons with  $Z_6$  symmetry. A melody, which is consistent with a given bioharmony, involves only notes belonging to the chords of the harmony so that it can induce a transition at a level of single chords. The number of these notes should be maximal. An emotionally intelligent conscious entity should have a wide repertoire of bio-harmonies and be able to rapidly find a bioharmony to generate emotional resonance to the signals of another conscious entity.
6. Cyclotron transitions would form a representation of bioharmony analogous to music piece. Reading of a gene could give rise to a music piece as a sequence of 3N-chords. The interpretation as a melody consistent with given bioharmony should make sense.

### How to perceive the bioharmony, resonate with it, and modify it?

In the sequel I christen the sender of emotional signal Alice and its receiver Bob since the world of physics contains only spherical cows besides Alice and Bob. Human interaction involves emotional aspects. In the ideal case, Alice and Bob are able to sense each other's emotional states and are able to communicate their emotions. Empathetic Alice with noble goals can even change the mood of Bob from confused or sad to vsl and happy. Empathy does not mean benevolence. Hitler was known as a very empathetic person. Empathetic but malevolent Alice can do the opposite. What could be the description of this at the fundamental level?

1. Even a single note of a melody can induce a transition between chords of a given bioharmony represented as dark codons if it corresponds to a difference of notes of two chords. Note or several of them can change the chord so that it does not belong to the same bioharmony anymore. This would tend to change the mood.

If Alice is an empathetic listener not trying to affect the mood of Bob, she must use frequencies, which resonantly induce transitions between the chords of the bioharmony of Bob. Alice and Bob must be tuned: i.e. they must have the same bioharmony with the same frequency scale.

2. The ability to resonate with Bob requires that the signal sent by Alice contains peak frequencies, which belong to the bioharmony of Bob. To be empathetic, Alice should be able to sense the frequencies associated with the chords of Bob's bioharmony. From these frequencies Alice might be even able to deduce the chords of the bioharmony of Bob.

If Alice manages to do this, she has the gift of empathy or emotional intelligence. Autists might be regarded as people with a low level of emotional intelligence and the reason might be that they are not able to perceive the needed frequencies. Perhaps mirror neurons play an essential role here in detecting these frequencies.

Empathy has nothing to do with the moral or ethical standards of Alice. Alice can do several things. She can generate resonant transitions supporting the bioharmony of Bob. She can also try to modify the mood of sad Bob, say comfort him. Alice can do this by generating frequencies which affect the chords of the bioharmony of Bob so that it changes.

If Alice is malevolent, she can modify the bioharmony of Bob so that his mood becomes sad or depressed. If Alice is a psychopath, she can even force a disharmony without any symmetries leading to a total emotional confusion. Basically Alice makes a choice between good and evil. Perhaps the ugly words do just this at the level of the DNA of rice in Emoto's experiments whereas nice encouraging words do the opposite.

How the voices or gestures of Alice are transformed to dark photons, their triplets or even dark genes?

1. The voice of Alice could be transformed to dark photons with the same frequency spectrum by a generalization of the piezoelectric effect (see this). These dark photons should affect the dark proton sequences of the MB of Bob at the biomolecular level in order to generate an emotional response.
2. The frequencies must be consistent with the bioharmony of Bob and define the emotional color of the speech of Alice, which can be warm or cold or lacking emotional content altogether if Alice and B are not emotionally "tuned". Also the gestures of Alice should be coded to the sequences of dark photons or even of dark photon triplets representing kind of emotional music pieces. The notes of the melody should correspond to differences for the chords of the bioharmony in question.

### Negentropy of bioharmony

Dark genetic code consists of 6-bit units and this aspect corresponds to the ordinary DNA as a bit sequence. Besides this there is bioharmony which relates to the information represented as emotions instead of bits. Emotional intelligence measures the ability to perceive the emotional state. One cannot give a simple measure for this ability. One can however consider information measures for the bioharmonies.

1. One can assign to the bioharmony a measure of its algebraic complexity and information content. The value of  $h_{eff} = nh_0$ , where  $n$  is a dimension of algebraic extension involved, would define a kind of IQ and perhaps also EQ. One can also assign a negentropy to the bioharmony, which could measure its information content. Of course, the EQ characterizes the ability to perceive the emotional state, and is not a property of bioharmony.
2. The intuitive picture is that the negentropy of the bioharmony characterizes the symmetries of the bioharmony. For a given bioharmony, one has 3 icosahedral symmetry groups  $Z_6$ ,  $Z_4$ , and  $Z_2$  corresponding to the 3 20-codon bio-harmonies. The symmetry group of a given 20-codon icosahedral code has orbits such that each codon at a given orbit codes for the same amino acid. There can be several orbits coding for the same amino acid. The  $k$ :th orbit contains  $n_k$  codons.

3. Consider first the definition of the entropy. The expression for the entropy of given bioharmony could be defined by the probabilities that a given chord belongs to the  $k$ :th orbit with  $n_k$  chords. The 3 20-chord harmonies are independent and the icosahedral contribution to the entropy is the sum  $\sum_{K=1}^3 S_K$  of the entropies  $S_K$  associated with them. Also the tetrahedral contribution is present. One would have  $S = -\sum p_k \log(p_k)$ .  $p_k$  would be given by  $p_k = n_k/N$ , where  $N = 20$  is the total number of chords in the icosahedral case  $N = 4$  is the total number of chords in the tetrahedral case.
4. One wants to assign an information measure, negentropy to cognition. p-Adic number fields serve as correlates of cognition. Formally the definition is similar to that for entropy: one sums over the contributions of 3 icosahedral harmonies and the unique tetrahedral harmony. For a given p-adic prime  $p$ , one can define p-adic negentropy  $N_p = \sum p_k \log(N_p(p_k))$ , where  $N_p(p_k)$  is the p-adic norm of the probability. Rather remarkably, this negentropy can be positive unlike entropy.

One can also define the sum  $\sum_p N_p$  of the p-adic negentropies as the total p-adic negentropy. This sum involves only a finite number of terms since the probabilities are rational numbers and the p-adic norm differs from unity only if  $p$  divides the numerator or denominator of  $p$ . In this way one obtains non-negative information measure. It can be shown that the difference N-S is non-negative.

#### 4.5.4 How to understand Emoto's experiments with freezing water and rice?

In Emoto's experiments with water at freezing point and with rice the emotional tone of the spoken words has a surprising effect on the system. How to understand this? Water is fundamental for life and in the TGD based view of life quantum criticality is fundamental for life and conscious intelligence.

Water makes possible quantum critical fluctuations involving large values of  $\hbar_{eff}$  measuring the algebraic complexity of the quantum state and also serving as a kind of IQ. The criticality for freezing and also other phase transitions would be basically quantum criticality and could have been essential for the emergence of primordial life. The ice crystals found by Emoto in the experiments could be corpses of small primordial life forms formed by water molecule clusters. They would be especially favored at quantum criticality and would have dark genetic code which would make it possible for these life forms to experience emotions. The biochemical realization of the genetic code would have emerged much later but would not be essential for the conscious emotional experience.

In the rice experiments, the Pollack effect [I46, L34, ?, I70] could play a key role [L206, L204]. The physiological temperature would be the quantum critical temperature for the phase transition taking place in the Pollack effect. Pollack effect creates matter with a very large value of  $\hbar_{eff} = \hbar_{gr}$ , where  $\hbar_{gr}$  is gravitational Planck constant introduced by Nottale [E1] characterizing the monopole flux tubes of the gravitational fields of the Sun, Earth and also other planets. In the Pollack effect, incoming photons kick protons to dark protons at the gravitational magnetic flux tubes. This gives rise to negatively charged exclusion zones characterizing cells and DNA.

Pollack effect would be associated with the sol-gel phase transition. Pollack effect is also essential for the metabolism and photosynthesis. Pollack effect requires energy feed and for instance solar radiation can provide it. Also the formation of molecules from atoms can liberate the needed energy.

The dark protons would be associated with the magnetic bodies of water molecule clusters. Water memory and homeopathy would involve Pollack effect and would be associated with primordial life forms formed by water clusters [K48]. Water memory would allow the magnetic bodies to recognize and mimic the magnetic bodies of the invader molecules as small life forms with the same cyclotron energy spectrum. This would make possible the evolution of the immune system and of chemical life.

Also the electric counterpart of the gravitational quantum coherence is possible in the long range classical electric fields of Sun, Earth and also of smaller objects is an essential element of life [L213]. The long range electric fields associated with the central nervous system might involve macroscopic quantum coherence with a large value of  $\hbar_{em}$ .



An induction of emotions similar to that occurring in human interactions could take place in the experiments of Emoto and transform the words of the experimenter to dark photon signals affecting the DNA and RNA of the rice. It is the peak frequencies determining the emotional tone which matter, not the content of the words in the usual sense. If the emotions are indeed universal at the level of dark genes, the emotional aspects of voice would be emotional also from the point of view of rice in water.

The words with an unfriendly tone would change the bioharmony to a less negentropic one. Friendly words would cause the opposite. This would not be about a direct modification of the metabolic energy feed but about its utilization: depressed people lose their appetite and this leads to metabolic deprivation. The sum of p-adic negentropies provides a quantitative measure for the negentropy of the bioharmony and it also could also serve as a parameter characterizing the mood.

## 4.6 Emotions and RNA

In the following fascinating findings related to RNA and possibly expression of emotions at molecular level are discussed.

### 4.6.1 Does RNA code for pain?

I learned about an extremely interesting finding [J70] (see <http://tinyurl.com/ycqxyeqk>) in neuroscience. The popular article “*Scientists Sucked a Memory Out of a Snail and Stuck It in Another Snail*” (see <http://tinyurl.com/y92w39gs>) tells that the conditionings of snails produced by painful sensations can be transferred to other snails or even snail neurons in Petri dish by adding just the RNA of the conditioned snails to the dish!

Let us summarize the findings.

1. RNA from snails is transferred to snails or to even populations of snail neurons in Petri dish!
2. The effect involves epigenetic changes in DNA by methylation induced by RNA somehow. The reaction is to the serotonin informing for the stimulus. Avoidance behavior emerges as a response.
3. How does RNA induce the epigenetic change? RNA should couple to a specific part of DNA and induce the effect. A pairing of DNA with RNA in question occurring also in transcription suggests itself strongly.
4. What in the RNA of the conditioned snail is different? RNA should somehow code for the conditioning induced by a painful sensory experience. RNA of sensory receptors should change somehow and communicate this change to DNA in brain by some mechanism. DNA-RNA pairing does not seem plausible. Could the pairing occur by some other means?

Before continuing it is good to summarize the TGD based models for music harmony providing also a model of genetic code (see <http://tinyurl.com/yad4tqwl>), for sensory perception (see <http://tinyurl.com/yczv2o5b>), for emotions (see <http://tinyurl.com/ydhxen4g>), and for imprinting of emotions in water (see <http://tinyurl.com/ycdywctw>).

1. TGD based model for emotions and communication of emotions suggests that the communication takes place in terms of what I call music of light (also sound might be involved). Music expresses and creates emotions. Emotional state, mood, is coded by harmony or disharmony for music of light.

12-note is fundamental for music and is represented as a closed self-non-intersecting path (Hamilton cycle) at icosahedron having 12 vertices. Icosahedron has 20 faces (triangles) and for given Hamilton cycle one can assign a 3-chord to each triangle. This gives 20-chord harmony (or disharmony). There is quite large number of 20-chord harmonies and those allowing  $Z_6$ ,  $Z_4$  and  $Z_2$  as symmetries is quite large. Besides this there 6 cycles with no symmetries and these could be identified as dis-harmonies.

2. 20 is also the number of amino-acids so that it is not totally surprising that the model for bioharmony as a union of 3 different 20-chord harmonies plus 4-chord harmony assignable to tetrahedron turns out to give a model of genetic code as 64 chord bioharmony. There are 64 basic 3-chords in one-one correspondence with DNA and RNA codons. tRNA corresponds to a union of 2 20-chord harmonies. Given amino-acid corresponds to the orbit of 3-chord under symmetries of the harmony so that number of 3-chords at the orbit is the number of DNAs coding for the amino-acid. These numbers come out correctly.
3. There are two other representations of genetic code. The ordinary chemical representation and the representation in terms of dark proton sequences at magnetic flux tubes. The model for dark proton triplet predicts that its states divided to 64 analogs of DNA codons, 64 analogs of RNA codons, 40 analogs of tRNA codons, and 20 analogs of amino-acids. Genetic code comes out correctly also now by a natural pairing of dark proton triplets. One must couple these 3 representations of genetic code with themselves and with each other.
4. There is indeed resonant coupling by 3-chords realized in terms of free frequencies of dark photons. The frequencies are rather low ( $E = h_{eff} \times f$ ,  $h_{eff}/h = n$ ) but energies are same as for biophotons with energies in visible and UV range.

Also dark variants of DNA, etc couple with each other via dark photon resonance. Dark DNA, etc couple with ordinary DNA, etc.. by energy resonance to form double strands. This means that dark photon transforms to ordinary photon in the coupling. Amino-acid couples to single frequency, which is the sum of codon frequencies coding for it.

There is quite large number of 3-chord 3-harmonies defining DNA and RNA moods, and 3-chord 2-harmonies tRNA moods, and amino-acid 1-chord harmonies. There also 6 disharmonies with 20 chords each possible assignable to negative moods such as those generated by pain.

So: Is the communication chemical by DNA-RNA pairing or by some other means? TGD based model suggests "some other means".

1. Pain in sensory receptor is certainly involved. In TGD based model differs from neuroscience view in that for sensory experiences sensory receptors are seats of the sensory qualia and brain only forms cognitive representations about them and also entangles with sensory receptors to share the pain. Somehow pain must affect RNA in sensory receptors? How?
2. In this framework the stimulus in nociceptors would induce a disharmony expressed in terms of the disharmony associated with the expression of RNA in terms of 3-chords. The dark variant of RNA in pain receptors would entangle with the dark DNA in certain neurons in brain of the snail. Nerve pulse patterns from the nociceptors would generate also magnetic flux tube connections parallel to the sensory pathway in question and make possible the communication by dark biophoton triplets to brain possible. The dark variant of DNA in brain would have resonant coupling with ordinary DNA and induce the epigenetic change by methylation as a response to the negative mood with the mediary of biophotons. After this the organism would have avoidance behaviour towards the stimulus inducing the pain.
3. The presence of mere RNA and associated dark RNA dis-harmonious mood would do the same for any neuron by the resonance mechanism. This would allow to transfer emotions even to snail neurons in Petri dish, not only those in living snails.

The proposed mechanism provides insights to many other poorly understood problems.

1. This mechanism also allows to understand how the transfer of emotions conditioning induces epigenetic change also in the germ cell DNA: this is not easy to understand in the standard framework requiring chemical communication through the germ cell membrane.
2. The models for learning (memories restricted to conditionings) based on formation of synaptic contacts on one hand and involving RNA are seen as exclusive in standard neuroscience. In TGD framework the formation of synaptic contacts might rely at the fundamental level on

the same epigenetic mechanism. Neuromodulators might induce the emotional states in RNA in turn doing the epigenetic editing.

In human brain the genomes differ in various neurons and epigenetic editing by the proposed mechanism might cause this. An interesting question is whether humans could edit their genomes intentionally. All conditionings are not useful and maybe it becomes someday possible to affect these conditionings at the level of dark DNA.

3. Squid and octopus are known to be able to edit their mRNA (see <http://tinyurl.com/m7m6c28>). Instead of DNA the mRNA produced in the transcription so that the translation produce different protein. The effect of emotional states of the dark variant of RNA associated with mRNA could be the mechanism involved.
4. The strong emotional state of single individual induces very effectively the same emotional state in people around: consider only concert as an example. Could the "music of dark light" mediate the emotions from the dark RNA of individual - say artist - to people around. If so all art would be basically music of light!

To sum up: this finding provides rather concrete support for the vision that emotions are coded by the music of light at molecular level.

#### 4.6.2 Did RNA replicate in codon-wise manner during RNA era?

There was an interesting popular article in Spacedaily with title "*Scientists crack how primordial life on Earth might have replicated itself*" (see <http://tinyurl.com/y92ng5vd>). The research paper [I33] is titled "*Ribozyme-catalysed RNA synthesis using triplet building blocks*" and published in eLife (see <http://tinyurl.com/ya5qyjfn>).

It is possible to replicate unfolded RNA strands in Lab by using enzymes known as ribozymes, which are RNA counterparts of enzymes, which are amino-acid sequences. In the presence of folding the replication is however impossible. Since ribozymes are in general folded, they cannot thus catalyze their own replication in this manner. The researchers however discovered that the replication using RNA triplets - genetic codons - as basic unit can be carried out in laboratory even for the folded RNA strands and with rather low error rate. Also the ribozyme involved can thus replicate in codon-wise manner. For units longer than 3 nucleotides the replication becomes prone to errors.

These findings are highly interesting in TGD framework. In TGD the chemical realization of genetic code is not fundamental. Rather, dark matter level would provide the fundamental realizations of analogs of DNA, RNA, tRNA, and amino-acids as dark proton sequences giving rise to dark nuclei at magnetic flux tubes [L110] (see <http://tinyurl.com/yalny39x>). Also ordinary nuclei correspond in TGD Universe to sequences of protons and neutrons forming string like entities assignable to magnetic flux tubes.

The basic unit representing DNA, RNA and tRNA codon and amino-acid would consist of 3 entangled dark protons. The essential aspect is that by entanglement the dark codons do not decompose to products of letters. This is like words of some languages, which do not allow decomposition to letters. This representation is holistic. As we learn to read and write, we learn the more analytic western view about words as letter sequences. Could the same hold true in evolution so that RNA triplets would have come first as entities pairing with dark RNA codons from dark proton triplets as a whole? Later DNA codons would have emerged and paired with dark DNA codons. Now the coupling would have been letter by letter in DNA replication and transcription to mRNA.

It is intriguing that tRNA consists of RNA triplets combined from amino-acids and analogs of mRNA triplets! The translation of mRNA to amino-acids having no 3-letter decomposition alone forces the holistic view but one can ask whether something deeper is involved. This might be the case. I have been wondering whether during RNA era RNA replicated using a prebiotic form of translational machinery, which replicated mRNA rather than translated RNA to protein formed from amino-acids (AAs) with AA serving as a catalyst.

1. During RNA era amino-acids associated with pre-tRNA molecules would served as catalysts for replication of RNA codons. The linguistic mode would have been "holistic" during RNA

era in accordance with the findings of the above experiments. RNA codon would have been the basic unit.

2. This would have led to a smaller number of RNAs since RNA and RNA like molecules in tRNA are not in 1-1 correspondence. A more realistic option could have been replication of subset of RNA molecules appearing in tRNA in this manner.
3. Then a great evolutionary leap leading from RNA era to DNA era would have occurred. AA catalyzed replication of RNA would have transformed to a translation of RNA to proteins and the roles of RNA and AA in tRNA would have changed. [Perhaps the increase of  $h_{eff}$  in some relevant structure as quantum criticality was reached led to the revolution]
4. At this step also (subset of) DNA and its transcription to (a subset of) mRNA corresponding to tRNA had to emerge to produce mRNA in transcription. In the recent biology DNA replicates and is transcribed nucleotide by nucleotide rather than using codon as a unit so that helicases and DNA and RNA polymerases catalyzing replication and transcription should have emerged at this step. The ability of DNA to unwind with the help of helicase enzyme helping DNA to unwind is essential for the transcription and translation of DNA. Therefore helicase must have emerged together with the “analytic linguistic mode” as an analog of written language (DNA) decomposing codons to triplets of letters. This would be a crucial step in evolution comparable to the emergence of written language based on letters. Also the counterpart of RNA polymerase and separate RNA nucleotides for transcription should have emerged if not already present.

An alternative option would involve “tDNA” as the analog of tRNA and the emergence of helicase and polymerases later as the transition from holistic to analytic mode took place.

The minimal picture would be emergence of a subset of DNA codons corresponding to RNAs associated with pre-tRNA and the emergence of the analogs of helicase and DNA and RNA polymerases as the roles of amino-acid and RNA codon in tRNA were changed.

5. How DNA could have emerged from RNA? The chemical change would have been essentially the replacement of ribose with de-oxiribose to get DNA from RNA and  $U \rightarrow T$ . Single O-H in ribose was replaced with H. O forms hydrogen bonds with water and this had to change the hydrogen bonding characteristics of RNA.

If the change of  $h_{eff} = n \times h_0$  was involved, could it have led to stabilization of DNA? Did cell membrane emerge and allow to achieve this? I have proposed [L110] (see <http://tinyurl.com/yalny39x>) that the emergence of cell membrane meant the emergence of new representation of dark genetic code based on dark nuclei with larger value of  $h_{eff}$ .

**Remark:** One has  $h = 6 \times h_0$  in the most plausible scenario [L62, L115] (see <http://tinyurl.com/goruuzm> and <http://tinyurl.com/y9jxyjns>).

The communication between dark and ordinary variants of biomolecules involves resonance mechanism and would also involve genetic code represented as 3-chords, music of light, and it is interesting to see whether this model provides additional insights.

1. The proposal is that 3-chords assignable to nucleotides as music of light with allowed 64 chords defining what I have called bio-harmony is essential for the resonance [L116, L120, L115](see <http://tinyurl.com/ydhxen4g>, <http://tinyurl.com/yd5t82gq>, and <http://tinyurl.com/y9jxyjns>). The 3 frequencies must be identical in the resonance: this is like turning 3 knobs in radio. This 3-fold resonance would correspond to the analytic mode. The second mode could be holistic in the sense that it would involve only the sum only the sum of the 3 frequencies modulo octave equivalence assigning a melody to a sequence of 3-chords.
2. The proposal is that amino-acids having no triplet decomposition are holistic and couple to the sum of 3 frequencies assignable to tRNA and mRNA in this manner. Also the RNAs in tRNA could couple to mRNA in this manner. One could perhaps say that tRNA, mRNA and amino-acids codons sing whereas DNA provides the accompaniment proceeding as 3-chords. The couplings of DNA nucleotides to RNA nucleotides would rely on the frequencies assignable to nucleotides.

3. If the sum of any 3 frequencies associated with mRNA codons is not the same except when the codons code for the same amino-acids, the representation of 3-chords with the sum of the notes is faithful. The frequencies to DNA and RNA nucleotides cannot be however independent of codons since the codons differing only by a permutation of letters would correspond to the same frequency and therefore code for the same amino-acid. Hence the information about the entire codon would be needed also in transcription and translation and could be provided either by dark DNA strand associated with DNA strand or by the interactions between the nucleotides of the DNA codon.
4. The DNA codon itself would know that it is associated with dark codon and the frequencies assignable to nucleotides could be determined by the dark DNA codon. It would be enough that the frequency of the letter depends on its position in the codon so that there would be 3 frequencies for every letter: 12 frequencies altogether.

What puts bells ringing is that this the number of notes in 12-note scale for which the model of bio-harmony [L31, L116] (see <http://tinyurl.com/yad4tqw1> and <http://tinyurl.com/ydhxen4g>) based on the fusion of icosahedral (12 vertices and 20 triangular faces) and tetrahedral geometries by gluing icosahedron and tetrahedron along one face, provides a model as Hamiltonian cycle and produces genetic code as a by-product. Different Hamiltonian cycles define different harmonies identified as correlates for molecular moods.

Does each DNA nucleotide respond to 3 different frequencies coding for its position in the codon and do the 4 nucleotides give rise to the 12 notes of 12-note scale? There are many choices for the triplets but a good guess is that the intervals between the notes of triplet are same and that fourth note added to the triplet would be the first one to realize octave equivalence. This gives uniquely  $CEG\sharp$ ,  $C\sharp FA, DF\sharp B\flat$ , and  $DG\sharp B$  as the triplets assignable to the nucleotides. The emergence of 12-note scale in this manner would be a new element in the model of bio-harmony.

There are  $4! = 24$  options for the correspondence between  $\{A, T, C, G\}$  as the first letter and  $\{C, C\sharp, D, D\sharp\}$ . One can reduce this number by a simple argument.

- (a) Letters and their conjugates form pyrimidine-purine pairs  $T, A$  and  $C, G$ . The square of conjugation is identity transformation. The replacement of note with note defining at distance of half-octave satisfies this condition (half-octave - tritonus - was a cursed interval in ancient music and the sound of ambulance realizes it). Conjugation could correspond to a transformation of 3-chords defined as

$$CEG\sharp \leftrightarrow DF\sharp B\flat, \quad C\sharp FA \leftrightarrow D\sharp GB.$$

- (b) One could have

$$\begin{aligned} \{T, C\} &\leftrightarrow \{CEG\sharp, C\sharp FA\}, & \{A, G\} &\leftrightarrow \{DF\sharp B\flat, D\sharp GB\}, \\ &\text{or} \\ \{T, C\} &\leftrightarrow \{DF\sharp B\flat, D\sharp GB\}, & \{A, G\} &\leftrightarrow \{CEG\sharp, C\sharp FA\}. \end{aligned}$$

- (c) One can permute  $T$  and  $C$  and  $A$  and  $G$  in these correspondences. This leaves 8 alternative options. Fixing the order of the image of  $(T, C)$  to say  $(C, C\sharp)$  fixes the order of the image of  $(A, G)$  to  $(D, D\sharp)$  by the half-octave conjugation. This leaves 4 choices. Given the bio-harmony and having chosen one of these 4 options one could therefore check what given DNA sequence sounds as a sequence of 3-chords [L31].

That the position the frequency associated with the nucleotide depends on its position in the codon would also reflect the biochemistry of the codon and this kind of dependence would be natural. In particular, different frequencies associated with the first and third codon would reflect the parity breaking defining orientation for DNA.

### 4.6.3 How do slime molds learn?

Quanta Magazine is a treasure trove of popular articles about hot topics in basic research and biology and neuroscience are the hottest topics now. The popular article “*Slime Molds Remember — but Do They Learn?*” about learning of slime molds (see <http://tinyurl.com/ydc8gh4d>) serves as a good example of pleasant surprises popping up on weekly basis. There are several research articles referred but the related to the following comments are about the work of Dussutour and others [I18, I21] (see <http://tinyurl.com/hbo88c> and <http://tinyurl.com/y83o5sfs> ).

1. The popular article tells that slime molds are monocellulars - for long time believed to belong to fungi - but actually somewhat like amoebas. They have neither neurons nor brains. The neuroscientific dogma says that neurons are necessary for learning so that slime molds should not learn. They should only adapt by selecting behaviors from a genetically inherited repertoire. Same would be true about plants, which are also known to learn.

For physicist these beliefs look strange. Both animals and plants and also slime molds share the basic aspects about what it is to be alive, why should they be unable to learn? The research of biologist Audrey Dussutour and her team described in the article indeed shows that slime molds are indeed able to learn.

2. Conditioning is the basic mechanism of learning, which by definition leads to a creation of a new kind of behavior rather than selecting some behavior from an existing repertoire as happens in adaptation. Typically the conditioning is created by associating unpleasant sensory stimulus such as electric shock to some other stimulus, which can be pleasant, say information about the presence of food. This leads to avoidance behavior and the mere presence of food can induce the avoidance behavior.
3. It was found that slime mold [I18] learns a habit of avoiding the unpleasant stimulus - habituation is said to take place. Habituation involves generation of new behavior and is not mere adaption. For instance, habituation can mean stopping noticing stimulus like smell if it is not dangerous or important for survival. In the experiments the slime molds were conditioned to avoid noxious substances (having bitter ”taste”) and they remembered the behavior after a year of physiologically disruptive enforced sleep as the technical terms expresses it. This learned behavior was also transferred in cell fusion to individual that had not learned the behavior [I21].
4. Central nervous system has been believed to be responsible for habituation since neurons receive and process the sensory the stimuli, build kind of cognitive representations about them, and generate motor response. Neuroscientist believe that learning means strengthening of synaptic contacts eventually giving rise to a learned motor response to a sensory stimulus by a sequence of associations

Against this background the ability of slime molds to learn looks mysterious. How do they perceive the stimulus, how do they process it, how do they respond to it? We know actually little about cognition and learning: we know a lot about the neural correlates of cognition but not what cognition is.

Forgetting the question about what cognition is, one can just ask what could lead to the change of behaviour of the slime mold. Some time ago I learned about another fascinating finding related to learning from the article “*Scientists Sucked a Memory Out of a Snail and Stuck It in Another Snail*” (see <http://tinyurl.com/y92w39gs>). What was found that one can take RNA of a snail that has been conditioned by some painful stimulus and transfer it to another snail by scattering RNA on its brain neurons [J70]! Same can be achieved also by feeding snail with the conditioned snail. RNA must somehow represent memories. If this is true for snail it can be true also for the slime mold.

Usually learning is assigned with cognition regarded as kind of linguistic cognition. One speaks also of emotional intelligence: could learning be based on emotions? The TGD based model for emotions (see <http://tinyurl.com/ydhxen4g>) inspired by the model of music harmony [L31, L123] (see <http://tinyurl.com/yad4tqwl> and <http://tinyurl.com/y8njuctq>) leading to a model of genetic code predicting correctly vertebrate coderelies on this idea and leads to a model for what learning could be also in the case of slime molds.

1. Music expresses and creates emotions coded in its harmony (think of major and minor scales as simple examples). This could be true in much more general sense. Not only music made of sound but also of light - dark photons in TGD framework - could realize these functions of music. DNA would have a representation in terms of a collection of 3-chords made of three dark photons with frequencies in proportions allowed by the harmony.
2. The model of harmony based on icosahedral and tetrahedral geometries predicts a large number of harmonies representing emotional states, moods. The music of light makes possible communication between DNA, RNA, amino-acids (AAs), even tRNAs and their dark variants DDNA, DRNA, DAA, DtRNA. Communications are possible if the three chords can resonate note by note: ideal situation occurs if the harmony defining the mood is same in sender and receiver. Emphatics are those, who experience also the sufferings of the other people. Moods can be transferred from RNA to DNA and here they can induce epigenetic change leading to a change in behavior.
3. The painful conditioning of snail would induce a new mood of RNA of snail (probably rather depressive!) and this would in turn infect the DNA of the snail (strong emotions are infective) and the mood of DNA would induce the epigenetic change leading to the avoidance behavior (see <http://tinyurl.com/yb4nuumr> and <http://tinyurl.com/ydhxen4g>). Emotions would be behind the learning and learning would take place at DNA level as epigenetic changes changing the gene expression. Habituation would involve epigenetic changes and adaptation involve only activation of appropriate inherited genes.

It must be added that TGD also leads to a vision about the role of neurons in many aspects different from the neuroscientific view although agreeing with the basic facts and explaining quite a number of anomalies [L87] (see <http://tinyurl.com/yczv2o5b>).

1. The notion of magnetic body (MB) containing dark matter as  $h_{eff}/h_0 = n$  phases of ordinary matter is central. The networks having as nodes objects consisting of ordinary matter (molecules, organelles, organs, even organisms) connected to a network made of flux tubes containing dark matter would give rise to both cellular and neuronal networks. Magnetic flux tube connecting two nodes would serve as a correlate of attention and communication pathway using supra currents or dark photons. Also classical signals can propagate along it.
2. The primary function of nerve pulse activity at the level of CNS would not be communication between neurons but building of communication pathways from flux tubes along which dark photon signals can propagate with maximal signal velocity. The situation would be same in travel phone connections: the communication pathway would be created first and only then the communications with light velocity would begin. Synaptic transmission would build a bridge between otherwise non-connected flux tubes. This would give rise to long waveguides. Dark photons transforming to ordinary photons would yield bio-photons, which have remained mysterious in standard bio-chemistry since their spectrum is not consistent with the discrete spectrum of lines produced if they were generated in molecular transitions.
3. Sensory experiences would be basically at the level of sensory organs and sensory percepts would involve pattern recognition involving repeated feedback signal from brain an leading a standard perception nearest to the sensory input. The new view about time provided by zero energy ontology allows to circumvent the counter argument inspired by phantom leg phenomenon.
4. Nerve pulse patterns would frequency modulate the generalized Josephson frequencies assignable to the membrane proteins acting as Josephson junctions and generating dark Josephson radiation as part of EEG propagating to the MB of the system. Thus nerve pulse patterns would code information but this information would be sent to MB.
5. It is quite possible that the proposed RNA level mechanism is the microscopic mechanism behind strengthening of synaptic connections believed to be behind neuron level learning although also here new findings suggests that situation is not quite it has been believed to be (see <http://tinyurl.com/ybglebph>).

This did not say anything about cognition yet. TGD leads also to a view about mathematical correlates of cognition requiring profound generalization of the mathematical structure of theoretical physics. Real number field is tailor made for the description of the sensory world but how to describe the correlates of cognition. Here p-adic number fields come in rescue and in TGD framework one ends up to a unification of real physics and their p-adic analogs to what I call adelic physics (see <http://tinyurl.com/ybepht6d> and <http://tinyurl.com/ybzkfevz>).

#### 4.6.4 Could also RNA and protein methylation of RNA be involved with the expression of molecular emotions?

Some time ago I wrote an piece of text [L116] (see <http://tinyurl.com/ydhxen4g>) about learning of slime molds [I18, I21]. The proposal was based on the vision inspired by the model of bio-harmony [L31, L123] and stating that harmony of music of light (and maybe of also sound) realized as 3-chords of dark photons with frequencies of 12-note scale expresses and creates emotions and that each harmony corresponds to a particular mood. The painful conditioning of the slime mold would generate a negative mood which would infect DNA and induce epigenetic change. This picture conforms also with the finding that RNA can induce learning of conditionings in snails [J70] (see <http://tinyurl.com/ycqxyeqk>) [L116]. Slime mold does not have central nervous system but a natural guess would be that also synaptic learning involves similar mechanism.

One can ask whether also RNA and protein methylation could be involved with learning. If molecular moods correspond to bio-harmonies and if the conditioning by say painful stimulus involves a change of the emotional state of RNA inducing that of DNA, it must change some of the chords of the bio-harmony. Since bio-harmony is essential for communications by dark photons between dark proton triplets representing dark variants of the basic biomolecules and also between communications between bio-molecules and their dark variants, one expects that the change of the harmony occurs for all dark analogs of biomolecules and also for their ordinary biomolecules. Some chords represented by DNA-, RNA-, and tRNA codons, and amino-acids - briefly basic bio-molecules - would be affected in the change of mood.

The recent finding (see <http://tinyurl.com/y9qsnfeo>) that synaptic connections involve more methyl marks of RNA than other parts of neurons and that the RNA marks tend associated with genes coding for proteins associated with synapses provides support for this view that emotions expressed as modifications of the basic biomolecules. The emotional states would have epigenetic effects changing the gene expression and inducing learning as modification of synapses in turn modifying the behavior. This picture provides also a mechanism for the inheritance of epigenetic modifications: what would be inherited would be emotional states represented in terms of bio-harmonies the level of magnetic body carrying dark protons.

#### Some background about modifications of the basic biomolecules

To get a some perspective consider first some background about the modifications of the basic bio-molecules.

1. In the case of DNA epigenetic modifications (see <http://tinyurl.com/kdd3qmp>) affect mRNA and thus also protein expression. There are two basic mechanisms involved. Methylation of C nucleotide of DNA and protein modification for histone.

Methylation (addition of  $\text{CH}_3$  to N) of C nucleotide leads to a silencing of gene expression. Methylation occurs typically for CpG pairs and for both strands. Before embryogenesis demethylation occurs for the entire DNA (stem cell state) but cell differentiation means methylation of genes not expressed. In vertebrates 60-80 percent of CpG is methylated in somatic cells. CpG islands form an exception involving no methylation. Demethylation (see <http://tinyurl.com/ybg3mz6v>) as the reversal of methylation occurs either spontaneously or actively.

The effects on gene expression can be also inherited to next generations. The mechanism of inheritance is poorly understood. The epigenetic change should be also somehow communicated to the DNA of germ cells but this seems impossible. The mystery is deepened because before embryogenesis demethylation occurs for the entire genome. It is difficult to



understand how the chemical storage of the information about methylation patterns to be transferred to the next generation is possible at all.

The TGD view about emotional expression inducing epigenesis by communications via dark photons between basic biomolecules and their dark variants suggests an elegant mechanism. What would be inherited would be the emotional states represented by bio-harmonies assignable to the dark variants of biomolecules.

2. In the case of pre-RNA post-transcriptional chemical modifications (see <http://tinyurl.com/y8c4w4mp>) - in particular methylation, are known to occur, and they affect RNA splicing rates and change the distribution of mRNAs and thus of proteins. The modifications affect also un-translated RNA (UTR) but not the protein translation from mRNA.
3. Protein modifications (see <http://tinyurl.com/jtczea5>) in turn affect the dynamics of proteins - in particular their properties as enzymes by affecting therefore the rates for various basic processes.

As already noticed, protein modifications are important in epigenesis by histone modification. Wikipedia article mentions lys acetylation by adding  $\text{CH}_3=\text{O}$  group (see <http://tinyurl.com/yd2y7s2m>), lys and arg methylation (see <http://tinyurl.com/ybxgdwhz>), ser and thr phosphorylation, lys ubiquitination and sumoylation. For N-terminus ( $\text{H}_2$  group in the start of protein) the process is irreversible and new amino acid residues emerge. Methylation in C terminus ( $\text{O}=\text{C}-\text{OH}$  end of protein) can increase chemical repertoire. Note that the methylation occurs at the ends of the protein just like it tends to occur in the case of RNA as will be found.

RNA modifications deserve to be discussed in more detail. This field of study is known as epitranscriptomics (see <http://tinyurl.com/y8c4w4mp>). These chemical modifications does not affect protein expression except in the case that they affect the rates of various alternative pre-RNA splicing so that the distribution of alternative protein outcomes changes. Clearly, the effect is somewhat like the effect of mood on overall activity. There are also many other modifications of RNA (see <http://tinyurl.com/y8c4w4mp>). One of them is A-I de-amination which changes in RNA but does not affect protein expression.

The methylation of RNA is the most common and best understood modification of RNA.

1. The modelling of the methylation of both DNA and RNA is based on writer-reader-eraser model. Writing corresponds to methylation. Reading corresponds to attachment of enzymes involved in the splicing or protein synthesis with higher rate to methylated sites. Demethylation is example of erasing.
2. Methylation is known to occur for various variants of RNA (ribosomal rRNA, tRNA, mRNA, and small nuclear RNA snRNA related to metabolic machinery) after transcription. The biochemical modifications of RNA are called epitranscriptomes (see <http://tinyurl.com/y8c4w4mp>).  $\text{N}^6$ -Methyladenosine ( $\text{m}^6\text{A}$ ) is the most common and best understood modification of RNA.  $\text{m}^6\text{A}$  tells that nitrogen in position 6 of adenosine (A) is methylated by adding group  $\text{CH}_3$ .  $\text{m}^6\text{A}$  sites are often located in the last exon near the end of mRNA, in untranslated RNA (UTR) at 3' end, and inside long exons.

It has been found that 3 members of so called YTH domain protein family acting as readers have larger affinity to bind to methylated sites. One of them shortens the lifetime of mRNA after translation.

3. Methylation in general shortens the UTR (un-translated regions) of mRNA in its 5' and 3' ends (head and tail of mRNA). One speaks of alternative poly-adenylation (APA, see <http://tinyurl.com/y7aratpv>) of the tail of the mRNA: poly-adenylation (PA) adds A-sequences to the end of mRNA affecting its dynamics: shortening of UTRs means shortening of PAs.
4. Methylation affects the rates in the dynamics of translation but does not affect the product of translation itself. A-sequences shields mRNA and during its life cycle its length is reduced somewhat like telomere (see <http://tinyurl.com/jpbkzzc>) consisting of a repeated

sequence TTAGGG and also shortening during the life cycle of DNA. APA affects rates for the dynamics of translation. Also stem loops of pre-RNA can be methylated and this can increase the rate of an alternative splicing and thus change relative rates of alternative gene expressions.

### Methyl marks in synaptic connections from the TGD point of view

What inspired this piece of text was a highly interesting popular article “Methyl marks on RNA discovered to be key to brain cell connections” about methylation of RNA in brain (see <http://tinyurl.com/y9qsnfeo>). The research article [J92] (see <http://tinyurl.com/ybg92nyd>) by Daria Merkuvjev *et al* has title “Synaptic N6-methyladenosine (m6A) epitranscriptome reveals functional partitioning of localized transcripts”. The researchers isolated brain cells from adult mice and compared epitranscriptomes found at synapses to those elsewhere in the cells. At more than 4,000 spots on the genome, the mRNA at the synapse was methylated more often. In more than half of genes the epitranscriptomes were found in genes coding for proteins found mostly in synapses. If the methylation was disrupted, the brain cells did not function normally. It was concluded that the methylation probably makes signalling faster.

These findings conform with the idea about representation of molecular emotions as bio-harmony. Synaptic contacts are the places where emotions should be expressed to give rise to learning by conditioning realized in terms of changed synaptic strengths. If the communication between dark and ordinary biomolecules relies on resonance frequencies, it is preserved only if the resonance frequencies for ordinary biomolecules are modified. Methylation would be one particular mechanism for changing some 3-chords of the harmony (in the simplest model only one of the 3 notes of 3-chord corresponding to A in various position). The methylations of DNA, RNA and proteins should also correlate if they are in common mood dictated by the bio-harmony.

### 4.6.5 How does brain predict future?

Quanta Magazine is a real treasure trove. The gem was at this time titled “*To Make Sense of the Present, Brains May Predict the Future*” (see <http://tinyurl.com/yb84wn7u>). The article gives links to various research articles: here I mention only the article “*Neural Prediction Errors Distinguish Perception and Misperception of Speech*” by Blank *et al* [J38] (see <http://tinyurl.com/y7edd3v>).

According to the article, brain acts as a prediction machine comparing predictions with what happened and modifying the predictions accordingly. Sensory perception would not be mere 3-D sensory time=constant snapshot as believed in last century but include also a prediction of future based on it that would be outcome of sensory perception and brain is able to modify the prediction by using the difference between prediction and reality.

In TGD framework one can go even further [L87] (see <http://tinyurl.com/yczv2o5b>). Sensory organs are the seats of sensory mental images constructed by repeated signalling between brain (maybe also magnetic body) and sensory organ using dark photons propagating forth and back with maximal signal velocity and contributing to the sensory input a virtual part. Nerve pulses would create by synaptic bridges connecting flux tubes to longer flux tubes acting as waveguides for dark photons to propagate. Sensory mental image would be essentially self organization pattern nearest to the actual sensory input. The percept itself would be artwork, a caricature selecting and emphasizing the features of sensory input important for the survival.

The term predictive coding used about the process reveals that the view about how brain achieves this relies on computational paradigm. This is one possible view. Personally I do not regard classical computation as a plausible option. A more neutral view relies on rather obvious assumption that that temporal sequences of associations giving rise to predictions. But how does this happen?

Neuroscientists speculate about deep connections between emotions and learning: the dopaminergic neurons are indeed very closely related to the neural reward system. If the difference between the predicted and actually perceived is large the reward is small - one might also call it punishment. “Surprise” would be rather neutral word to express it. Big discrepancy causes big surprise. The comparison of predicted and what really happened would be essential. This was one of the first predictions of TGD and might apply to simple emotions but - as I have proposed - emotions such

as experience of beauty, compassion or love need not correspond to emotions need not be mere reactions.

The finding suggests a connection with the ideas about the fundamental role of emotions in learning. I have already developed this theme in this article.

1. The first finding made for snails [J70] (see <http://tinyurl.com/ycqxeyek>) was that RNA somehow codes the experience and induces epigenetic change at the level of DNA in turn inducing a change in behavior. The popular article “ *Scientists Sucked a Memory Out of a Snail and Stuck It in Another Snail*” tells about the finding (see <http://tinyurl.com/y92w39gs>).

This led to a TGD based model based on the notion of bio-harmony for music of dark photon triplets representing 3-chords predicting genetic code correctly. Music expresses and creates emotions: same would happen already at RNA level. DNA would get in the same mood and by resonating with the 3-chords of RNA music and changing its harmony/mood coded by resonance frequencies of nuclei, which would slightly change. Epigenetic change would take place as a consequence and change the genetic expression in turn changing the behaviour.

This brings in something genuinely new: TGD based view about dark matter, realizations of genetic code by dark proton sequences defining the dark analogs of DNA, RNA, tRNA, and amino-acids at the magnetic flux tubes of magnetic body of living system plus realization of the genetic code.

It must be emphasized that magnetic body is 4-D and corresponds to a preferred extremals connecting to two 3-surfaces at the boundaries of causal diamond. Hence the basic objects are deterministic time evolutions, analogous to programs or behavioral patterns. The sequence of associations assignable to percept could be seen as space-time surface, a predicted space-time time evolution.

2. Just a couple of days before writing this I learned about slime molds (see <http://tinyurl.com/ydc8gh4d>), which are monocellulars, which contrary to expectations learn new behaviours [I18, I21]. Nervous system is not therefore necessary for learning. Emotional RNA could be at work also here.
3. RNA would be naturally also behind the learning in CNS as a change of synaptic strengths generating effectively different synchronously firing neuron groups representing mental images and new sequences of associations providing predictions. The mismatch between prediction and real percept would be represented in terms of dopamine concentration and this in turn would generate at RNA level emotion, which would be negative for mismatch and induce corresponding DNA emotion generating epigenetic change in turn changing synaptic strengths in turn changing the prediction as a sequence of associations regarded as temporal sequence in turn changing the behavior! Long sequence of causations!

Also the speculated unification of motor control and sensory perceptions is mentioned in the popular article. In sensory perception internal environment as a model for external environment is updated. In motor action it is external environment. Connection with arrow of time? Motor action as perception of changing environment where own biological body is part of environment. In TGD framework sensory perception and motor action would be time reversals of each other at the level of sensory mental images. This view is allowed by ZEO and encouraged by the discovery of Libet that volitional act is preceded by neural activity by a fraction of second.

Motor action would be generated by a negative energy signal to the geometric past which would correspond to mental images with reversed arrow of time in TGD inspired theory of consciousness. This duality would mean that in opposite time direction motor action would be a perceptions about say hand moving in desired direction! The counterpart of predictive coding would take care of comparisons and modifying the predicted “sensory percept” so that it corresponds to reality. This sounds strange but maybe the motor actions is just passive perception from the point of view of time reversed self!

## Chapter 5

# Dark valence electrons and color vision

### 5.1 Introduction

By its large orbital radius dark valence electron (dark in TGD sense,  $h_{eff} = n \times h$ ) sees atomic nucleus and other electrons, which are ordinary, effectively as an object of charge  $Z_{eff} = 1$ . Dark valence electron has reduced mass which in excellent approximation equals to that of electron so that the spectrum of bound state energies and transition energies is scaled down by the factor  $(h/h_{eff})^2$ . This irrespective of what the atom is. The only condition is that there is single unpaired valence electron guaranteed if  $Z$  for the atom is odd. For even  $Z$  an odd number of valence electrons must be associated with valence bonds: this would be the case for OH radical for instance.

The dynamics of dark valence electrons is universal with universal transition energy spectrum. One obtains a fractal hierarchy of dynamics labelled by the value of  $(h/h_{eff})^2$ , where  $h_{eff} = n \times h_0$ ,  $h_0$  the minimal value of Planck constant, not necessary equal to  $h$  so that one has  $h = n_0 \times h_0$ . The quantum critical dynamics characterizing living matter in TGD Universe is indeed universal.

The dark photon communications in living matter could utilize these universal energy spectra besides cyclotron energy spectrum and Larmor spectrum assignable to dark particles at flux tubes and the spectrum of generalized Josephson frequencies assignable to cell membrane [K44, K33]. In particular, vision and even other sensory modalities could rely on the transitions induced by the absorption of dark valence electron. In TGD also other sensory percepts are communicated from sensory receptors to the sensory areas of cortex [L87] and also here same universal transition energies of dark valence electrons might be involved.

This hypothesis when combined with the earlier ideas about color qualia leads to a highly predictive and testable model for the perception of colors. In particular the condition  $h = n_0 \times h_0$ ,  $n_0 > 1$ , is necessary for the model to work.  $n_0 = 4$  and  $n_0 = 6$  look the most realistic options. For  $n_0 = 4$  the number of values of  $n = 8, 9, 10$  and correspond to the number 3 of color sensitive receptors whereas  $n_0 = 6$  the number of values  $n = 12, 13, 14, 15$  suggests the existence of a fourth color receptor sensitive to red light.

The statistical aspects of color summation can be understood from TGD inspired theory of consciousness in terms of the hypothesis that self experiences the mental images of sub-self as kind of statistical averages. The identification of quark colors as fundamental color qualia, the entanglement of quarks and antiquarks to form states in one-one correspondence with charged gluons, and the twistor space of  $CP_2$  play key roles in the model of color summation.

**Remark:** There is experimental evidence for the notion of dark valence electron coming from the decades old anomaly related to rare Earth metals [L95] (see <http://tinyurl.com/ybejzq87>) for which TGD provides an explanation [L95] (see <http://tinyurl.com/y8pqcc8s>). This finding led to a proposal that valence bonds could also involve non-standard values of Planck constant [L92] (see <http://tinyurl.com/ycg94xpl>).

### 5.1.1 What could happen in seeing?

For years ago I developed a model for color qualia [K44]. In QCD strong interactions are jokingly called color interactions because the algebra of color charges for quarks is analogous to that assignable to color summation. The sum of color charges of quarks vanishes and the situation is analogous to the summation of the basic colors with proper intensities to white color. If one considers charged gluons, one can extend the algebraic picture so that one has 3 pairs of complementary colors with black and white included as a complementary pair.

In case of quarks one has also the interpretation that quarks and antiquarks have complementary colors so that black and white are included as a pair of complementary colors. In this case the standard color summation would mean that white color assignable to rods and black color assignable to dark current would remain in visual field. This interpretation seems to be the most reasonable one.

As I realized that TGD “almost-predicts” a hierarchy of p-adic fractal copies of hadron physics and that the length scale range  $10\text{ nm} - 2.5\text{ }\mu\text{m}$  contains as many as 4 Gaussian Mersenne primes defining excellent candidates for copies of hadron physics, it became obvious that much more than analogy could be in question. Also the finding of topologist Barbara Shipman [A20, A21, A19] that honeybee dance seems to relate to the flag manifold  $F = SU(3)/U(1) \times U(1)$  defining the twistor space of  $CP_2$  and playing a key role in twistor lift of TGD [K114, L61, L99, L127] suggests that dark hadron physics might be highly relevant for living matter and visual consciousness [L114]. The realization of the hierarchy of Planck constants  $h_{eff} = n \times h_0$  defining second length scale hierarchy gave further good reasons to take the analogy very seriously.

I have also studied several models for the visual qualia and perception.

1. TGD approach differs from neuroscience in that our sensory qualia are assigned to sensory receptors [K44] [L87] (see <http://tinyurl.com/yczv2o5b>). Note that we would represent only single level in self hierarchy. Entanglement would allow brain and also our magnetic body to share these qualia. In neuroscience approach they are believed to be somehow generated in brain, and the basic unsolved problem is to understand how this is possible: the neural network looks locally exactly the same at various sensory areas.

Phantom limb phenomenon is the basic objection against this proposal but can be circumvented [K90]. The pain in non-existing limb would be memory of pain and sensory memories can be induced by electrical stimulation of temporal lobes. In zero energy ontology (ZEO) the pain would be in geometric past where the pain was felt in still existing limb.

What is essential would be quantum entanglement between magnetic body, brain, and sensory organs and classical communications using dark photons propagating with light velocity. This allows very rapid virtual sensory input as feedback from brain (and MB) to brain and allows to build standardized sensory mental images by forth-and-back communications between brain and sensory organ [L87]. This is nothing but pattern recognition leading to standardized sensory mental images nearest to the sensory input. In the case of REM dreams one would have only the virtual sensory input.

2. Sensory capacitor model for sensory receptor [K44] assumes that sensory qualia correspond to flows of particles with fixed quantum numbers specifying the quale in question. In the case of color qualia quantum numbers would be color quantum numbers of quark or gluon. One would have the analog of di-electric breakdown occurring at critical voltage, whose analog would be generated by sensory input. Note that this model is based on kinetics but that the identification of quale as color quantum numbers resulting in state function reduction is an essential element of the model.
3. Second - more quantal - model for sensory receptor emerged during writing this article. One would have a pair (A,B) of systems such that A contains quarks and B antiquarks (possible in principle since TGD predicts hierarchy of QCDs), which are entangled to form states analogous to gluon like states. The density matrix is  $3 \times 3$  matrix and measurement of color quantum numbers produces an ensemble of quark states. The 3 quark states would correspond to basic colors (blue, red, white) having (yellow, green, black) as complementary colors represented by antiquarks.

The ensemble would give rise to the experience of colors obtained by color summation: density matrix would correspond to intensities of various colors in color summation. White/dark would correspond to brightness/darkness of the color. If the ensemble would be associated with sub-self of self (perceiver) TGD inspired theory of consciousness [K59] [L100] predicts that the experience corresponds to a kind of ensemble average.

4. I have constructed a ZEO based model for the generation of color qualia. In ZEO [L100] ordinary states are replaced by zero energy states identified as pairs of ordinary states at opposite boundaries of causal diamond (CD, intersection of future and past directed light-cones of  $M^4$  with points replaced with  $CP_2$ ) serving as the embedding space correlate for self as a conscious entity and analogous to events. “Zero energy” means that the total conserved quantum numbers of the members of the pair are opposite, which is only a way state the conservation laws used also in QFT context. At either boundary one has ordinary states with a fixed sign of energy.

CD sizes form a hierarchy and for sensory qualia the sizes are rather small: time scale would be around .1 seconds. During the sequence of state function reductions determining the life cycle of self the active boundary of CD drifts farther away from the passive one (flow of geometric time) and the states at it change reduction by reduction. These reductions would be analogous to so called weak measurements in standard quantum measurement theory. The states at the passive boundary of CD are unaffected in the sequence of state function reductions as also passive boundary itself. As a special case these states could correspond to quarks in eigenstates of color quantum numbers ( $Y, I_3$ ) giving rise to a sensation of pure basic color with black and white counted also as pair of conjugate colors.

The ensemble of quarks with well-defined color quantum numbers would correspond to sub-selves of sub-self and would give rise to color summation at the level of conscious experience.

At this moment it is better to keep mind open for various options. The kinetic picture could be consistent with this picture if the particles with fixed quantum numbers correspond to the passive boundaries of sub-CDs associated with sub-CD.

I was somewhat surprised as I realized that I have not considered what might happen in the series of events leading to color sensation at the first step after photon is absorbed by sensory receptor. In the following I shall look what comes out if one takes the idea about the universality of color vision realized in terms of transitions of dark valence electrons.

### 5.1.2 Could the transitions of dark valence electron produce the universality associated with quantum criticality?

The basic hypothesis is that the value of Planck constant is quantized:  $h_{eff} = n \times h_0$ . Here  $h_0$  is the minimum value of  $h_{eff}$ , which need not be equal to ordinary Planck constant  $h$  but one has  $h = n_0 \times h_0$ .  $n_0 > 1$  is quite possible, and the experiments of Randell Mills in fact suggest  $h = 6 \times h_0$  [L62](see <http://tinyurl.com/goruuzm>). What Mills claims [D7] is that hydrogen has states with binding energy scale larger than for the ordinary hydrogen atom. Therefore the scaling factor binding energy scale would be. The scaling factor for the binding energy scales would be

$$\left(\frac{h}{h_{eff}}\right)^2 = \left(\frac{n_0}{n}\right)^2, \quad n = 2n_0, 2n_0 + 1, \dots$$

At fundamental level the real Planck constant would be  $h_0$ , and  $h_{eff}$  would be effective Planck constant and due the  $n$ -sheet covering character of the space-time surface equal the dimension of extension rationals defining the adele at the given level of hierarchy of adeles giving rise to a number theoretic characterization of evolutionary hierarchy [L97, L98].

The orbital radius of dark electron scales as  $(n/n_0)^2$ . This might have dramatic consequences concerning the understanding of the quantum criticality of biology strongly suggested by the quantum criticality of TGD Universe meaning that any system is quantum critical in some scale. Quantum criticality implies universal dynamics and this would be obviously true for dark valence electrons. Quantum criticality involves also fractality and the hierarchy of size scales of dark electron orbits would imply this.

1. Lonely dark electron of any atom seems the effective charge  $Z_{eff} = 1$  because almost complete screening takes place because of other electrons with much smaller orbital radii. The atom behaves effectively like hydrogen as far as the lonely valence electron is considered.
2. The spectra of effective dark hydrogen could correspond to energies central for biology. Note that the frequencies (wavelengths) would be scaled down (up) by  $n_0/n$  ( $n/n_0$ ). These energies would correspond to transitions  $n_P = m_1 \rightarrow m_2$ ,  $m_i = 1, 2, \dots$  of hydrogen atom changing the principal quantum number denoted by  $n_P$  instead of  $n$  now). The transition energies would be given by

$$E(n, m_1, m_2) = \left(\frac{n_0}{n}\right)^2 \left[ \frac{1}{m_1^2} - \frac{1}{m_2^2} \right] \times E_I(H) \quad , \quad E_I(H) = 13.6 \text{ eV} \quad .$$

These spectra produce a fractal being related to each other by a scaling of a square of rational number.

3. What ranges of  $n$  one can consider for given  $n_0$ ?
  - (a) A reasonable working hypothesis is that the values of  $n$  are such that the energies are above thermal energy about .027 eV at physiological temperature 37 K. The maximal value of  $n$  would correspond to  $n_{max} \in \{89, 112, 134\}$  for  $n_0 \in \{4, 5, 6\}$  and lowest value of  $n$  taken to be  $2n_0$  and corresponding to the energy 3.4 eV somewhat above the visible energies (2.39 eV corresponds to the boundary between UV and visible).
  - (b) A stronger working hypothesis is that the values of  $n$  are such that the transition energy associated with the ionizing transition  $n_P = 1 \rightarrow \infty$  is such that the transition energies belong to the energy range of bio-photons containing at least visible and UV photons. UV region corresponds to the values  $n < 2n_0$ .
  - (c) Even stronger condition is that these energies containing the energy range of visible photons spanning in good approximation one octave. For given value of  $n_0$  this would give  $n = 2n_0, 2n_0 + 1, \dots, 2n_0 + \Delta$ , where  $\Delta$  is determined by octave condition and therefore satisfies  $\Delta \geq 2(\sqrt{2} - 1) \times n_0$ .

Some remarks are in order.

1. An energy conserving  $h_{eff}$  changing transition increasing  $n_0$  to  $n$  must occur before the transition of dark valence electron. These transitions would be fundamental in TGD and could also involve emission or absorption of energy. I have proposed that the temporary reduction of the value of  $h_{eff}$  liberating energy and followed by return to the original value is a basic mechanism of catalyst action [?]see <http://tinyurl.com/goruuzm>). The reduction of  $h_{eff}$  would reduce the length of flux tubes connecting the reacting molecule and catalyst and liberate this energy kicking the reacting molecules over the potential wall making reaction fast. In particular, the transitions changing the value of  $n$  for lonely dark valence electron could play an important role in bio-catalysis. If so, the dynamics behind bio-catalysis could be extremely simple at the dark level.
2. The model for visual perception would fail for the conservation option  $n_0 = 1$  so that the finding of Mills [?]onforms with the proposed view about vision. The model is most realistic for  $n_0 = 4$  and  $n_0 = 6$ . for  $n_0 = 6$  the model however suggests a yet un-identified photoreceptor sensitive to red light.
3. How the model of color qualia in terms of measurement of color quantum numbers of quark and antiquark could relate to the proposed model? The most natural proposal is that the excited dark electron returns to a lower excited state by emitting dark photon decaying to dark quark-antiquark pair. Quarks could correspond to the p-adically scaled up variants of hadron physics assignable to the Gaussian Mersennes with p-adic length scales in the length scale range relevant for cell nucleus are excellent candidates.

## 5.2 Could dark photon absorption give rise to visual perception?

What really happens as photon is absorbed by photoreceptor? Could the absorption give rise to transitions of dark valence electrons and have therefore scaled variant of hydrogen spectrum? In studying this hypothesis I will utilize information about visual perception in Wikipedia (see <http://tinyurl.com/y88k583f> and <http://tinyurl.com/d6tdw54>) and various web sources (see for instance <http://tinyurl.com/yarthc6u>).

### 5.2.1 Is vision at basic level seeing of dark photons?

Before continuing some general remarks are in order.

1. Color perception is defined as the ability of organism to distinguish between different wavelengths (or frequencies). In standard quantum theory one could replace wavelength with energy but if the hierarchy of Planck constants is accepted one must be cautious. If incoming photons have  $h_{eff} = h = n_0 \times h_0$  the dark photons produced in the process have longer wavelength but same energy.
2. The colors produced by single frequency are so called pure colors. The mixing of light with different wavelengths and varying intensities produces colors, which need not be pure. For instance, brown cannot be produced by single wavelength. Summation of colors means that the mixing of light with two colors produces large number of colors produced by single wavelength.
3. TGD suggests that all sensory qualia involve transitions of dark valence electrons induced by dark photons in various wavelength ranges. In the case of olfaction there is indeed strong support that it is seeing in infrared [I74], [J135, J2] [K44]. The transitions of dark valence electrons with values of  $n$  corresponding to energies outside the visible range might be involved.
4. One cannot exclude the possibility that the absorption of ordinary photons is followed by emission of dark photon generated as dark valence electrons drops to the ground state. This option will not be however considered in the following.

One could argue that visual perception relies on universal mechanisms in the sense that very many molecular structures could allow it. The observations made above inspire the idea that the absorption of photon in photoreceptor involves the transformation of incoming ordinary photons to dark photons with  $n = 2n_0, \dots, 2n_0 + \Delta$  for  $n_0$ , which could be in the range  $\{4, 5, 6\}$  as will be found, and induces a transition of dark valence electron to a state with higher energy.

1. This transformation could involve absorption and subsequent emission as dark photon with energy in the spectrum of effective dark hydrogen atom with discrete spectrum in the interval

$$\left(\frac{n_0}{n}\right)^2 E_I(H) \times [3/4, 1] \quad , \quad n \in \{2 \times n_0, \dots, 2 \times n_0 + \Delta\}$$

consisting of lines  $(n_0/n)^2 E_I(H) \times [3/4, 8/9, 24/25, \dots, n^2 - 1/n^2, \dots]$ . There would be 4 clearly distinguishable basic energies corresponding to  $(3/4) \times (n_0/n)^2 E_I(H)$  perhaps identifiable as basic colors. One as  $\Delta = 2$  and 3 bands for  $n_0 = 4$  and  $\Delta = 3$  and 4 bands for  $n_0 \in \{5, 6\}$ .

The conditions that the number 3 of cones equals to the number of values of  $n$  and that the range of visible wavelengths spans an octave selects  $n_0 = 4$  uniquely.  $n_0 = 6$  satisfies the octave condition but suggests strongly the existence of 4:th yet un-identified color-sensitive receptor.

**Remark:** The transitions  $n_P = m_1 > 1 \rightarrow m_2$  from higher states would correspond to energies below the visible range and are not considered. They might however plays some role.



2. The model assumes that the incoming light - assuming that it has  $h_{eff} = h$  - transforms to dark light in the receptors having  $h_{eff} = (n/n_0) \times h$ ,  $n = 2n_0, 2n_0 + 1, \dots, 2n_0 + \Delta$ , where  $\Delta$  must be such that the range of visible wavelengths is covered. Wavelength would therefore increase by factor  $n/n_0$  from that for incoming photon wavelength in the range  $[2, 2 + \Delta/2]$  whereas energy would be same. Dark valence electron would be kicked to an excited state by the absorption of dark photon. This would lead to the color perception. How this happens is a separate problem.

The beauty of the mechanism would be that the atom involved could be almost anything: what is only required that there is lonely valence electron that can become dark. This hypothesis will be studied in the sequel. I try also to relate it to earlier ideas about vision and color qualia.

### 5.2.2 Comparison with empirical facts

In the following the predictions of the model are compared with empirical facts about photoreceptors and the conclusion is that  $n = 4$  and  $n_0 = 6$  options are the most realistic ones.  $n = 6$  option however suggests the existence of a not yet identified receptor sensitive to red.

#### Basic facts about photoreceptors

Consider now a comparison with basic empirical facts about photoreceptors.

1. There are 4 kinds of receptors. 3 photoreceptors giving rise to color sensation are called blue, green, and red cones. Rods are receptors, which do not produce color sensation unless one counts white and black as colors. The sensation of black does not mean absence of visual consciousness so that black could be regarded as color. Black could be interpreted as the color produced by so called dark current (see <http://tinyurl.com/6tu3q26>) present in retina also in the absence of light stimulus. Furthermore, rods are sensitive to same wavelengths as green cones and also other receptors to some extent in accordance with the fact that color is not a property of light but characterizes the qualia induced by the absorption of light.
2. The Wikipedia article gives the wavelengths  $\lambda_{max}$  at which maximum absorbance occurs. Figure 14a)(<http://tinyurl.com/yc6dcqn7>) of the article of Helga Kolb gives slightly different values for  $\lambda_{max}$ . According to the Wikipedia article the maximum absorbance occurs for
  - red cones at  $\lambda_{max} = 564$  nm, which is in yellow rather than red. Red cones respond to red, orange and yellow but very weakly to red light, which raises the question whether there could exist yet unidentified receptors sensitive to the red wavelengths;
  - green cones at  $\lambda_{max} = 534$  nm; green cones respond mostly to green light;
  - blue cones at  $\lambda_{max} = 420$  nm in violet. Blue cones respond to cyane, blue and violet and even in UV but the lense prevents the UV radiation from arriving to the receptors;
  - rods  $\lambda_{max} = 498$  nm in cyane at the boundary of cyane and blue.
3. The absorption curves decrease rather rapidly above  $\lambda_{max}$  but approach to much larger value for small wavelengths, which suggests that given receptor is sensitive for values  $n \leq n_{max}$  rather than single value of  $n$ . The absorbance curves are given only in finite interval, and I do not know whether this is due to the lack of empirical data or whether the absorbance reduces to zero outside the range spanned by the curve. For the model assigning single value of  $n$  to the receptor this would happen.

#### Predictions for $h = n_0 \times h_0$ , $n_0 \in \{4, 5, 6\}$

In the following tables the energy and wavelength ranges for options  $n_0 \in \{4, 5, 6\}$  are listed together with the list of  $\lambda_{max}$  values to see whether the option is realistic. Energy range for the photons corresponds to the range between the photon energy  $3E_I(n, n_0)/4$  associated with  $n_P = 1 \rightarrow 2$  transition equal and  $E_I(n, n_0)$  corresponds to the ionization energy. The allowed photons energies form a discrete band like structure.

1.  $n_0 = 4$  case

The predictions for  $n_0 = 6$  are given in table 7.2.

| $n$ | E/eV        | $\lambda/nm$ | $\lambda_{max}/nm$ |
|-----|-------------|--------------|--------------------|
| 8   | [2.55,3.40] | [365,486]    | 420                |
| 9   | [2.02,2.68] | [462,615]    | 534 (498)          |
| 10  | [1.63,2.18] | [570,759]    | 564                |

**Table 5.1:** Table gives energy and wavelength ranges for photons for option  $n_0 = 4$  for various values of  $n$ . The last column gives the values of  $\lambda_{max}$  for cones and rods (in brackets) helping to see whether the option is realistic.

The wave length ranges look rather realistic except that  $\lambda_{max}/nm = 534$  for red receptors does not belong to the range of wavelengths for  $n = 10$  being slightly below it. Note however that the assumption  $n \leq n_{max}$  is strongly suggested (if not forced) by the properties of absorbance curves: since there is considerable overlap between  $n = 9$  and  $n = 10$  bands,  $\lambda_{max}$  could be shifted towards  $n = 9$ . Visible spectrum extends to 750 nm in red and the prediction is that it should extend to 759 nm.

2.  $n_0 = 5$  case

The predictions for  $n_0 = 5$  are given in table 7.3.

| $n$ | E/eV        | $\lambda/nm$ | $\lambda_{max}/nm$ |
|-----|-------------|--------------|--------------------|
| 10  | [2.55,3.4]  | [365,486]    | 420                |
| 11  | [2.11,2.81] | [442,588]    | 534 (498)          |
| 12  | [1.77,2.36] | [526,700]    | 564                |
| 13  | [1.51,2.01] | [617,822]    | ~662?              |

**Table 5.2:** Table gives energy and wavelength ranges for photons for option  $n_0 = 5$  for various values of  $n$ . The last column gives the values of  $\lambda_{max}$  for cones and rods (in brackets) helping to see whether the option is realistic.

One can assign to each  $\lambda_{max}$  a unique value of  $n$  such that the corresponding wavelength range contains  $\lambda_{max}$ . The visible spectrum extends to 750 nm in red whereas for  $n = 12$  the end of the spectrum would be at 700 nm. The inclusion of also  $n = 13$ : this would give additional wavelength range [617, 822] nm which would contain red wavelength range [620, 750] nm. The estimate for the corresponding  $\lambda_{max}$  is obtaining by assuming that it scales like  $n^2$ . In this picture, red cones would be called yellow cones, and  $n = 13$  would correspond to a new receptor sensitive to red and IR wavelengths. The upper bound 822 nm for visible wave lengths makes possible IR vision unless the receptors absorbing the incoming photons and transforming them to dark photons are insensitive to IR photons.

3.  $n_0 = 6$  case

The predictions for  $n_0 = 6$  are given in table 7.4.

Wave length ranges look rather realistic. If one is accept that  $n = 15$  corresponds to a new yet unidentified receptor, one can assign to each  $n$  a unique receptor and  $\lambda_{max}$  belongs to the wavelength range in question.

It would not be surprising if  $\lambda_{max}$  would scale as  $n^2$  (for absorbance curves see <http://tinyurl.com/y7t5w2m2>). One should have  $r(n) = \lambda_{max}(n+1)/\lambda_{max}(n) = (n/(n+1))^2$ . Let  $r_1(n)$  denote the corresponding ratio for cones (green/blue and red/green). The ratios  $(r(n)/r_1(n))$ ,  $n = 12, 13$  would .9 and 1.1: ideally they should be equal to 1. For  $n = 14$  one would  $r(n) =$

| $n$ | E/eV        | $\lambda/nm$ | $\lambda_{max}/nm$ |
|-----|-------------|--------------|--------------------|
| 12  | [2.55-3.4]  | [365-486]    | 420                |
| 13  | [2.17-2.89] | [429-571]    | 534 (498)          |
| 14  | [1.87-2.49] | [498-663]    | 564                |
| 15  | [1.63-2.18] | [570-761]    | $\sim 649?$        |

**Table 5.3:** Table gives energy and wavelength ranges for photons for option  $n_0 = 6$  for various values of  $n$ . The last column gives the values of  $\lambda_{max}$  for cones and rods (in brackets) helping to see whether the option is realistic.

$(15/14)^2 = 1.15$ . This gives an estimate for  $\lambda_{max}$  of possibly existent  $n = 15$  receptors as  $\lambda_{max} \sim 1.15\lambda_{max}(14) = 649$  nm (red begins at 620 nm).

**Remark:** That  $n = 13$  should correspond to both green and white cones is somewhat disturbing.  $n = 14$  receptor for red - or rather yellow - however covers the wavelength range 498-663 nm whereas the upper boundary of  $n = 12$  is 486 nm. Only the range [486, 498] nm remains uncovered. Could  $n = 13$  correspond to color white? Perhaps this could be tested by using incoming radiation in the wavelength range [486, 498] nm.

The cautious conclusion is that  $n_0 = 4$  and  $n_0 = 6$  are the most realistic options. For  $n_0 = 4$  there would be only three cones but for  $n_0 = 6$  the existence of new receptor is suggestive.

Some further remarks concerning are in order.

1. The absorbance graphs suggest that the receptors do not correspond to single value of  $n$  but to several values  $n \leq n_{max}$ .
2. Each receptor is sensitive in a region containing two values of  $n$ . Consider  $n_0 = 6$  as example.  $n = 15$  touches  $n = 13$  if the transitions inducing large changes of the principal quantum number  $n_P$  are allowed (almost ionization). For given receptor the values  $n < n_{max}$  are strongly represented: the value of absorbance decreases to a non-vanishing value in the region  $\lambda < \lambda_{max}$  and can even slightly increase. For  $n > n_{max}$  absorbance approaches zero rapidly. Blue cones would correspond to  $n_{max} = 12$  and green cones to  $n_{max} = 13$ . Red cones would correspond to both  $n_{max} = 14$  ja  $n_{max} = 15$ . Rods would correspond to  $n = 13$ .
3. Due to the overlap of the energy ranges, the same energy can correspond to two values of  $n$  and thus different dark wavelengths. This forces to ask how the color quale is determined: does the transition energy or the corresponding dark wavelength determine the color? If it is energy then very nearly the same transition energies for say  $n = 14$  and  $15$  in case of  $n_0 = 6$  would correspond to nearly the same color although the dark wavelengths would differ by factor  $14/15$ . If it is wavelength then same energy for incoming photon could correspond to 2 different colors for overlapping dark energy bands.

**Remark:** This raises a question about the determination of the sensitivity to photoreceptors to the incoming visible light: is it wavelength or energy? If would be wavelength according to Wikipedia definition and this one might expect since the experiments about color vision were carried out before emergence of quantum theory. It however seems that the incoming visible light must correspond to  $h_{eff} = h = n_0 \times h_0$ : otherwise the model leads to difficulties.

4. Evolution as a growth of  $h_{eff}$  would predict that small values of  $n$  have emerged before the low values. In particular, IR vision would correspond to a higher level in the evolution and larger values of  $n$ . Small values of  $n$  would correspond to a lower level and would have been reached. Indeed, no examples about IR vision are known whereas UV vision requiring  $n < 2n_0$  is common: bees provide one particular example.
5. Tetra-chromacy (see <http://tinyurl.com/mntowuw>) occurs for birds, fish, amphibians, reptiles, insects and some mammals and sometimes even for humans, means that there is additional color receptor in UV with  $\lambda_{max} = 370$  nm slightly above minimum wavelength 365 nm for blue cones. For  $n_0 = 6$ , the most natural interpretation would in terms of  $n = 11$  which corresponds to wavelength range [307, 408] nm.

### Further phenomena that one should understand

Color vision involves several phenomena that one should understand.

1. In the summation of colors light beams with several wavelength and varying intensities are superposed. The perceived color need not correspond to a sensation created by single wavelength. One can however produce colors produced by single wavelength by using summation of two colors (actually not all of them). The perceived color depends on the ratio of the intensities: only its brightness depends on the intensity scale.

This suggests that at quantum level the perceived color is determined as a kind of statistical average. In TGD inspired theory of consciousness this could mean that color qualia correspond to sub-sub-selves. The resulting mental images is sub-self determined as a kind of statistical average over sub-sub-selves defining mental images of sub-self.

2. In the subtraction of light one mixes different colored substances. In the mixture only the common wavelengths are reflected and the color becomes darker for this reason (one could see this as a mixture of colors with black regarded as a color).
3. There is also the phenomenon of complementary colors. Consider as an example  $n_0 = 6$  option.
  - (a) Red and green form pair of complementary colors. Complementary colors sum up to white in color summation, when the intensities are suitably chosen. For  $n_0 = 6$  red is contained by  $n = 14$  and  $n = 15$  bands and green by  $n = 13$  and  $n = 14$ . Could the complementary colors of colors in  $n = 13$  band be in  $n = 14, 15$  bands? Note that  $n = 15$  band contains orange and yellow (partially).
  - (b) Blue and yellow are also complementary colors. Yellow is contained partially in  $n = 14$  ja  $n = 15$ . Blue is contained  $n = 12$  ja partially  $n = 13$ .
  - (c) As already argued that black and white could be seen as complementary colors and this interpretation would allow to see also rods as color receptors and dark currents as a generator of black background color. This view would also fit nicely with the TGD based model of color qualia to be discussed in the sequel.

### 5.2.3 What color summation could correspond in TGD framework?

In color summation the light stimuli at different wavelengths sum up. By combining two wavelengths one obtains other colors produced by single wavelengths. Not all of them can be produced and there are also composite colors not produced by single wavelength.

The rough rule is that for two colors one can find a third color such that the sum of all three is white. This means that one can construct colors as composites of two basic colors. These wavelengths are not unique but correspond to some wavelengths in some wavelength ranges. The third color corresponds to a suitable for the intensities of the summands. The empirically deduced summation rules are described by “horse shoe” diagram (see <http://tinyurl.com/yc5yg4dg>).

1. One selects two wavelengths  $\lambda_1, \lambda_2$ , which correspond to two basic colors, say green and red. One mixes these wavelengths with fractions  $p$  ja  $1 - p$ . Mixing fractions correspond to coordinate axes  $x$  for red ja  $y$  for green. One assigns to each pair  $(p, 1 - p)$  a rectangle, whose vertices are at  $(0, 0)$  (pure blue),  $(0, p)$  (pure green),  $(1 - p, p)$  (pure red), and at  $(p, 1 - p)$ , which corresponds to the sum color and is located at the edge of a triangle connecting points  $(1, 0)$  and  $(0, 1)$ . This points of this edge are labelled by wavelengths. The mixing ratios for the desired composite color can be read from the diagrams.
2. One however encounters a problem. One does not obtain all possible colors created by single wavelength in this manner. If one wants all colors one must allow also negative fractions  $p$  or  $1 - p$  so that the portion of one color would be larger than one and that of another color negative. The edge of the triangle indeed continues as “horse shoe” curve (see <http://tinyurl.com/yc5yg4dg>) to the negative values of  $x$  coordinate and  $y$ -coordinate going

through origin (pure blue). The various nuances of blue correspond to the regions  $x < 0$  and  $y < 0$ . In these regions one must use other pair of basic colors to construct the colors.

At the negative values of  $x$  one would have blue, which is even more blue than origin  $(0,0)$  and this is not possible since the portion of red would be negative. Hence one must use another pair of colors to produce the colors along for  $x < 0$  portion of the curve.

3. The ratio of the intensities of the mixed colors determines the resulting color. In quantum theory context this would suggest that mixed colors correspond to entangled quantum states such that the eigenvalues of the density matrix correspond to the portions  $p$  and  $1-p$ . A more realistic interpretation would be that quantum measurements of color for these entangled pairs produce pure states with red and green appearing with probabilities  $p$  and  $1-p$  in the resulting ensemble.

TGD suggests two basic models for the generation of color qualia quantum model and geometric model, which might correspond to quantum model via quantum classical correspondence.

1. One could assume that a particle with color hyper charge and color isospin given by  $(Y, I_3)$  determines basic colors and their number is given by those states of color multiplet for which one has  $(Y, I_3) \neq (0,0)$ . For the complementary color of  $(Y, I_3)$  the color quantum numbers would be  $(-Y, -I_3)$ .

Color summation would correspond to the summation of the quantum numbers of quarks to zero. Quark triplet and its conjugate would give 3 colors and their complementary colors. One would not obtain black and white as colors. It is not however clear how to understand color summation in this picture. As a matter of fact, the color summation means that only the rods contribute to the color sensation and give rise to a sensation of white color. It would be better to say that the sum of color and its conjugate gives no sensation at all.

2. Another option is that the 6 charged members of gluon octet corresponds to the 3 basic colors and their complementary colors. Also now black and white are most naturally counted as a pair of complementary colors.

One can also consider a model in which there is a geometrical entity possessing naturally color quantum numbers. Both quark and gluon option can be formulated in this framework.

1. For quark option the two complex  $CP_2 = SU(3)/SU(2) \times U(1)$  coordinates transforming linearly under  $U(2)$  satisfy the criterion. The rays of the Hilbert space for 3 quarks could be parameterized by  $CP_2$ . Note however that the superposition of states cannot be described if one uses  $CP_2$  since phase information relevant to the superposition is lost in projective equivalence.

This would suggest a geometric model of color summation in which three basic colors correspond to 3 different coordinate patches of  $CP_2$ . Given coordinate patch would correspond to a particular choice of 2 basic colors in the summation. Color rotations acting linearly would generate different choices of complex coordinates in given patch and would correspond to different choices of the 2 basic colors. The intensities of summed colors would correspond to the moduli squared for the complex  $CP_2$  coordinates. As a matter of fact, the complex coordinates have anomalous hypercharge  $-2/3$  due to the division of the first two coordinates with the third coordinate having  $(Y, I_3) = (2/3, 0)$ .

2. For the gluon option the two neutral gluons are eliminated by using instead of  $C^8$  twistor space  $F = SU(3)/U(1) \times U(1)$  of  $CP_2$  playing key role in twistor lift of TGD [K114, L61, L99, L127].  $F$  is 6-D and has 3 complex coordinates and is a bundle with  $CP_1$  as fiber and  $CP_2$  as base.  $CP_1$  corresponds to charged members of isospin triplet representing the two colors black and white.  $CP_2$  corresponds to the two gluon pairs with opposite isospins, which correspond to two quarks out of 3 appearing in the color summation with the choice of basic colors interpreted as the choices of a particular coordinate patch for  $CP_2$ .

For  $CP_1$  one has two coordinate patches and now the selection of patch would correspond to the selection of black or white as basic color the intensity of this color in the superposition

of 3 colors would determine the darkness/brightness of the color. The generalization of color summation would mean that also the effect of the rod receptors is taken into account as counterpart for  $CP_1$ .

Could the geometric pictures based on  $F$  and  $CP_2$  be interpreted in terms of Hilbert space picture? The twistor space picture indeed suggests quantum classical correspondence at the level of twistor lift of  $M^4 \times CP_2$ . Since the basic for quarks corresponds to a choice of free basic frequencies, one can however argue that the twistor space actually parametrizes different choices of basic colors.

### Generalization of color summation to include black and white as colors

The simplest interpretation for color summation would be in terms of quark triplet representing points of complex Hilbert space  $C^3$ .

1. Quarks correspond to three basic colors and antiquarks to their conjugates. Other colors could be described in terms of entanglement of two quark states with reference states. Density matrix would describe the states.
2. The reference states could be states with opposite color quantum numbers that is antiquarks. What comes in mind first is that the entangled state has vanishing color quantum numbers but would be color singlet. This modification of color confinement in TGD framework to require only the vanishing of net values of  $Y$  and  $I_3$  has been discussed already earlier in [L127].
3. Standard color summation would correspond to a superposition of two chosen quark states entangled with 2 reference states. The probabilities determined by the density matrix would correspond to normalized intensities for light stimuli at corresponding wavelengths. The perceived colors would be obtained by the empirical “horse shoe” rule (see <http://tinyurl.com/yc5yg4dg>). The statistical aspect could be understood if state function reduction occurs for the ensemble of paired states. The observed color would be determined as the average color quale as already explained.

In the geometric picture color summation could be interpreted at the level of  $CP_2$  and basic colors would be determined by the moduli of 2 complex  $CP_2$  coordinates. Apart from brightness, the perceived color would depend on the ratio  $|\xi^1/\xi^2|$  of these coordinates so that one would obtain the standard view about color summation but black and white could not be understood as colors.

Ordinary color summation is however problematic from the point of view of Hilbert space interpretation since it means projection to 2-D subspace. Projectivity for Hilbert space does not mean that third state has vanishing coefficient but only that it can be transformed to unity. As a matter of fact, in given coordinate patch of  $CP_2$  the coefficient must be non-vanishing! In Hilbert space interpretation that sum of 3 probabilities equals to one. The 3 probabilities of the density matrix would correspond to the normalized intensities assignable to the three chosen frequencies with one corresponding to white as color (rods).

Ordinary color summation tells nothing about colors dark and white and darkness/brightness of the color. This suggests a modification in which one considers normalized states of quarks in  $C^3$ . If the states are entangled pairs of 3 quarks with antiquarks with opposite quantum numbers, the density matrix would reduce to diagonal  $3 \times 3$  matrix and one would have 3 probabilities summing to unity. Physically the probability for  $(Y, I_3) = (2/3, 0)$  state would correspond to the contribution of white and black to the superposition affecting the darkness of the color. Rods would be responsible for white contribution. Black would correspond to the dark current creating kind of background color sensation.

For this option the connection of Hilbert space description with flag manifold  $F$  and  $CP_2$  would be accidental and different quarks states would not correspond to points of  $CP_2$  or  $F$ .

### The choices of basic colors triplets as points of flag manifold

There exists an infinite number of choices of the 3 basic colors if the frequencies are continuous: the identification as transition frequencies of dark electrons however discretizes the situation. Could the different allowed choices of these triplets be related by a discrete subgroup of color rotations relating various state basis for quarks to each other?

1. Color rotations would produce different basis assignable to different choices of three basic frequencies defining the basic colors. Color groups is 8-D  $SU(3)$  on 8-D and quark states correspond to  $C_3$ .  $U(1) \times U(1)$  leaves invariant entangled quark-antiquark states which have vanishing color quantum numbers but are not color singlets. There the space of entangled quark-antiquark states which do not include color singlet is  $SU(3)$  orbit for a single state of this kind and equals to flag manifold  $F = SU(3)/U(1) \times U(1)$  with complex dimension 3 or equivalently the space for the choices of color quantization axes. I have discussed the space-time representation of points of  $F$  in the model of honeybee dance [L114].
2. As explained,  $F$  has fiber space structure with  $CP_1$  as a fiber parameterized by a complex coordinate with color isospin  $I_3 = 1$ . Base is  $CP_2$  has two complex coordinates. This would suggest that the complex coordinate  $z$  of  $CP_1$  fiber of  $F$  would correspond  $n = 13$  and rods and its conjugate to its conjugate and dark current.  $CP_2$  base of  $F$  would correspond to all 4 values of  $n$  with coordinates and their conjugates representing colors and conjugate colors identifiable as two pairs  $(n_1, n_2)$ .

$CP_2$  is non-trivial as a manifold and 3 coordinate patches are needed. One can choose from the complex  $C^3$  coordinates  $(z_1, z_2, z_3)$  two coordinates and there are 3 choices corresponding to 3 coordinate patches. These would correspond to the 3 choices for basic color pairs used to obtained other colors in color summation. For instance, one could have  $z_1 \leftrightarrow \text{red}$ ,  $z_2 \leftrightarrow \text{green}$ ,  $z_3 \leftrightarrow \text{blue}$  as basic colors. By projectivity

3. Since the flag manifold  $F$  labels the possible choices of color basis, one expects that the choice of the basic color triplets as triplets of frequencies is not completely free. Certainly one must keep the variation of the basic frequencies within some limits. Could only a discrete set of basic frequencies be allowed? Could the allowed frequencies correspond to the transition energies for dark valence electron? Could this discrete set of frequencies correspond to a discrete set of points of  $F$  for various values of  $n \in \{12, 13, 14, 15\}$ . Could this correspond to a number theoretic discretization of  $F$  by replacing  $SU(3)$  with its discrete finite sub-group  $U(1) \times U(1)$  with its discrete counterpart in discrete sub-group of  $SU(3)$ ?

$\lambda(z_1, z_2, z_3)$  and  $(z_1, z_2, z_3)$  correspond to the same point, and one can use the coordinates  $(\xi_1 = z_1/z_3, \xi_2 = z_2/z_3, 1)$  in one particular coordinate patch, which could correspond to red and green as basic colors whose mixing would give the remaining colors but not all of them since single coordinate patch is not enough. The ratio  $r_{12} = |z_1/z_2|$  would determine the color in the standard picture about color summation. Including white and black, the ratios  $r_1 = |z_1/z|$  and  $r_2 = |z_2/z|$  would determine the color and its brightness. The phases of the  $F$  coordinates would not affect the experienced color quale.

A couple of remarks are in order.

1. It would seem that the space of color qualia is locally like projective space  $RP_3$ , which is real variant of twistor space  $CP_3$  appearing in the twistorialization of 4-momenta to be distinguished from the geometric twistor space  $M^4 \times CP_2$  appearing at the level of  $M^4$  geometry and possessing generalized Kähler structure ( $M^4 \times CP_2$  is unique because the twistor spaces for the factors allow Kähler structure).
2. The obvious question concerns the qualia assignable to  $M^4$  and interpretation of the corresponding twistor space. The point of twistor space could correspond to the choice of energy and spin quantization axes (energy quantization axis would define the rest frame). A possible identification for qualia could be as energy and spin in the rest frame. They would be analogous to brightness and color. Color triplet would correspond to spin 1 triplet.

### How the two views about color vision might relate?

I have discussed above two views about color vision.

1. The transitions of dark valence electrons induced by the absorption of dark photon preceded by the absorption of ordinary visible photon by photoreceptor would represent the first step in the process leading to a color sensation.
2. The second step would give rise to a formation of entangled state of quarks and antiquarks with non-standard value of Planck constant and the measurement of color quantum numbers of quark as a state function reduction for the ensemble of entangled quark pairs would give rise to qualia, which in general would represent mixed colors.

A more detailed view about the second step could look like follows.

1. Quark-antiquark pair could be formed by the return of the dark valence electron to an excited or ground state by an emission of virtual dark photon decaying to a possibly dark quark-antiquark pair, which should be non-relativistic. This is of course only the simplest option that one can imagine.
2. Quark and antiquark would naturally correspond to a copy of hadron physics labelled by Gaussian Mersenne  $M_{G,n}$ ,  $n \in \{151, 157, 163, 167\}$ : the appearance of 4 Gaussian Mersennes in the biologically most interesting p-adic length scale range  $[10, 250]$  nm covering the length scale relevant to cell nucleus is a number theoretical miracle.

The p-adic mass scales for quarks need not correspond to those for hadron physics itself. For instance, for ordinary  $M_{107}$  hadron physics only  $c$  quark corresponds to  $M_{107}$  whereas  $s$  quark most naturally corresponds to  $M_{G,k}$ ,  $k = 113$  assignable to nucleus [K57, K68] and  $u$  and  $d$  current quarks with masses about 5 and 20 MeV correspond to even longer p-adic length scales. Thus light quarks would correspond to longer mass scales than hadron: the interpretation is in terms of the assignment of quarks to the magnetic body of hadron.  $t$  and  $b$  quarks would correspond p-adic length scales considerably shorter than hadronic length scales.

Whatever the detailed picture is, Gaussian Mersennes are excellent candidates for mass scales of  $u$  and  $d$  quarks involved. The mass scale of quark for  $k = 167$  corresponding to a p-adic length scale about  $2.5 \mu\text{m}$  would be same as that of electron scaled from  $k = 127$  to  $k = 167$  and by p-adic length scale hypothesis equal to  $2^{(167-127)/2} \times .5 \text{ MeV} \simeq .5 \text{ eV}$  in IR and identifiable as the nominal value of the metabolic energy quantum. The mass scales for  $k = 151, 157, 163$  would be related by the scaling  $2^{(k-167)/2}$  to this scale and would be given by 128 eV, 16 eV, and 2 eV (this corresponds to red light) for  $k = 151, 157, 163$ . For  $k = 151$  and  $k = 157$  the mass scales are too high for photons in the range of visible energies.

3.  $k = 163$  is the most realistic option but also 167 can be considered although now quarks must be produced from virtual photons decaying to a non-relativistic mass shell quark pair. Note that also decays of dark valence quark to excited state are possible and could give rise to on mass shall non-relativistic quark pairs with energies around .2 eV for  $k = 167$ .
4. Charge separation must take place for quark and antiquark. One option is that negatively (positively) charged quarks and antiquarks move to the outside (interior) of the cell membrane in the membrane potential of photoreceptor neuron.



## Chapter 6

# Geometric Theory of Bio-harmony

### 6.1 Introduction

The model for bio-harmony predicted vertebrate genetic code correctly has evolved to its recent form during 4 years. The recent progress in the understanding of the model motivated writing of a separate chapter summarizing the earlier results and adding the new results achieved during 2018.

**Remark:** In the sequel I will use the shorthand AA for amino-acids and shorthands DDNA, DRNA, DtRNA, DAA for the dark analogs of DNA, RNA, tRNA, and AA realizes as dark proton sequences with codon represented as dark proton triplet.

#### 6.1.1 Some background

For some years 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 [L36]. 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 (AAs) 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 AA and solve the problem of simplest model due to the fact that the required Hamilton's cycle does not exist.

The article [L31] 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 icosahedral 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 AAs 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 12th and 22nd AAs. 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 AA level.

1. 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.
2. 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 AAs 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 AA under some circumstances.

Tetrahedral code is second member in the hierarchy of genetic codes [K46] 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.

3. 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 there are only three different triplets  $n$ .
4. The original idea was that the rules of bio-harmony could be applied to AA 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 4, 5 or 10 AAs coded by the 20 DNAs in question, the hypothesis had to be modified by replacing AA sequences with DNA sequences.

These DNA sequences however define also AA sequences identifiable as specific triangle at the orbit of  $Z_n$  defining the DNA codons assigned to that AA (there is a singular fiber space structure). Together the three 20-plets of DNAs define an AA harmony with  $(4+5+10=19)$  chords with tetrahedral extension defining a harmony with 22 chords/AAs). Hence both DNA sequences and AA sequences define "bio-music".

5. 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 AA sequences. Negentropy Maximization Principle (NMP) [K61] 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 be polished out under evolutionary pressures.
6. Could icosahedron, tetrahedron, and tetra-icosahedron have direct physical counterparts in living matter? For instance, water molecules form icosahedral clusters and the clathrates 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 than 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.
7. Music is language of emotions and peptides are molecules of emotion as Candace Pert [J46] 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 [K85]. 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 [A7, A16] (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 [L36].

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 they 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.

This summarizes the original article about geometric model of harmony [L31] and contributions in online books [K119, K85]. This chapter contains besides this article also some new results and considerations related to music harmony. Most of them have emerged during 2018.

### 6.1.2 Questions emerged during 2018

The model of music harmony is separate from the model of genetic code based on dark proton triplets [L52] and one of the challenges has been to demonstrate that they are equivalent. One can raise several questions.

1. Could the number of harmonies be actually larger than 256 as the original model predicts? One could rotate the 3 fused Hamilton’s cycles with respect to each by icosahedral rotations other leaving the face shared by icosahedron and tetrahedron invariant. There are however conditions to be satisfied.
  - (a) There is purely mathematical restriction. If the fused 3 harmonies have no common 3-chords the number of coded AAs is 20. Can one give up the condition of having no common 3-chords and only require that the number of coded AAs is 20?
  - (b) There is also the question about the chemical realizability of the harmony. Is it possible to have DNA and RNA molecules to which the 3-chords of several harmonies couple resonantly? This could leave only very few realizable harmonies.
2. The model predicts the representation of DNA and RNA codons as 3-chords. Melody is also an important aspect of music. Could AAs couple resonantly to the sums of the frequencies (modulo octave equivalence) of the 3-chords for codons coding for given AA? Could coding by the sum of frequencies appear in the coupling of tRNA with mRNA by codewords and coding by separate frequencies to the letterwise coupling of DNA and RNA nucleotides to DNA during replication and transcription? Could the emergence of DNA be interpreted as an evolutionary step from a holistic picture using codons as basic units (dark codons cannot be decomposed to letters) to more analytic picture in which letters are treated separately?
3. As I developed the model of bio-harmony [L31] (see <http://tinyurl.com/yad4tqw1>) it did not occur to me that also the tRNA part of the dark code should have counterpart in the icosahedral model. Could tRNA correspond to pairs of harmonies with  $20+20+4=44$  codons? What about single  $20+4=24$  codon representation as kind of pre-tRNA? Could tRNA correspond to a union of 2 20-codon codes? Combining only 2 20-codon codes with 40 codons and tetrahedral code with 4 codons would give maximally 44-letter code and

the upper bound for tRNAs is according to Wikipedia 45! Dark proton model predicts 40 DtRNAs suggesting that only the 40 isosahedral codons contribute to DtRNA code. The additional tRNAs could result from homonymy. The code sequences could be seen as a hierarchical sequence  $3 \rightarrow 2 \rightarrow 1$  in this framework.

An important implication is that there are many realizations of DtRNA and tRNA harmony:  $(Z_6, Z_4)$ ,  $(Z_6, Z_2)$ ,  $(Z_4, Z_2)$  and  $Z_2$  could be either  $Z_{2,rot}$  or  $Z_{2,refl}$ . This could explain the homonymy of mRNA-tRNA pairing via difference in the chords in turn affecting biochemical counterparts. Note however that the chords for tRNA must be a subset of chords for mRNA so that RNA harmony determines tRNA harmony apart from the three choices  $(Z_6, Z_4)$ ,  $(Z_6, Z_2)$  or  $(Z_4, Z_2)$  giving rise to 3 different contexts. If DAAs code by 3-chords the AAs then this choice does not affect AAs.

4. What is the origin of 12-note scale? Does genetic code force it? The affirmative answer to this question relies on the observation that 1-1 correspondence between codons and triplets of photons requires that the frequency assignable to the letter must depend on its position. This gives just 12 notes altogether. Simple symmetry arguments fix the correspondence between codons and 3-chords highly uniquely: only 4 alternatives are possible.

Hence it would be possible to listen what DNA sequences sounds in given mood characterized by the bio-harmony: the allowed 3-chords of harmonies with symmetries are given in [L31] and I can provide the basic Python modules allowing to transform DNA sequences for given harmony to audible form using Garage Band program.

5. What disharmony could mean? A possible answer comes from 6 Hamiltonian cycles having no symmetries. These disharmonies could express “negative” emotions.

**Remark:** I proposed the theory of bio-harmony in the article [L31]. I have discussed the model of bio-harmony also in the chapter “Quantum Model of Hearing” [K85] of book “TGD and EEG” and in the chapter “Three new physics realizations of the genetic code and the role of dark matter in bio-systems” [K119] of book “Genes and Memes”. The recent findings motivated writing a chapter including the previous results plus new results emerged during 2018.

## 6.2 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.

### 6.2.1 Icosahedral harmonies

1. 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  $\sharp$ s of the key increases by one unit in standard direction and the number of  $\flat$ s by one unit in opposite direction.

2. It turns out that major and minor 3-chords 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 tritonius 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.

### 6.2.2 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  $C \rightarrow G$  and  $C \rightarrow F$  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.

1. 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.
2. 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 tritonius interval which was forbidden by catholic church. Fourth (C-F) corresponds to 1- step in opposite direction and 11 steps in standard direction.
3. 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.

4. 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 fifths away from the basic chord would have 3-adic interpretation.

### 6.2.3 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?

1. 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.

2. 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.
3. 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 dodecahedron 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.
- 4. 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 allows computational construction of the allowed chord sequences as random sequences.
- 5. 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  $\text{maj}7_-$ ,  $\text{sus}4_+$ , 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.

### 6.2.4 More general notion of harmony

The notion of harmony discussed in previous section is rather conservative and certainly too stringent.

1. 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.
2. 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 step that they have single common note. The two 1-quint steps for downwards step  $Am - G$  are between 3rd and 1st ( $C \rightarrow G$ ) and 5th and 3rd ( $E \rightarrow H$ ). For upwards 0-quint steps  $E - H7$  1-quint steps are between 5th and 5th ( $H \rightarrow F\sharp$ ) and 1st and 1st ( $E \rightarrow H$ ). For  $H7 \rightarrow E$  the reversals of these steps occur. For  $E7 \rightarrow Am$  one has 3 1-quint steps: (the reversals 1-quint steps  $E \rightarrow A$  and  $H \rightarrow E$  steps and 1 quint step  $D \rightarrow A$ . The last step seems to be the smallest one in a well-defined sense.

For G-F step the number of 1-quint steps is one ( $C \rightarrow C$ ): 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 one 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.

1. 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 7.2 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 7.3 for  $Z_4$  chords the groups consist of 4 similar chords and in the tables 7.4 and 7.5 for  $Z_2$  harmony the chord groups consist of 2 similar chords.
2. 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.

1. 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.
2.  $Z_n$  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.
3.  $Z_2^{refl}$  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.
4. 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.

1. 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  $Z_n$ .



2. 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.

1.  $Z_2$  would induce half-octave shift and map  $C = (C, E, G)$  to  $F\sharp m = F\sharp, B\flat, D\sharp$ . The assignment of  $F\sharp$ -tritonius - with  $C$  note sounds strange in the ears of harmonic conservatives.
2.  $Z_4$  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.
3.  $Z_6$  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.

## 6.3 Harmony and biology

### 6.3.1 Could harmonic principles be realized in biology?

The basic idea behind icosahedral harmony is the 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.

Could the application of harmonic principles to biology make sense? The triangles of the ico-tetrahedron correspond to amino-acids or DNA codons for the amino-acids coded by 20 codons in question.

1. 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.
2. 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.
3. 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.
4. 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.

### Icosahedral water clusters made from tetrahedra

The obvious questions concern the concrete realization of the icosahedron - or more generally icosahedral symmetries. One should also understand 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 consist 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.

1. 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.
2. 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.
3. 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.
4. 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?
5. 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.

6. 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 be represented in terms of water icosahedra?

1. 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.
2. 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.
3. 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 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?

1. 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.
2. 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.
3. 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?

### 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 post-synaptic 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.

### 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?

1. 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 than 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.
2. The recent TGD inspired model of microtubules [L33], [K82] was inspired by the findings of the group of Bandyopadhyay (see <http://tinyurl.com/ze366ny>) [J20], [J110] 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.

3. 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.
4. The first possibility coming in mind is that the continually varying microtubule length codes for the frequency [L33]. 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.

5. 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 [L33] 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.
6. 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.
7. 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.

1. 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.
2. 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 [L33]. Long range correlations would mean enhance 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.
3. 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.

4. 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 [K74]. Discovering the precise realization of the proposal has however required time.

### 6.3.2 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?

1. 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?
2. 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  $((3/2)^{12} = 2^7$  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.

1. 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 CEG and chord containing EG and third note would be introduced.
2. 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  $\sharp$ s or  $\flat$ s are obtained. The chord chosen for extension must be  $CGA$ , which can 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.
3. One can perform the modification also for the inverted harmony. The transformation to reverted harmony  $X \rightarrow Y$  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  $CEE\flat$ .

4. 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.
5. 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)).

### 6.3.3 About the interpretation of bioharmonies

#### 1. How ideas about harmony evolved?

A brief summary about the evolution of the notion of bio-harmony is in order.

1. The first guess [L36] 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.
2. 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 aminoacid 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 (selenocysteine) 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>).

3. 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.

4. 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.
5. 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.

1. 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.
2. 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.

3. 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.

4. 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.
5. 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  $Z_4 \rightarrow Z_2^{rot}$  and  $Z_4 \rightarrow Z_2^{refl}$  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.

6. 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 ( $G \rightarrow G$ ) 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.

7. 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.

1. 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.

2. 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.
3. 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 gives just the ordinary genetic code so that the proposal is consistent with the proposal that dark proton sequences realize genetic code [K48].
4. 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.

1. 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  $(4, 8, 8)$ .
2. 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.
3. 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.

1. 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  $Z_6 = Z_3 \times Z_2^{refl}$ ,  $Z_4 = Z_2^{rot} \times Z_2^{refl}$  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.
2. 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.
3. 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

|   |   |   |   |   |   |   |   |   |      |
|---|---|---|---|---|---|---|---|---|------|
| 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 6.1:** The representations of the associations of amino-acids to the orbits 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.

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.

4. It is clear how to choose amino-acids from the orbits.

- (a) 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.

- (b)  $Z_2 = Z_2^{rot}$  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.

5. 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.

**Table 6.1** 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 the candidate with  $Z_2^{rot}$  symmetry but for its reversal 4 of them are present as images of  $D7, E7$  and  $G\sharp7, B\flat7$  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.

1. 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 paradise. 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 paradise is simple!

2. 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 “paradise 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 6.1) 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 7.5 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).

3. 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  $Z_n$ ,  $n = 6, 4, 2$ .
4. The banishing from the paradise 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.
5. 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.
6. 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.

1. 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.
2. 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.
3. The transitions between different amino-acid regions would be governed by this rule. Also 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
4. 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.

1. 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 [L42] 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.

2. 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.

3. 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!)
4. 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.

1. 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  $g_1G_2g_1^{-1}$  and  $g_1G_3g_1^{-1}$ . 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.

2. 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.
3. 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 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.

1. 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?
2. 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.
3. 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.
4. 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 [L44].

5. 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.

1. 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.
2. Morphogenesis provides examples of this kind of phenomena [I60, I61, I80]. The first key idea is that DNA and cell replication is induced by the replication of magnetic bodies serving as information carriers [K82]. 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.
3. 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.

1. 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/y9kwrwx>). 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.

2. 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.

3. The notions of epigenetic code (see <http://tinyurl.com/y8ztzza>) 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 [L31] [K85] 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 [K65, K48]: it is an open question whether these codes imply each other as they should.

4. 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.
5. Gregory Carey (see <http://tinyurl.com/ydyznasq>) 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 transfer of RNA or DNA molecules is necessary to achieve this. In TGD dark DNA, RNA, tRNA, and amino acids 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 suggests 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/hhdtth5j>) summarizing the findings discussed in the article [I27] (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.

1. 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 extremely 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 consists of endogenous retroviruses capable of doing the same. The huge genome of maize is due to this kind of process.

2. 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.

3. 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 germ 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 expressing 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?

1. 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.
2. 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 appearance 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 of RNA to germ cells occurs. There are also other hints: it is known that alleles (variants of 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.

### Epigenesis, inherited memories and moods lasting over several generations

Nikolina Benedikovic had an interesting comment concerning multiverse interpretation. This motivated to write a summary about the connection between epigenesis, inherited memories interpreted as behaviors and moods lasting for several generations. Nikolina's comment was following.

*"One can imagine an intelligent amoeba with a good memory. As time progresses, the amoeba is constantly splitting, each time the resulting amoebas having the same memories as the parent. Our amoeba hence does not have a life line, but a life tree."* - Huge Everett

Nikolina: Dear Mr. Everett! Before we find out what the true interpretation of quantum mechanics is, we will have to answer this question; why the amoeba possesses this "super power" of splitting and the electron and human being don't.

I agree with Nikolina. The following is my comment about what is involved. I proceed by questions.

#### 1. What behaviors are?

The behavior of amoeba has nothing to do with parallel universes of Everett. The behavior as such is however highly interesting and challenges standard theories of biology and perhaps also of physics. Memories seem to replicate.

1. What do we mean with memories now: do we mean behaviors, skills, conditionings? Or episodal, sensory memories. I think it is memories in the first sense of the word. Suppose that essentially conditionings are in question.

In this respect a lot of progress happened as it was discovered that RNA somehow represents the memories: taking RNA of conditioned sea snail and scattering it over the neurons of second snail in lab induces the conditions of the snail to these neurons.

2. Epigenetic approach would suggest that the behaviours essentially the same but now one does not have any convincing model for the model of the epigenesis.

#### 2. What TGD inspired quantum biology and neuro-science can tell?

There are two key questions that one must answer.

1. What replication is?

In TGD Universe we are 4-D entities - quantum states are superpositions of space-time surfaces obeying deterministic dynamics. This solves the problem of free will and basic problem of quantum measurement theory. The superposition of space-time surface would be analogous to superposition of deterministic computer programs, behaviours, or biological functions in classical sense. Free will would select the program [L100, K66, L119, L32] .

2. What memories as learned behaviours are? One can imagine several models, which need not exclude each other.

- (a) For instance, could it be that the replicas of ameba have geometric past that is partially shared: the part of the past as amoeba before the replication?
- (b) Second TGD explanation would be based on what conditionings are? They involve emotions in an essential manner. Emotions are induced and induce behaviors and conditionings involve long term moods. The mysterious epigenetic inheritance could be inheritance of moods affecting gene expression: moods could be inherited and have time-span of several generations: this conforms with the first option.

### 3. What moods are?

Suppose that conditions are due to long term moods in turn correlating with behavior and at basic level with genetic expression. Consider a TGD based model for moods, second option.

1. Music - its harmony defined by allowed chords - represents emotions and generates them. The allowed 3-chords of bio-harmony, the set of which can vary, would define the mood.
2. Genes are associated with information. Codon contains 6 bits of information. Magnetic body with large  $h_{eff} = nh_0$  is the boss, the "wise guy", controlling biological body and biochemistry so that genetic code must have primary representation at the level of flux tubes. Dark proton sequences at flux tubes interpreted as dark nuclei indeed represent codons as 3-proton units. The states of 3-proton units turn out to correspond to DNA, RNA, tRNA, amino-acids and vertebrate genetic code is predicted.

Chemical representation would be only a secondary representation only, mimicry, and often incomplete.

Dark proton sequences also realizing vertebrate genetic code would also have positive charge neutralizing the negative charge of nucleotides and make DNA stable. Pollack effect would generate the dark flux tube and this would require metabolic energy and in absence of it DNA would not be stable.

3. Dark proton sequences must also communicate by dark photons with large  $h_{eff}$ . The communications must rely on resonance, actually there must be resonance between similar 3-proton units, dark codons. Therefore 3-chords consisting 3 dark photons must represent the codons represented by 3 protons [L110]. Only identical codons have resonant coupling. This makes possible remote replication of DNA reported by HIV nobelist Montagnier [L16] (see <http://tinyurl.com/yygqen5g>).
4. Allowed 3-chords define the harmony and emotional state mood. In TGD representations of emotions in terms of bio-harmony would provide the representation of genetic codons defined by RNA as 3-chords of light, triplets of 3 dark photons. The icosatetrahedral model for harmony realizing bioharmony [L31, L140]. gives also rise to vertebrate genetic code: the 6-bit units defined by codons correspond to ordinary temporarily local intellect, and the harmony to the holistic emotional intellect.
5. RNA and DNA, tRNA, amino-acids would naturally be represented by light 3-chords in communications. Given codon would only tell its name by the chord and resonate with codon having same name. The codons would couple by chords via triple resonance. Same DNA sequences could be in different mood defined by bioharmony and its expression would depend on this: this would give rise to epigenetics. Epigenetic inheritance would be emotions lasting for several generations.  
The bioharmony associated with RNA could represent the mood infecting also DNA and generating DNA expression giving rise to the behavior related to conditioning.
6. If this were the case then the inheritance of memories (in this sense could be inheritance of conditionings as long term moods. The replications of RNAs and DNAs and possible other biomolecules carrying the conditioning would give rise to replication of memories as behaviors induced by moods.

7. These moods can be very long term moods and extend over generations. This would fit with the model in which replicated amoebas have the 4-D magnetic body amoeba of the geometric past as part of their 4-D magnetic body.

To sum up, behaviors as conditionings could be caused by moods, which can last for several generations. This would bring in magnetic body as active agent. The representation genetic code in terms dark proton sequences and by 3-chords of dark photons would give a realization of both the "bitty" and emotional aspects of intelligence. Also the notions of 4-D brain and organism having temporal span of several generations as space-time surfaces would be essential for the understanding the inheritance of emotions. We should be very careful for what we do since also our children can feel themselves proud of or guilty for what we did.

### $E_8$ symmetry, harmony, and genetic code

Bee gave in Facebook a link to an article about a connection between icosahedron and  $E_8$  root system [B15] (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.

1. 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.
2. 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 pinors also orientation reversing ones. They mean something else than usually a being 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.

3. 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.
4. 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.

1. 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.
2. 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?
3. McKay correspondence emerges also for inclusions of hyper-finite factors of type  $II_1$  [K124] 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 [K85] [L31] (see <http://tinyurl.com/yad4tqw1>) 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.

1. 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  $\pi$  and by reflection) appear. Each Hamiltonian cycle defines a particular notion of harmony with allowed 3-chords identified by the 20 triangles of icosahedron.
2. 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 than 12-note harmony.
3. 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 manners (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.

1. 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!).
2. 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.

3.  $E_8$  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  $\text{CoNb}_2\text{O}_6$  (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  $E_8$  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.

1. 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.
2. 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)?

3. 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?

## 6.4 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.

### 6.4.1 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.

1. 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.
2. 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  $BbCDG\sharp F\sharp E$  and  $D\sharp C\sharp HFGA$ .
3.  $Z_2^{rot}$  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 [K119, K4, ?].

1. 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.

2. 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.

1. The correspondence matters in the proposed scenario since the chords 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.
2. 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.
3. 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.

## 6.4.2 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 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  $F$  minor ( $Fm$ ), dominant to  $G$ . The notation for chords is such that quints correspond to

$$\begin{aligned}
CEG &\equiv C, & CD\sharp G &\equiv Cm, & CD\sharp F\sharp &\equiv C^o, & CEG\sharp &\equiv Caug, \\
CFG &\equiv C4, & CF\sharp G &\equiv C4_+, & CGG\sharp &\equiv C6_-, & CGA &\equiv C6, \\
CGB\flat &\equiv C7, & CGB &\equiv Cmaj7, & CGC\sharp &\equiv C9_-, & CGD &\equiv C9.
\end{aligned} \tag{6.4.1}$$

**Table 6.2:** Notation of chords inspired by popular music notations.

subsequent notes in the chord. For 1-quint chords this means that first two notes define the quint. **Table 6.2** 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.

$$\begin{aligned}
CC\sharp D &\equiv Cex1, & CC\sharp D\sharp &\equiv Cex2, & CDD\sharp &\equiv Cex3, & CDE &\equiv Cex4, \\
CD\sharp E &\equiv Cex5, & CC\sharp E &\equiv Cex6, & CDF\sharp &\equiv Cex7, & CDG\sharp &\equiv Cex8.
\end{aligned} \tag{6.4.2}$$

Clearly, the sets  $\{ex1\}$ ,  $\{ex2, ex3\}$ ,  $\{ex4, ex5, ex6\}$ ,  $\{ex7\}$ ,  $\{ex8\}$ , corresponds to the span of 2, 3, 4, 6, 8 half notes for the chord. The following summarizes the results. Note that  $Cex7$  can be seen as part of  $D7$  chord.

1. 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.
2. 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.

3. 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.

- (a) 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.
  - (b) 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.
  - (c) 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  $B\flat ex2 \equiv B\flat BC\sharp G$ .
4. 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. ??** ).

- (a) The 8 2-quint chords appear as four-plet  $H9, C\sharp9, D\sharp9, F9$  and its half octave shift (tritone 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  $CDG$ ).
- (b) Using the popular music notation introduced earlier, the 8 1-quint chords are  $D7, Amaj7, A4+, E7$  and their half-octave shifts  $G\sharp7, D\sharp7, D\sharp4+, Bb7$ .

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.

5. The four 0-quint chords appear in two types.  $D\sharp ex2 \equiv D\sharp EF\sharp$  and its half-octave shift  $Aex2 \equiv ABbC$  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. ??** ).

1. 2-quint chords appear as reflection related multiplets  $C9, D9, H\sharp9, D\sharp9$  and  $C\sharp9, H9, F9, Bb9$ .
2. 1-quint chords appear as symmetry related mutiplets  $G, D7, Amaj7, E7$  and  $C\sharp m, F\sharp6, H6-, E6$ . Key G major and  $C\sharp$  minor would be natural looking keys even without tetrahedral extension. For the mirror image  $Bb$  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.

### 6.4.3 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  $C \leftrightarrow C, F\sharp \leftrightarrow F\sharp, H \leftrightarrow C\sharp, F \leftrightarrow G, D \leftrightarrow Bb, E \leftrightarrow G\sharp, A \leftrightarrow D\sharp$  and produces a new scale with minor type chords mapped to major type chords and vice versa. Also one must remember that all 3-chords except those which are simple majors or minors lack the third so that their emotional tone remains uncharacterized. For instance,  $C6$  does could be replaced with  $Cm6$  and  $G7$  with  $Gm7$ . The reader can check the chords by direct inspection of the figures. The convention used is that vertex number one corresponds to  $C$  note.

| $(\mathbf{n}_0, \mathbf{n}_1, \mathbf{n}_2)$ | 0-chords       | 1-chords                                   | 2-chords                                   |
|--|----------------|--|--|
| (2, 12, 6)                                   | $(Faug, Gaug)$ | $(Cm, Dm, Em, F\sharp m, G\sharp m, Bbm),$ | $(C9, D9, E9, F\sharp 9, G\sharp 9, Bb9).$ |
|  |                | $(F6, G6, A6, B6, C\sharp 6, D\sharp 6).$  |  |

**Table 6.3:** Table gives various types of 3-chords for harmonies with  $Z_6$  rotational symmetry. Note that half-octave shift is an exact symmetry. Note that  $G^{aug} = CEG\sharp, F^{aug}$  act as bridges between the groups related by half octave shift. The chords have been arranged so that they form orbits of  $Z_6$ . “Amino-acid chords” correspond to preferred chords at the orbits.

| $(\mathbf{n}_0, \mathbf{n}_1, \mathbf{n}_2)$ | 0-chords                            | 1-chords                                      | 2-chords                          |
|--|-------------------------------------|---|-----------------------------------|
| (0, 16, 4)                                   |                                     | $(D7, D6, G\sharp 7, G\sharp 6),$             | $(Bb9, B9, E9, F9).$              |
|  |                                     | $(G4+, A9-, C\sharp 4+, D\sharp 9-),$         |                                   |
|  |                                     | $(Emaj7, Gmaj7, Bbmaj7, C\sharp maj7),$       |                                   |
|  |                                     | $(C9-, A9-, F\sharp 9-, D\sharp 9-).$         |                                   |
| (4, 8, 8)                                    | $(Cex3, Eex2, F\sharp ex3, Bbex2).$ | $(Dmaj7, E9-, A7, A6),$                       | $(Bb9, F9, C9, G9).$              |
|  |                                     | $(G\sharp maj7, Bb9-, D\sharp 7, D\sharp 6).$ | $(E9, B9, F\sharp 9, C\sharp 9).$ |

**Table 6.4:** 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 ??, ??

| $(\mathbf{n}_0, \mathbf{n}_1, \mathbf{n}_2)$ | 0-chords                           | 1-chords                                    | 2-chords                            |
|--|------------------------------------|---|-------------------------------------|
| (0, 16, 4)                                   |                                    | $(Em, Bbm), (Cm, F\sharp m),$               | $(D9, G\sharp 9),$                  |
|  |                                    | $(G6, C\sharp 6), (A6, D\sharp 6),$         | $(E9, Bb9).$                        |
|  |                                    | $(D4+, G\sharp 4+), (B4+, F4+),$            |                                     |
|  |                                    | $(Cmaj7, F\sharp maj7), (G6-, C\sharp 6-).$ |                                     |
| (2, 12, 6)                                   | $(Aex4, D\sharp ex2).$             | $(Am, D\sharp m), (G9-, C\sharp 9-),$       | $(C9, F\sharp 9),$                  |
|  |                                    | $(C4, F\sharp 4), (E4+, Bb4+),$             | $(A9, D\sharp 9),$                  |
|  |                                    | $(Dmaj7, G\sharp maj7),$                    | $(D9, G\sharp 9).$                  |
|  |                                    | $(Bmaj7, Fmaj7).$                           |                                     |
| (4, 8, 8)                                    | $(Aex2, Hex8, D\sharp ex2, Fex8).$ | $(D7, G\sharp 7), (Amaj7, D\sharp maj7),$   | $(G9, C\sharp 9), (A9, D\sharp 9),$ |
|  |                                    | $(A4+, D\sharp 4+), (E7, Bb7).$             | $(B9, F9), (E9, Bb9).$              |

**Table 6.5:** Table gives various types of 3-chords for harmonies with  $Z_2$  rotation symmetry acting as half-octave shift. The doublets represent 2-chord orbits. The cycles correspond to figures ??, ??, and ??.

| $(n_0, n_1, n_2)$ | 0-chords                                  | 1-chords                              | 2-chords                               |
|-------------------|---|---------------------------------------|--|
| (2, 12, 6)        | $(F\sharp ex3, Hex4),$                    | $(Am, D\sharp), (A6, D\sharp7),$      | $(C9, F9), (B9, F\sharp9),$            |
|                   |   | $(D7, B\flat6), (G6-, Fmaj7),$        | $(E9, C\sharp9).$                      |
|                   |   | $(D4+, B\flat9-), (E9-, G\sharp4+),$  |  |
| (2, 12, 6)        | $(Dex4, Hex4).$                           | $(F, Fm), (C6-, B\flatmaj7),$         | $(C9, D\sharp9),$                      |
|                   |   | $(D7, G\sharp6), (Gmaj7, D\sharp6-).$ | $(D\sharp9, C\sharp9),$                |
|                   |   | $(C\sharp4-, A4+), (E4+, F\sharp6).$  | $(E9, B9).$                            |
| (4, 8, 8)         | $(Fex1, D\sharp ex3, G\sharp ex1, Aex2).$ | $(E7, E6), (Amaj7, B9-),$             | $(D9, B9), (C9, C\sharp9),$            |
|                   |   | $(G, C\sharp m), (D7, F\sharp6).$     | $(F9, G\sharp9), (D\sharp9, B\flat9).$ |
| (2, 12, 6)        | $(Hex3, Eex7).$                           | $(D7, G\sharp6), (G, D\sharp m),$     | $(C9, D\sharp9),$                      |
|                   |   | $(F, Fm), (C6-, B\flatmaj7),$         | $(D9, C\sharp9),$                      |
|                   |   | $(A9-, C\sharp4+), (E7, F\sharp6).$   | $(E9, B9).$                            |
| (2, 12, 6)        | $(F\sharp ex2, Fex3).$                    | $(F, B\flat m), (C7, G\sharp6),$      | $(B\flat9, D\sharp9),$                 |
|                   |   | $(Amaj7, B9-), (E6, E7),$             | $(C9, C\sharp9),$                      |
|                   |   | $(G, C\sharp m), (D7, B6).$           | $(D9, H9).$                            |

**Table 6.6:** Table gives various types of 3-chords for harmonies with single reflection symmetry. The cycles correspond to figures ??, ??, ??, ??, ??.

## 6.5 New results related to the notion of bio-harmony

This section contains some new results related to music harmony. During 2018 some new results related to the model of bio-harmony emerged. In the sequel they are collected together.

**Remark :** In the sequel I will use the shorthand AA for amino-acids and shorthands DDNA, DRNA, DtRNA, DAA for the dark analogs of DNA, RNA, tRNA, and AA realizes as dark proton sequences with codon represented as dark proton triplet.

### 6.5.1 Summary of the background

For some years ago I developed a model of music harmony [L31] (see <http://tinyurl.com/yad4tqw1>), which should define map of dark codons to 3-chords represented as dark photon triplets and defining allowed 3-chords of music harmony (music of light and perhaps also of sound). The Appendix provides the tables describing the details of the harmonies.

1. The model relies on the geometries of icosahedron and tetrahedron and representation of 12-note scale as so called Hamiltonian cycle at icosahedron going through all 12 vertices of icosahedron [A18, A7, A16, A5, A12]. The 20 faces correspond to allowed 3-chords for harmony defined by given Hamiltonian cycle. This brings in mind 20 AAs.

Single step of Hamiltonian cycle connecting vertices of a face of icosahedron (triangle) is assume to correspond to a scaling of the frequency by factor  $3/2$ . This leads to a problem since 12 scalings of this kind does not quite give 7 octaves which reduced octave equivalence to the basic octave would give 12-note scale. The solution is to add single note slightly differing from 7 octaves and represented as vertex  $P$  of a tetrahedron glued to icosahedron along face. The Hamilton cycles are deformed so that they begin and end from this vertex. This also gives the missing 4 DNA codons realized as 3-chords and also defines unique ground note for the scales.

2. One obtains 3 basic types of harmonies depending on whether the symmetries of icosahedron leaving the shape of the Hamiltonian cycle is  $Z_6$ ,  $Z_4$  or  $Z_2$ . For  $Z_2$  there are two options:  $Z_{2,rot}$  is generated by rotation of  $\pi$  and  $Z_{2,refl}$  by reflection with respect to a median of equilateral triangle.

Combining together one harmony from each type one obtains union of 3 harmonies and if there are no common chords between the harmonies, one has  $20+20+20$  3-chords and a strong resemblance with the code table. To given AA one assigns the orbit of given face under icosahedral isometries so that codons correspond to the points of the orbit and orbit to the corresponding AA.



4 chords are however missing from 64. These one obtains by adding tetrahedron. One can glue it to icosahedron along chosen face or keep is disjoint. The model predicts a highly unique and realistic model for numbers of DNA codons coding for a given AA. The model in its original form predicts two codes and also explains the fact that there are two additional AAs Pyl and Sec that appear as end-products.

3. AAs correspond to single 20-codon code, DNA and RNA to a union of 3 20-codon codes with symmetries  $Z_6$ ,  $Z_4$  or  $Z_2$ : here  $Z_2$  would correspond to  $Z_{2,rot}$  or  $Z_{2,refl}$  and this would give to two two different codes.
4. The model in its original form predicts 256 different harmonies with 64 3-chords defining the harmony. DNA codon sequences would be analogous to sequences of chords, pieces of music. Same applies to mRNA.

Music expresses and creates emotions and the natural proposal is that these bio-harmonies correlate with moods that would appear already at molecular level. They could be realized in terms of dark photon triplets realized in terms of light and perhaps even music (living matter is full of piezo-electrets). In fact, also the emotions generated by other art forms could be realized using music of dark light. [L116]. Dark photons in various wavelength ranges and correspond to various values of  $h_{eff}$  would correspond to various sensory qualia and are represented at pineal gland ("third eye") as imagined sensory percepts [L87]. They can be transformed to real sensory percepts at sensory organs by using DMT molecules as bridges allowing the propagation of dark photons (or the bio-photons resulting in their energy conserving transformation to ordinary photons) to sensory organs, where they generate genuine sensory experience identified as dream, psychedelic experience, hallucination, etc...

The model of music harmony is separate from the model of genetic code based on dark proton triplets [L52] and one of the challenges has been to demonstrate that they are equivalent. One can raise several questions.

1. Could the number of harmonies be actually larger than 256 as the original model predicts? One could rotate the 3 fused Hamilton's cycles with respect to each by icosahedral rotations other leaving the face shared by icosahedron and tetrahedron invariant. There are however conditions to be satisfied.
  - (a) There is purely mathematical restriction. If the fused 3 harmonies have no common 3-chords the number of coded AAs is 20. Can one give up the condition of having no common 3-chords and only require that the number of coded AAs is 20.
  - (b) There is also the question about the chemical realizability of the harmony. Is it possible to have DNA and RNA molecules to which the 3-chords of several harmonies couple resonantly? This could leave only very few realizable harmonies.
2. The model predicts the representation of DNA and RNA codons as 3-chords. Melody is also an important aspect of music. Could AAs couple resonantly to the sums of the frequencies (modulo octave equivalence) of the 3-chords for codons coding for given AA?
3. As I developed the model of bio-harmony [L31] (see <http://tinyurl.com/yad4tqwl>) it did not occur to me that also the tRNA part of the dark code should have counterpart in the icosahedral model. Could tRNA correspond to pairs of harmonies with  $20+20+4=44$  codons? What about single  $20+4=24$  codon representation as kind of pre-tRNA? Could tRNA correspond to a union of 2 20-codon codes? Combining only 2 20-codon codes with 40 codons and tetrahedral code with 4 codons would give maximally 44-letter code and the upper bound for tRNAs is according to Wikipedia 45! Dark proton model predicts 40 DtRNAs suggesting that only the 40 icosahedral codons contribute to DtRNA code. The additional tRNAs could result from homonymy. The code sequences could be seen as a hierarchical sequence  $3 \rightarrow 2 \rightarrow 1$  in this framework.

An important implication is that there are many realizations of DtRNA and tRNA harmony:  $(Z_6, Z_4)$ ,  $(Z_6, Z_2)$ ,  $(Z_4, Z_2)$  and  $Z_2$  could be either  $Z_{2,rot}$  or  $Z_{2,refl}$ . This could explain the homonymy of mRNA-tRNA pairing via difference in the chords in turn affecting biochemical

counterparts. Note however that the chords for tRNA must be a subset of chords for mRNA so that RNA harmony determines tRNA harmony apart from the three choices  $(Z_6, Z_4)$ ,  $(Z_6, Z_2)$  or  $(Z_4, Z_2)$  giving rise to 3 different contexts. If DAAs code by 3-chords the AAs then this choice does not affect AAs.

4. What is the origin of 12-note scale? Does genetic code force it? The affirmative answer to this question relies on the observation that 1-1 correspondence between codons and triplets of photons requires that the frequency assignable to the letter must depend on its position. This gives just 12 notes altogether. Simple symmetry arguments fix the correspondence between codons and 3-chords highly uniquely: only 4 alternatives are possible so that it would be possible to listen what DNA sequences sounds in given mood characterized by the harmony.
5. What disharmony could mean? A possible answer comes from 6 Hamiltonian cycles having no symmetries. These disharmonies could express “negative” emotions.

### 6.5.2 Some questions about the realization of the bio-harmony

In the sequel by I will proceed by posing questions related to the relationship between the 3 representations of genetic code [K119] in terms of bio-molecules, their dark analogs represented as sequences dark proton triplets, and as 3-3-chords of bio-harmony.

#### What conditions pairings pose on the frequency triplets?

The realization of DDNA-DtRNA and DDNA-DAA pairings in terms of frequencies must involve a loss of information since the correspondence is many-to-one.

1. For DNA-mRNA pairing information is not lost and the pairing must be of form  $(f_1, f_2, f_3) \rightarrow (f_1, f_2, f_3)$ . Note that the frequencies cannot be associated with the letters. It is however possible to consider the assignment of  $(f_1, f_2)$  to the first letter pair XY as a whole and  $f_3$  to the third letter Z.
2. For DDNA-DAA and DmRNA-DAA pairing the natural hypothesis is  $(f_1, f_2, f_3) \rightarrow f_1 + f_2 + f_3$ . AA couples to the sum of the frequencies of the triplet. The simplest possibility is that the  $f_1 + f_2 + f_3$  is same for all codons codin for given AA. One might say that AA sequence defines melody and mRNA sequence the accompaniment. If the sums for codons coding given AA are different they must couple resonantly to it. If there are several harmonies the sum must same for all realizable 3-harmonies or all chords of 3-chord harmonies coding for same AA couple to it resonantly. Since one has linear 1-D structures one might ask whether frequency differences coming as multiples of lattice frequencies are allowed. Second natural possibility is octave equivalence. mRNA-AA pairing would take place directly rather than with the mediation of of tRNA.
3. In the case of DmRNA-DtRNA pairing one one does not lose so much information since the number of dark DNAs is 40 (as also the 3-chords if tetrahedron does not contribute). One must remember that tRNAs are pairs of RNA like codons - call them  $\text{RNA}_t$ , and AAs. Therefore there pairing involves also the pairing mRNA-AA give by  $(f_1, f_2, f_3) \rightarrow f_1 + f_2 + f_3$  and guaranteeing that the code is realized by this pairing alone irrespective of mRNA- $\text{RNA}_t$  pairing. At chemical level the first to mRNA codons pair with tRNA anticodons according to the standard rules. Could  $\text{RNA}_t$  have completely passive role in carrying the AA? This cannot be the case since the last two letters of  $\text{RNA}_t$  couple in standard manner to the first two letters of mRNA.

**Remark:** tRNA is analogous to melody + accompaniment using one of the 3 possible 2-harmonies for a given 3-harmony.

Suppose that mRNA- $\text{RNA}_t$  pairing corresponds to 3 possible choices of 2-harmonies as sub-harmonies of 3-harmony. This would suggest these different sub-harmonies define maps  $(f_1, f_2, f_3) \rightarrow (f_1, f_2, f_3)$  such that  $\text{RNA}_t$  pairs only with two sub-harmonies. For each choice  $\text{RNA}_t$  would correspond effectively to 40 sub-codons of the entire code (forgetting the tetrahedral part giving 4 additional codons). The three different realizations of the projection would give rise to the homonymy. Also the AA-trNA coupling would come out correctly.

DAAAs would be different in the sense that they couple only to the sum of the frequencies. This is in accordance with bio-harmony in which AAs correspond to orbits of 3-chords for DNA under isometries rather than single 20-chord harmony. The coupling to the sum of frequencies is in accordance with the quantal interpretation as 3-dark-photon state whose energy is  $E = h_{eff}(f_1 + f_2 + f_3)$  and couples to AA chemically via the transition to ordinary photons with the same energy.

This leaves some questions.

1. Could one consider the possibility that the chords of one of the 20-chord harmonies corresponds to AAs? There would be 3 basic types of AAs. This does not look plausible and the association of AAs with the orbits of 20-note chords is more natural and fits nicely with  $f = f_{XYZ}$  picture.
2. It would be nice to assign notes to the individual letters of codons. This is not possible since codons with 2 or 3 identical letters would reduce to 2-chords or 1-chords. It is also impossible to assign frequencies with letters at dark level since letter decomposition does not exist. Thus the 3-chord has resonant interaction with the entire codon.
3. The symmetries of the genetic code however suggest that it might make sense to treat the first two letters XY of the codon as a single unit and the third letter as separate single unit. Could one assign to XY a 2-chord not reducible to frequencies for the letters X and Y, and to letter Z its own frequency. The frequencies of A, G, T, C as third letter must be different. Four 32 codons of standard code the AA would not be sensitive to the frequency of Z: this is possible if these frequencies are resonance frequencies of the same AA. For the remaining 32 codons the AA would not distinguish between frequencies of T and C *resp.* A and G so that the two frequencies would be both resonance frequencies of the corresponding AA.

### Probabilistic estimates for single 20-chord harmony

One can make first some naïve probabilistic estimates about single 20-chord harmony.

1. Given 20-chord harmony makes  $20/220 = 1/11 \simeq 9$  per cent about all possible 3-chords. Three 20 chord harmonies would make  $3 \times 9 = 27$  per cent about all possible 3-chords if there are no common chords so that the optimistic expectation might make sense. Of course, one cannot exclude the possibility that there are also triplets of 20-codon codes which gives smaller number of codons.
2. The total number of chords with different notes is  $12 \times 11 \times /3! = 220$ . Bio-harmony has 64 chords corresponding to faces of icosahedron: this is about  $64/220$  making 29 per cent of all possible 3-chords with different notes. Given bio-harmony thus throws out roughly  $2/3$  of all possible codons. This should be easy to test. For instance, does given gene correspond to a fixed bioharmony? Or does even entire genome do so. If bio-harmony is realized for non-nuclear genomes, it must satisfy rather strong constraints.
3. Given 20-chord harmony corresponds to 12 edges. Each edge is shared by two adjacent triangles. If all 20 triangles would contain just single face, there would be 24 triangles altogether. Therefore there must be triangles containing two subsequent edges of the cycle. Each triangle of this kind reduces the number of 24 neighbours by 2 units. Hence it seems that one must have at least 2 triangles with 2 edges at the cycle (two quints in the 3-chord). If there are more than 2 triangles of this kind, there must be triangles having no edges along the path. Each vertex of icosahedron is shared by 5 triangles and there are 5 edges starting from it.
4. The notion of Hamilton cycle generalizes to any graph and magnetic flux tube networks define such graphs as tensor networks. Why only icosahedron? Could one consider the possibility that any tensor network is characterized by harmonies characterize by Hamiltonian cycles and that one could assign some kind of codes with the combinations of these cycles? In the general case symmetries would be absent so that the notion of code in the proposed sense would fail: one could not identified codons as points at orbits of symmetry group. Rather,

one can imagine that the notion of code could be defined quite generally in terms of orbits as AAs and points at them as DNAs coding them. For regular polygons in any dimension the symmetries are present and one could define the notion of code and also fuse the codes.

For arbitrary tensor network the faces need not be symmetry related and one can also have faces that can be interpreted as higher-dimensional polytopes.

One can also ask whether the icosahedron is realized physically. Icosahedral geometry is indeed very common in biology. Could the fusion of icosahedral and tetrahedral geometries have some concrete realization at molecular level?

### Is the maximal number of codons for the fusion of 3 20-codon codes possible?

It has not earlier occurred to me to wonder whether the chords associated with the 3-different icosahedral harmonies giving 20 codons each correspond to  $20+20+20=60$  different chords as assumed. Could there be common 3-chords? This question could be answered by studying the Hamiltonian cycles at icosahedron.

**Remark:** Perhaps more important constraint than absence of common chords is the chemical realizability of the codes. If same mRNAs and DNAs realized different bio-harmonies then they must be able to respond resonantly to several 3-chords.

One can make naïve probability estimates for a pair of codes to allow the maximal number of 60 codons. It seems natural to assume that the isometries of icosahedron (or their subgroup) can be applied separately and only the isometries acting on both in similar manner are symmetries. The situation would be the same as in the case of many-particle system: only the translations acting on all particles simultaneously remain symmetries and relative translations cease to be symmetries.

With this assumption the icosahedral group gives a large number of code pairs. For the fusion of 3 20-codon codes giving DNA/RNA the number is even higher. By choosing suitably the relative isometries it might be possible to obtain the maximal number of 60 different codons for the icosahedral genetic code. On the other hand, by a suitably choice of relative isometries one might have undesired common 3-chords. In any case, the earlier estimate 256 for the number of bio-harmonies [L31] suggested to correlate with “emotional” states of the basic biomolecules is expected to change.

Before going to estimates one must consider some delicacies related to the notion of 12-note scale as Hamiltonian cycle.

1. One can regard the cycles as purely geometric objects without orientation or assign to them orientation. For two different orientations the scales would run in opposite directions as scalings by  $3/2$  along single edge of the cycle. If two codes have common edge, the scaling must be same along it. If the orientation of the second cycle is changed, the common edge ceases to be common.
2. The basic note of the 12-note scale at cycle can be chosen arbitrarily; this corresponds to the choice of the key in music (one could of course argue that the key does not make sense in 12-note scale if one has tempered scale with notes comes as powers of  $2^{1/2}$  scaling of ground note rather than Pythagorean scale with rational ratios of notes).

The fusion of tetrahedron to icosahedron selects one particular triangular face and brings in one additional vertex outside the icosahedron, call it  $P$ . It would be natural to assign the ground note as  $P$ . The isometries not affecting  $P$  would correspond to those of icosahedron leaving the common face invariant and isometries of tetrahedron leaving  $P$  un-affected and continuable to icosahedral isometries. One would have subgroup of icosahedral group as allowed isometries acting on the cycles to be fused.

3. If one assigns note sequences to the cycle by quint rule, cycles  $C_1$  and  $C_2$  can have common triangle in geometric sense but if the distances of the vertices  $A, B, C$  of the triangles from  $P$  measured as the number of edges of cycle portion connecting them are not same along  $C_1$  and  $C_2$ , the triangles correspond to different chords and are thus orthogonal in the proposed description as many-fermion states.
4. To sum up, the states associated with triangles would be characterize by the position of triangle (20 values), by the notes of the triangle characterized by the distances from  $P$ , and

the number 0, 1, 2 of the edges belonging to the cycle and should make easier to find orthogonal basis.

Again one can make probabilistic estimates: cycles are treated as purely geometric entities without orientation and without assignment of notes to the triangles.

1. Given cycles  $C_1$  and  $C_2$  what is the probability that they have at least one common edge as purely geometric entities without the sequence of notes? There are 30 edges so that given edge is shared with probability  $1/30$ . If the edges of cycles were chosen randomly (certainly not true), the probability of having a common edge for two cycles would be  $P(1) = 12/30$ . The assumption of note sequence reduces this probability dramatically.
2. By the above estimate each cycle contains at least two triangles with 2 edges at the cycle with minimal angle between them. One can call these these edge pairs V-corners. Assume that for cycle  $C_1$  one has V-corner ABC at vertex A, call it  $V_{1,A}$ . What is the probability that one one of the V-corners of  $C_2$  is located at A co-incides with ABC. The probability of V-corner of  $C_2$  to locate at A is  $1/12$  and the probability that the edge of  $C_2$  from B is BC is  $1/4$  so that the probability of having common V-corner is  $1/48$ . If  $C_2$  contains  $n$  V-edges the probability is naïvely  $n/48$ .

This estimate takes into account only geometry. The situation changes if one assumes that the cycles are oriented. In this case one can have common V-corner if the local orientations of  $C_1$  and  $C_2$  are opposite at the V-corner. If one assumes that the external vertex  $P$  of the tetrahedron defines the ground note then the number of edges connecting  $P$  to A defining distance  $d(P, A)$  must be same for  $C_1$  and  $C_2$ .

3. Given  $C_1$  and  $C_2$  (and vertices A with same distance  $d(P, A)$ ) it might be possible to perform suitable isometry for  $C_2$  that there is common V-corner. Therefore not all possible combinations of three code types allowing relative isometries need not maximal number of 3-chords.

**Remark:** An interesting question is whether these can be allowed meaning that some codons are missing in the chemical realization of the dark codons in terms of ordinary DNA codons. Also the 1-1 pairing between dark DNA and dark RNA would not be 1-1 if mediated by 3-chord resonance and one would have homonymy. This suggests that only codes without common chords can be allowed.

4. What about chords having 1 edge at cycle for two cycles  $C_1$  and  $C_2$ ? Let the edge be  $AB$ . As found, the naïve probability for this is  $P(1) = 12/30$ . Both cycles must go through the third vertex  $C$  of the triangular face. The subsequent notes along cycle differ by a quint that is scaling of the frequency by factor  $3/2$ . Notes are same if the numbers of the needed quints are same for  $C_1$  and  $C_2$ . For  $C_1$  the number  $n_B > 1$  of quints is known. In the approximation that possible portions of  $C_1$  represent  $n$ -step non-self-intersecting random walks from  $B$  to  $C$ , one must estimate the number of all non-self-intersecting  $n$ -step-paths from  $B$  to  $C$  and find what is the number of the paths leading to  $C$ . One can go from A to C with  $n_A$  steps and similar estimate applies.
5. The third possibility is that the one has 3 common vertices A, B, C forming a triangular face such that neither cycle contains any of its edges.

The cautious conclusion is that it is plausible that one can find 3 cycles having no common chords if one allows relative rotations of the cycles and that this condition is necessary for realizing the absence of homonymies at dark level. The automatic orthogonality of the Hamiltonian cycles cannot be excluded but would allow also codes with codons containing more than 3 letters so that one could have kind of super-DNA. Whether they can be realized chemically depends on whether there are biomolecules resonating with the the  $n$  frequency triplets involved. Octave equivalence for frequencies might give hopes about chemical realization of several harmonies. Therefore the evolution might be seen as gradual emergence of molecules able to pair with DDNA and one can even imagine artificial evolution by tailoring the frequencies involved (maybe cyclotron frequencies).

### How the symmetries of the model of harmony could relate to those of the genetic code?

Genetic code has surprisingly strong symmetries. I have discussed a possible interpretation of these symmetries using analogies with particle physics and considered also a mechanism explaining their emergence earlier [K4, ?]. The proposal was that 3-letter code emerged as a fusion of 2-letter code with 16 codons and 1-letter coded with 4 codons. In the recent framework, a more natural option is that the third codon of 3-letter code was originally passive and became active via symmetry breaking distinguishing first between UC and AG pairs and later between U and C *resp.* A and G. Note that for the standard code the breaking is minimal and caused by odd number of Start and Stop codons.

1. For vertebrate code one half of codons has very high symmetry in the sense that the two first letters dictate the AA for 32 cases. Exception is UUU, which codes for Phe or Leu for some modifications of the standard code.  $UUU \rightarrow \text{Leu}$  means breaking of maximal symmetry.
2. There is also a second symmetry, which I have referred to as isospin symmetry. It is only slightly broken. For general codons XYU and XYC code for same AA as also XYA and ad XYG. For the standard code this symmetry is broken only in columns containing initiation codon or stop. The Start codon AUG codes also for met. UGA and UGG code for Stop and Trp. For the remaining codons one has slightly broken “isospin symmetry”. The breaking of isospin symmetry is minimal for vertebrate code. The modifications of the code tend to break the isospin symmetry and even the maximal symmetry of 32 codons. This must be important.

If the model of genetic code based on music harmony [L31] is correct, the symmetries for the model of music harmony must relate to those of genetic code.

1. How the symmetries of the genetic code relate to the symmetries of icosahedron (60-element group) and tetrahedron (permutation group  $S_4$  with 24 elements) in the model of bio-harmony? Icosahedral symmetry group has 60 elements and has sub-groups  $Z_2, Z_4, Z_5, Z_6 = Z_2Z_3$ . Note that there are two  $Z_2$ :s having rotation by  $\pi$  and reflection as generators.

The gluing of tetrahedron to icosahedron along single face reduces its group of symmetries to  $S_3$  leaving the point  $P$  not belonging to icosahedron invariant.  $S_3$  has as subgroups reflection group  $Z_{2,refl}$  and  $Z_4$  consisting of rotations.

2. What is the counterpart for maximal symmetry in icosahedral and tetrahedral groups? Do the 3-chords for codon XYZ decompose to two-chord characterizing XY and a note characterizing  $Z = A, U, C, G$ , which can depend on XY. The symmetry relating UC pair and AC pair could correspond to  $Z_{2,refl}$  reflection symmetry, which is shared by icosahedral and tetrahedral groups. For 32 icosahedral codons the action of  $Z_{2,refl} \times Z_{2,rot}$  would be trivial so that AA would not depend on the third letter at all. For most of the remaining codons the action of the symmetry group on icosahedral codons would reduce to  $Z_{2,rot}$  permuting the third letters U and C *resp.* A and G. At the level of frequencies the sums of frequencies for codons coding for the same AA could be same modulo octave equivalence.

The addition of tetrahedron brings in 4 tetrahedral codons with one of them shared with icosahedron. Icosahedral  $Z_{2,rot}$  does not make sense for these codons. Intriguingly, there are 4 codons in vertebrate code which break isospin symmetry AUA and AUG coding for I and Met/start and UGA and UGG coding for Stop and Trp. If these codons correspond to the tetrahedral codons which cannot have  $Z_{2,rot}$  as isospin symmetry, the breaking of  $Z_{2,rot}$  would follow from the breaking of symmetry induced by the attachment of tetrahedron to icosahedron.

### What is the origin of 12-note scale?

One fundamental question is why dark photon realization of genetic code should involve 12-note scale as icosahedral model requires.

**Remark:** The gluing of tetrahedral codons gives 4 additional codons but if tetrahedron is glued to icosahedron along one of its faces, the additional vertex gives only one additional note,

which should be very near to the 12:th one. This could relate to the basic problem observed already by Pythagoras that 12-note Pythagorean scale with rational valued frequency ratios does not quite close.

A popular article in Spacedaily with title “*Scientists crack how primordial life on Earth might have replicated itself*” (see <http://tinyurl.com/y92ng5vd>) led to a possible answer to the above question. The research paper [I33] is titled “*Ribozyme-catalysed RNA synthesis using triplet building blocks*” and published in eLife (see <http://tinyurl.com/ya5qyjfn>).

It is possible to replicate unfolded RNA strands in Lab by using enzymes known as ribozymes, which are RNA counterparts of enzymes, which are amino-acid sequences. In the presence of folding the replication is however impossible. Since ribozymes are in general folded, they cannot thus catalyze their own replication in this manner. The researchers however discovered that the replication using RNA triplets - genetic codons - as basic unit can be carried out in laboratory even for the folded RNA strands and with rather low error rate. Also the ribozyme involved can thus replicate in codon-wise manner. For units longer than 3 nucleotides the replication becomes prone to errors.

These findings are highly interesting in TGD framework. In TGD the chemical realization of genetic code is not fundamental. Rather, dark matter level would provide the fundamental realizations of analogs of DNA, RNA, tRNA, and amino-acids as dark proton sequences giving rise to dark nuclei at magnetic flux tubes [L110] (see <http://tinyurl.com/yalny39x>). Also ordinary nuclei correspond in TGD Universe to sequences of protons and neutrons forming string like entities assignable to magnetic flux tubes.

The basic unit representing DNA, RNA and tRNA codon and amino-acid would consist of 3 entangled dark protons. The essential aspect is that by entanglement the dark codons do not decompose to products of letters. This is like words of some languages, which do not allow decomposition to letters. This representation is holistic. As we learn to read and write, we learn the more analytic western view about words as letter sequences. Could the same hold true in evolution so that RNA triplets would have come first as entities pairing with dark RNA codons from dark proton triplets as a whole? Later DNA codons would have emerged and paired with dark DNA codons. Now the coupling would have been letter by letter in DNA replication and transcription to mRNA.

It is intriguing that tRNA consists of RNA triplets combined from amino-acids and analogs of mRNA triplets! The translation of mRNA to amino-acids having no 3-letter decomposition alone forces the holistic view but one can ask whether something deeper is involved. This might be the case. I have been wondering whether during RNA era RNA replicated using a prebiotic form of translational machinery, which replicated mRNA rather than translated RNA to protein formed from amino-acids (AAs) with AA serving as a catalyst.

1. During RNA era amino-acids associated with pre-tRNA molecules would served as catalysts for replication of RNA codons. The linguistic mode would have been “holistic” during RNA era in accordance with the findings of the above experiments. RNA codon would have been the basic unit.
2. This would have led to a smaller number of RNAs since RNA and RNA like molecules in tRNA are not in 1-1 correspondence. A more realistic option could have been replication of subset of RNA molecules appearing in tRNA in this manner.
3. Then a great evolutionary leap leading from RNA era to DNA era would have occurred. AA catalyzed replication of RNA would have transformed to a translation of RNA to proteins and the roles of RNA and AA in tRNA would have changed. [Perhaps the increase of  $h_{eff}$  in some relevant structure as quantum criticality was reached led to the revolution]
4. At this step also (subset of) DNA and its transcription to (a subset of) mRNA corresponding to tRNA had to emerge to produce mRNA in transcription. In the recent biology DNA replicates and is transcribed nucleotide by nucleotide rather than using codon as a unit so that helicases and DNA and RNA polymerases catalyzing replication and transcription should have emerged at this step. The ability of DNA to unwind with the help of helicase enzyme helping DNA to unwind is essential for the transcription and translation of DNA. Therefore helicase must have emerged together with the “analytic linguistic mode” as an analog of

written language (DNA) decomposing codons to triplets of letters. This would be a crucial step in evolution comparable to the emergence of written language based on letters. Also the counterpart of RNA polymerase and separate RNA nucleotides for transcription should have emerged if not already present.

An alternative option would involve “tDNA” as the analog of tRNA and the emergence of helicase and polymerases later as the transition from holistic to analytic mode took place.

The minimal picture would be emergence of a subset of DNA codons corresponding to RNAs associated with pre-tRNA and the emergence of the analogs of helicase and DNA and RNA polymerases as the roles of amino-acid and RNA codon in tRNA were changed.

5. How DNA could have emerged from RNA? The chemical change would have been essentially the replacement of ribose with de-oxiribose to get DNA from RNA and  $U \rightarrow T$ . Single O-H in ribose was replaced with H. O forms hydrogen bonds with water and this had to change the hydrogen bonding characteristics of RNA.

If the change of  $h_{eff} = n \times h_0$  was involved, could it have led to stabilization of DNA? Did cell membrane emerge and allow to achieve this? I have proposed [L110] (see <http://tinyurl.com/yalny39x>) that the emergence of cell membrane meant the emergence of new representation of dark genetic code based on dark nuclei with larger value of  $h_{eff}$ .

**Remark:** One has  $h = 6 \times h_0$  in the most plausible scenario [L62, L115] (see <http://tinyurl.com/goruuzm> and <http://tinyurl.com/y9jxyjns>).

One can of course ask whether something simpler could be imagined by utilizing the potential provided by dark variants of bio-molecules present already from beginning and providing both genes and metabolism simultaneously.

1. Viruses are probable predecessors of cellular life. So called positive sense single stranded RNA (ssRNA) associated with viruses can form temporarily double strands and in this state replicate just like DNA (see <http://tinyurl.com/yc5f8b3t>). The resulting single stranded RNA can in turn be translated to proteins by using ribosomal machinery. RNA replication takes place in so called viral replication complexes associated with internal cell membranes, and is catalyzed by proteins produced by both virus and host cell.

Could ribozyme molecules have catalyzed RNA replication during RNA era? For this option AA translation would have emerged later and the storage of genetic information to DNA only after that. There is however the question about the emergence of AAs and of course, DNA and RNA. Which selected just them from enormous variety of options.

2. Lipid membranes are formed by self-organization process from lipids and emerge spontaneously without the help of genetic machinery. It would be surprising if prebiotic life would not have utilized this possibility. This idea leads to the notion of lipid life as a predecessor of RNA life. In this scenario metabolism would have preceded genes (see <http://tinyurl.com/y7ehv8cq> and <http://tinyurl.com/y8nltb9e>). The basic objection against both genes-first and metabolism-first options is that they need each other!
3. In TGD framework the dark variants of DNA, RNA, AA, and tRNA would provide the analogs of genes and all basic biomolecules. They would also provide a mechanism of metabolism in which energy feed by (say) solar radiation creates so called exclusion zones (EZs) of Pollack [L34] in water bounded by a hydrophilic substance. EZs are negatively charged regions of water giving rise to a potential gradient (analog of battery) storing chemically the energy provided by sunlight and the formation of these regions gives rise to dark nuclei at magnetic flux tubes with scaled down binding energy.

When the p-adic length scale of these dark nuclei is liberated binding energy is liberated as metabolic energy so that metabolic energy feed giving basically rise to states with non-standard value  $h_{eff}/h = n$  of Planck constant is possible. For instance, processes like protein folding and muscle contraction could correspond to this kind of reduction of  $h_{eff}$  liberating energy and also a transformation of dark protons to ordinary protons and disappearance of EZs.



The cell interiors are negatively charged and this is presumably true for the interiors of lipid membranes in general and they would therefore correspond to EZs with part of protons at magnetic flux tubes as dark nuclei representing dark variants of basic biomolecules. Already this could have made possible metabolism, the chemical storage of metabolic energy to a potential gradient over the lipid membrane, and also the storing of the genetic information to dark variants of biomolecules at the magnetic flux tubes formed in Pollack effect.

4. In TGD framework biochemistry would have gradually learned to mimic dark variants of basic processes as a kind of shadow dynamics. Lipid membranes could have formed spontaneously in water already during prebiotic phase when only dark variants of DNA, RNA, AAs and tRNA, water, and lipids and some simple bio-molecules could have been present. The dark variants of replication, transcription and translation would have been present from the beginning and would still provide the templates for these processes at the level of biochemistry.

Dark-dark pairing would rely on resonant frequency pairing by dark photons and dark-ordinary pairing to resonant energy pairing involving transformation of dark photon to ordinary photon. The direct pairing of basic biomolecules with their dark variants by resonance mechanism could have led to their selection explaining the puzzle of why so few biomolecules survived.

This is in contrast with the usual view in which the emergence of proteins would have required the emergence of translation machinery in turn requiring enzymes as catalyzers so that one ends up with hen-or-egg question: which came first, the translation machinery or proteins. In RNA life option similar problem emerges since RNA replication must be catalyzed by ribozymes.

5. Gradually DNA, RNA, tRNA, and AA would have emerged by pairing with their dark variants by resonance mechanism. The presence of lipid membranes could have been crucial in catalyzing this pairing. Later ribozymes could have catalyzed RNA replication by the above mentioned mechanism during RNA era: note however that the process could be only a shadow of much simpler replication for dark DNA. One can even imagine membrane RNAs as analogs of membrane proteins serving as receptors giving rise to ionic channels. Note however that in TGD framework membrane proteins could have emerged very early via their pairing with dark AA associated with the membrane. These membrane proteins and their RNA counterparts could have evolved into transcription and translation machineries.

DNA molecules would have emerged through pairing with dark DNA molecules. The difference between deoxy-ribose and ribose would correspond to the difference between dark RNA and dark DNA manifesting as different cyclotron frequencies and energies making possible the resonant pairing for frequencies and energies. Proteins would have emerged as those proteins able to pair resonantly with dark variants of amino-acid sequences without any pre-existing translational machinery. It is difficult to say in which order the basic biomolecules would have emerged. They could have emerged even simultaneously by resonant pairing with their dark variants.

The communication between dark ordinary variants of biomolecules involves resonance mechanism and would also involve genetic code represented as 3-chords, music of light, and it is interesting to see whether this model provides additional insights.

1. The proposal is that 3-chords assignable to nucleotides as music of light with allowed 64 chords defining what I have called bio-harmony is essential for the resonance [L116, L120, L115](see <http://tinyurl.com/ydhxen4g>, <http://tinyurl.com/yd5t82gq>, and <http://tinyurl.com/y9jxyjns>). The 3 frequencies must be identical in the resonance: this is like turning 3 knobs in radio. This 3-fold resonance would correspond to the analytic mode. The second mode could be holistic in the sense that it would involve only the sum only the sum of the 3 frequencies modulo octave equivalence assigning a melody to a sequence of 3-chords.
2. The proposal is that amino-acids having no triplet decomposition are holistic and couple to the sum of 3 frequencies assignable to tRNA and mRNA in this manner. Also the RNAs in

tRNA could couple to mRNA in this manner. One could perhaps say that tRNA, mRNA and amino-acids codons sing whereas DNA provides the accompaniment proceeding as 3-chords. The couplings of DNA nucleotides to RNA nucleotides would rely on the frequencies assignable to nucleotides.

3. If the sum of any 3 frequencies associated with mRNA codons is not the same except when the codons code for the same amino-acids, the representation of 3-chords with the sum of the notes is faithful. The frequencies to DNA and RNA nucleotides cannot be however independent of codons since the codons differing only by a permutation of letters would correspond to the same frequency and therefore code for the same amino-acid. Hence the information about the entire codon would be needed also in transcription and translation and could be provided either by dark DNA strand associated with DNA strand or by the interactions between the nucleotides of the DNA codon.
4. The DNA codon itself would know that it is associated with dark codon and the frequencies assignable to nucleotides could be determined by the dark DNA codon. It would be enough that the frequency of the letter depends on its position in the codon so that there would be 3 frequencies for every letter: 12 frequencies altogether.

What puts bells ringing is that this the number of notes in 12-note scale for which the model of bio-harmony [L31, L116] (see <http://tinyurl.com/yad4tqwl> and <http://tinyurl.com/ydhxen4g>) based on the fusion of icosahedral (12 vertices and 20 triangular faces) and tetrahedral geometries by gluing icosahedron and tetrahedron along one face, provides a model as Hamiltonian cycle and produces genetic code as a by-product. Different Hamiltonian cycles define different harmonies identified as correlates for molecular moods.

Does each DNA nucleotide respond to 3 different frequencies coding for its position in the codon and do the 4 nucleotides give rise to the 12 notes of 12-note scale? There are many choices for the triplets but a good guess is that the intervals between the notes of triplet are same and that fourth note added to the triplet would be the first one to realize octave equivalence. This gives uniquely  $CEG\sharp$ ,  $C\sharp FA$ ,  $DF\sharp Bb$ , and  $DG\sharp B$  as the triplets assignable to the nucleotides. The emergence of 12-note scale in this manner would be a new element in the model of bio-harmony.

There are  $4!=24$  options for the correspondence between  $\{A, T, C, G\}$  as the first letter and  $\{C, C\sharp, D, D\sharp\}$ . One can reduce this number by a simple argument.

- (a) Letters and their conjugates form pyrimidine-purine pairs  $T, A$  and  $C, G$ . The square of conjugation is identity transformation. The replacement of note with note defining at distance of half-octave satisfies this condition (half-octave - tritonus - was a cursed interval in ancient music and the sound of ambulance realizes it). Conjugation could correspond to a transformation of 3-chords defined as

$$CEG\sharp \leftrightarrow DF\sharp Bb \quad , \quad C\sharp FA \leftrightarrow D\sharp GB \quad .$$

- (b) One could have

$$\begin{aligned} \{T, C\} \leftrightarrow \{CEG\sharp, C\sharp FA\} \quad , \quad \{A, G\} \leftrightarrow \{DF\sharp Bb, D\sharp GB\} \quad , \\ \text{or} \\ \{T, C\} \leftrightarrow \{DF\sharp Bb, D\sharp GB\} \quad , \quad \{A, G\} \leftrightarrow \{CEG\sharp, C\sharp FA\} \quad . \end{aligned}$$

- (c) One can permute  $T$  and  $C$  and  $A$  and  $G$  in these correspondences. This leaves 8 alternative options. Fixing the order of the image of  $(T, C)$  to say  $(C, C\sharp)$  fixes the order of the image of  $(A, G)$  to  $(D, D\sharp)$  by the half-octave conjugation. This leaves 4 choices. Given the bio-harmony and having chosen one of these 4 options one could therefore check what given DNA sequence sounds as a sequence of 3-chords [L31].

That the position the frequency associated with the nucleotide depends on its position in the codon would also reflect the biochemistry of the codon and this kind of dependence would be natural. In particular, different frequencies associated with the first and third codon would reflect the parity breaking defining orientation for DNA.

### What disharmony could mean?

Harmonies - also those, which are sad (consider only passions of Bach) - are usually thought of as something beautiful. Could negative emotions really correspond to any bio-harmonies characterized by symmetries. In a discussion with Sini Kunnas I realized that also the notion of disharmony could make sense. There are indeed 6 Hamiltonian cycles without any symmetries [A7, A12, A5]. I neglected them in the model of harmony because they would represent which one might call disharmony. Could one of the contributing 3 Hamiltonian cycles in bio-harmony correspond to this kind of dis-harmony and bring in 20 3-chords without any symmetries? If so the relationship between geometry and aesthetics would become very concrete. The alternative view would be that there are several harmonies realized simultaneously and this creates disharmony.

The faces of the icosahedron belonging to the orbits of the symmetries of the harmony correspond to DNA codons coding for the same AA assignable to the orbit. The fact that there are no symmetries for these 6 bio-disharmonies, suggests one-to-one correspondence between DNA and AAs if also stop codon corresponds to ordinary AA.

### How to concretely realize emotions as music of light?

Music expresses emotions and also create higher level emotions. As all art, it also induces experience of beauty. Since  $h_{eff}/h = n$  [?, K78] serves as a kind of IQ in the evolutionary hierarchy, there are good reasons to expect that the emotions/feelings induced by music and other art forms are assignable to MB.

The dynamics of MB involves oscillations characterized by frequencies and in EEG frequencies are of key importance for the part of MB outside biological body. The communications from cell membrane to MB involve modulation of EEG frequencies identified as generalized Josephson frequencies by nerve pulse patterns [K86] and would define a coding of sensory data to higher level emotions. The control signals from MB via DNA inducing gene expression would use dark photons at cyclotron frequencies to control BB. How to realize the music of genes represented as sequences of 3-chords of dark light as a communication tool between dark and ordinary DNA/RNA and possibly even dark and ordinary variants of tRNA and amino-acids?

1. Communication between ordinary and dark matter levels must be possible. This is guaranteed if the transition energy spectra at different levels of  $h_{eff}/h = n$  hierarchy contain common transition energies so that a resonant interaction by exchange of dark photons becomes possible. This condition is extremely demanding and could explain why basic bio-molecules are selected amongst numerous alternatives [L110] - this is indeed one of the hen-egg problems of pre-biotic evolution.
2. A hypothesis worth of studying is that the cyclotron transition energies of both ordinary DNA and RNA nucleotides and their dark variants represented as dark proton sequences are same [L110]. Cyclotron transition energies should cover several octaves and the natural proposal is that magnetic field strength associated with the flux tube codes for the notes. In music experience roughly 10 octaves are needed corresponding to the range of audible sounds.
3. The cyclotron frequencies of DNA nucleotides A, T, C, G are very nearly the same and near 1 Hz for  $B = B_{end} = .2$  Gauss since their masses do not differ much. Since the nucleotides are negatively charged, also the cyclotron energies for codons and codon sequences are around 1 Hz.  $h_{eff} = h_{gr}$  hypothesis states that the cyclotron energies of DNA are in the energy range of bio-photons in visible and UV [K78, K14, K23] [L115].

There should be correspondences between a) the 64 ordinary DNA codons and allowed 3-chords and b) 64 dark variants of DNA codons and allowed 3-chords. These correspondences fix that between ordinary and dark codons. One would have triality.

1. To realize music of genes one the value of  $B$  must have values in a range of several octaves. The magnetic field strengths  $B$  associated with the flux tubes accompanying DNA strand should have a spectrum given by 12-note scale. Both 64 dark DNA codons and  $4^3 = 64$  ordinary DNA codons should correspond to  $20 + 20 + 20 + 4 = 64$  allowed 3-chords formed from the notes of 12-note scale.

2. Dark codons correspond to entangled states of 3 dark protons. The positions of dark protons are different so that permutations of the positions of dark protons are involved. The invariance of 3-chord under permutations of notes would correspond to fermionic statistics. These permutations are lifted to braidings if dark protons are connected by flux tubes to some other system, for instance ordinary DNA.

If the dark protons are ordered linearly along flux tube, it would seem that these positions correspond to those of ordinary code letters. This does not make sense. If the letters of codon are connected to the dark protons by flux tubes, the permutations of dark codons induce braiding of the flux tubes but do not affect the order of the letters of the ordinary codon. Braiding would become an essential part of the correspondence between ordinary and dark codons.

3. One should understand the correspondence of dark codons with the allowed 3-chords of a given harmony and also with the ordinary DNA codons. Bio-harmony is defined as a composite of 3 harmonies with 20 allowed 3-chords and having symmetries  $Z_6$ ,  $Z_4$ , and  $Z_2$  and of tetrahedral harmony with 4 chords. Tetrahedron can be regarded as disjoint object or attached to DNA, and this gives two variants of code.

How could these the icosahedron Hamilton cycles relate to the physical realization of dark proton triplets? Each icosahedron cycle should give rise to 20 dark proton triplets. Why the icosahedron geometry with Hamiltonian cycle should make itself manifest in the quantum physics of dark proton triplet?

4. Could icosahedron geometry quite concretely correspond to a tensor network? The vertices of the icosahedron would be connected by a sequence of flux tubes connecting nearest neighbors to form a Hamiltonian cycle. Dark proton triplets would quite concretely be localized at the triangular faces of the icosahedron.

Braided triplet of flux tubes would emerge from the vertices of an icosahedron triangle defining 3-chord and would connect it to the nucleotides of the corresponding ordinary DNA codon. Magnetic field strengths at these flux tubes would correspond to the notes of 12-note scale as defined by the Hamiltonian cycle in question. The permutations of the dark proton states at the vertices of the triangle would induce braidings of the flux tube triplet actually defining minimal braid in topological quantum computation (sic!) The braiding accompanying the states of 3 dark protons would make the correspondence with ordinary ordered DNA codons possible.

Note that each dark proton triplet could be also connected (without braiding) to its conjugate dark proton triplet by a triplet of flux tubes so that one would obtain closed flux loops and one could speak of knots instead of braids.

**Remark:** Braiding brings strongly in mind the many TGD inspired proposals for DNA as topological quantum computer [K4, K119]: maybe DNA as topological quantum computer could be (also?) realized in this manner.

What physical objects could the 20 vertices of icosahedron correspond to? Hydrogen bonded water clusters give rise to both tetrahedral and icosahedral structures. Could one associate dark proton triplets to the dark parts of these structures? Could one try to experimentally identify possible sequence of icosahedron water molecule clusters with vertices connected by hydrogen bonds associated with the DNA sequence? If the hydrogen bonds correspond to flux loops as suggested, they can be rather long (proportional to  $\hbar_{eff}/\hbar = n$ ) so that even distant water molecules can become hydrogen bonds and one could have a fractal hierarchy of icosahedra.

5. Resonance condition suggests that at the level of ordinary DNA double strand the cyclotron energies of dark protons associated with the hydrogen bonds connecting DNA nucleotides correspond to those of flux tube triplets connecting ordinary and dark DNA codons. The magnetic field strengths associated with the dark flux tubes accompanying hydrogen bonds would correspond to those associated with the triangles of icosahedron triangle. This would make possible communication between the two dark sectors by dark-photon triplets as music of genes.

This leaves unanswered questions.

1. Why the  $20+20+20=60$  3-chords from 3 harmonies with different icosahedral symmetries ( $Z_6, Z_4, Z_2$ ) and 4 chords from tetrahedral harmony would combine to form single bio-harmony with 64 chords? This requires the presence of 3 Hamiltonian cycles with different symmetries. Why all three different symmetry types for DNA and RNA? Could the 20 amino-acids correspond to single symmetry type? Could tRNA codons correspond to two symmetry types?
2. How the 3-chords of dark photons could be played? 3-chord should be a collective effect affecting both dark and ordinary codon by inducing emission of 3-photon state like - like playing a chord by string instrument. The notes of the light chord need not emerge simultaneously but as arpeggios. Could there be a pulse travelling along the Hamiltonian cycle and picking all the cyclotron notes at the vertices containing dark proton and sending a cyclotron signal along flux tubes to ordinary DNA codon. This pulse would travel along dark DNA and play the music defined by dark DNA sequence.

### 6.5.3 Can one imagine a modification of bio-harmony?

The model for how one can understand how 12-note scale can represent 64 genetic codons has the basic property that each note belongs to 16 chords. The reason is that there are 3 disjoint sets of notes and given 3-chord is obtained by taking 1 note from each set. For bio-harmony obtained as union of 3 icosahedral harmonies and tetrahedral harmony note typically belongs to 15 chords. The representation in terms of frequencies requires 16 chords per note.

If one wants consistency one must somehow modify the model of icosahedral harmony. The necessity to introduce tetrahedron for one of the 3 fused harmonies is indeed an ugly looking feature of the model. The question is whether one of the harmonies could be replaced with some other harmony with 12 notes and 24 chords. If this would work one would have 64 chords equal to the number of genetic codons and  $5+5+6=16$  chords per note. The addition of tetrahedron would not be needed.

One can imagine toric variants of icosahedral harmonies realized in terms of Hamiltonian cycles and one indeed obtains a toric harmony with 12 notes and 24 3-chords. Bio-harmony could correspond to the fusion of 2 icosahedral harmonies with 20 chords and toric harmony with 24 chords having therefore 64 chords. Whether the predictions for the numbers of codons coding for given amino-acids come out correctly for some choices of Hamiltonian cycles is still unclear. This would require an explicit construction of toric Hamiltonian cycles.

### Previous results

Before discussing the possible role of toric harmonies some previous results will be summarized.

#### 1. Icosahedral bio-harmonies

The model of bio-harmony [L31, L123] starts from a model for music harmony as a Hamiltonian cycle at icosahedron having 12 vertices identified as 12 notes and 20 triangular faces defining the allowed chords of the harmony. The identification is determined by a Hamiltonian cycle going once through each vertex of icosahedron and consisting of edges of the icosahedral tessellation of sphere (analog of lattice): each edge corresponds to quint that is scaling of the frequency of the note by factor  $3/2$  (or by factor  $2^{7/12}$  in well-tempered scale). This identification assigns to each triangle of the icosahedron a 3-chord. The 20 faces of icosahedron define therefore the allowed 3-chords of the harmony. There exists quite a large number of icosahedral Hamiltonian cycles and thus harmonies.

The fact that the number of chords is 20 - the number of amino-acids - leads to the question whether one might somehow understand genetic code and 64 DNA codons in this framework. By combining 3 icosahedral harmonies with different symmetry groups identified as subgroups of the icosahedral group, one obtains harmonies with 60 3-chords.

The DNA codons coding for given amino-acid are identified as triangles (3-chords) at the orbit of triangle representing the amino-acid under the symmetry group of the Hamiltonian cycle.

The predictions for the numbers of DNAs coding given amino-acid are highly suggestive for the vertebrate genetic code.

By gluing to the icosahedron tetrahedron along common face one obtains 4 more codons and two slightly different codes are the outcome. Also the 2 amino-acids Pyl and Sec can be understood. One can also regard the tetrahedral 4 chord harmony as additional harmony so that one would have fusion of four harmonies. One can of course criticize the addition of tetrahedron as a dirty trick to get genetic code.

The explicit study of the chords of bio-harmony however shows that the chords do not contain the 3-chords of the standard harmonies familiar from classical music (say major and minor scale and corresponding chords). Garage band experimentation with random sequences of chords requiring conservability that two subsequent chords have at least one common note however shows that these harmonies are - at least to my opinion - aesthetically feasible although somewhat boring.

## 2. Explanation for the number 12 of notes of 12-note scale

One also ends up to an argument explaining the number 12 for the notes of the 12-note scale [L123]. There is also second representation of genetic code provided by dark proton triplets. The dark proton triplets representing dark genetic codons are in one-one correspondence with ordinary DNA codons. Also amino-acids, RNA and tRNA have analogs as states of 3 dark protons. The number of tRNAs is predicted to be 40.

The dark codons represent entangled states of protons and one cannot decompose them into a product state. The only manner to assign to the 3-chord representing the triplet ordinary DNA codon such that each letter in  $\{A, T, C, G\}$  corresponds to a frequency is to assume that the frequency depends on the position of the letter in the codon. One has altogether  $3 \times 4 = 12$  frequencies corresponding to 3 positions for given letter selected from four letters.

Without additional conditions any decomposition of 12 notes of the scale to 3 disjoint groups of 4 notes is possible and possible chords are obtained by choosing one note from each group. The most symmetric choice assigns to the 4 letters the notes  $\{C, C\sharp, D, D\sharp\}$  in the first position,  $\{E, F, F\sharp, G\}$  in the second position, and  $\{G\sharp, A, B\flat, B\}$  in the third position. The codons of type XXX would correspond to  $CEG\sharp$  or its transpose. One can transpose this proposal and there are 4 non-equivalent transposes, which could be seen as analogs of music keys.

**Remark:**  $CEG\sharp$  between C-major and A-minor very often finishes finnish tango: something neither sad nor glad!

One can look what kind of chords one obtains.

1. Chords containing notes associated with the same position in codon are not possible.
2. Given note belongs to 6 chords. In the icosahedral harmony with 20 chords given note belongs to 5 chords (there are 5 triangles containing given vertex). Therefore the harmony in question cannot be equivalent with 20-chord icosahedral harmony. Neither can the bio-harmony with 64 chords satisfy the condition that given note is contained by 6 3-chords.
3. First and second notes of the chords are separated by at least major third as also those second and third notes. The chords satisfy however octave equivalence so that the distance between the first and third notes can be smaller - even half step - and one finds that one can get the basic chords A-minor scale: Am, Dm, E7, and also G and F. Also the basic chords of F-major scale can be represented. Also the transposes of these scales by 2 whole steps can be represented so that one obtains  $A_m, C\sharp_m, F_m$  and corresponding major scales. These harmonies could allow the harmonies of classical and popular music.

These observations encourage to ask whether a representation of the new harmonies as Hamiltonian cycles of some tessellation could exist. The tessellation should be such that 6 triangles meet at given vertex. Triangular tessellation of torus having interpretation in terms of a planar parallelogram (or perhaps more general planar region) with edges at the boundary suitable identified to obtain torus topology seems to be the natural option. Clearly this region would correspond to a planar lattice with periodic boundary conditions.

### Is it possible to have toric harmonies?

The basic question is whether one can have a representation of the new candidate for harmonies in terms of a tessellation of torus having  $V = 12$  vertices and  $F = 20$  triangular faces. The reading of the article “Equivelar maps on the torus” [A23] (see <http://tinyurl.com/ya6g9kwe>) discussing toric tessellations makes clear that this is impossible. One however have  $(V, F) = (12, 24)$  (see <http://tinyurl.com/y7xfomc>). A rather promising realization of the genetic code in terms of bio-harmony would be as a fusion of two icosahedral harmonies and toric harmony with  $(V, F) = (12, 24)$ . This in principle allows also to have 24 3-chords which can realize classical harmony (major/minor scale).

1. The local properties of the tessellations for any topology are characterized by a pair  $(m, n)$  of positive integers.  $m$  is the number of edges meeting in given vertex (valence) and  $n$  is the number of edges and vertices for the face. Now one has  $(m, n) = (6, 3)$ . The dual of this tessellation is hexagonal tessellation  $(m, n) = (3, 6)$  obtained by defining vertices as centers of the triangles so that faces become vertices and vice versa.
2. The rule  $V - E + F = 2(1 - g) - h$ , where  $V$ ,  $E$  and  $F$  are the numbers of vertices, edges, and faces, relates  $V - E - F$  to the topology of the graph, which in the recent case is triangular tessellation.  $g$  is the genus of the surface at which the triangulation is im eded and  $h$  is the number of holes in it. In case of torus one would have  $E = V + F$  giving in the recent case  $E = 36$  for  $(V, F) = (12, 24)$  (see <http://tinyurl.com/y7xfomc>) whereas in the icosahedral case one has  $E = 32$ .
3. This kind of tessellations are obtained by applying periodic boundary conditions to triangular lattices in plane defining parallelogram. The intuitive expectation is that this lattices can be labelled by two integers  $(m, n)$  characterizing the lengths of the sides of the parallelogram plus angle between two sides: this angle defines the conformal equivalence class of torus. One can also introduce two unit vectors  $e_1$  and  $e_2$  characterizing the conformal equivalence class of torus.

Second naïve expectation is that  $m \times n \times \sin(\theta)$  represents the area of the parallelogram.  $\sin(\theta)$  equals to the length of the exterior product  $|e_1 \times e_2| = \sin(\theta)$  representing twice the area of the triangle so that there would be  $2m \times n$  triangular faces. The division of the planar lattice by group generated by  $pe_1 + qe_2$  defines boundary conditions. Besides this the rotation group  $Z_6$  acts as analog for the symmetries of a unit cell in lattice. This naïve expectation need not of course be strictly correct.

4. As noticed, it is not possible to have triangular toric tessellations with  $(V, E, F) = (12, 30, 20)$ . Torus however has a triangular tessellation with  $(V, E, F) = (12, 36, 24)$ . An illustration of the tessellation can be found at <http://tinyurl.com/y7xfomc>. It allows to count visually the numbers  $V, E, F$ , and the identifications of the boundary edges and vertices. With good visual imagination one might even try to guess what Hamiltonian cycles look like.

The triangular tessellations and their hexagonal duals are characterized partially by a pair of integers  $(a, b)$  and  $(b, a)$ .  $a$  and  $b$  must both even or odd (see <http://tinyurl.com/y7xfomc>). The number of faces is  $F = (a^2 + 3b^2)/2$ . For  $(a, b) = (6, 2)$  one indeed has  $V = 12$  and  $F = 24$ . From the article [A23] (see <http://tinyurl.com/ya6g9kwe>) one learns that the number of triangles satisfies  $F = 2V$  for  $p = q$  at least. If  $F = 2V$  holds true more generally one has  $V = (a^2 + 3b^2)/4$ , giving a tight constraints on  $a$  and  $b$ .

**Remark:** The conventions for the labelling of torus tessellation vary. The above convention based on integers  $(a, b)$  used in the illustrations at <http://tinyurl.com/y7xfomc> is different from the convention based on integer pair  $(p, q)$  used in [A23]. In this notation torus tessellation with  $(V, F) = (12, 24)$  corresponds to  $(p, q) = (2, 2)$  instead of  $(a, b) = (6, 2)$ . This requires  $(a, b) = (3p, q)$ . With these conventions one has  $V = p^2 + q^2 + pq$ .

1. *The number of triangles in the 12-vertex tessellation is 24: curse or blessing?*

One could see as a problem that one has  $F = 24 > 20$ ? Or is this a problem?

1. By fusing two icosahedral harmonies and one toric harmony one would obtain a harmony with  $20+20+24=64$  chords, the number of DNA codons! One would replace the fusion of 3 icosahedral harmonies and tetrahedral harmony with a fusion of 2 icosahedral harmonies and toric harmony. Icosahedral symmetry with toric symmetry associated with the third harmony would be replaced with a smaller toric symmetry. Note however that the attachment of tetrahedron to a fixed icosahedral face also breaks icosahedral symmetry.

This raises questions. Could the presence of the toric harmony somehow relate to the almost exact  $U \leftrightarrow C$  and  $A \leftrightarrow G$  symmetries of the third letter of codons. This does not of course mean that one could associated the toric harmony with the third letter. Note that in the ico-tetra model the three harmonies are assumed to have no common chords. Same non-trivial assumption is needed also now in order to obtain 64 codons.

2. What about the number of amino-acids: could it be 24 corresponding ordinary aminoacids, stopping sign plus 3 additional exotic amino-acids. The 20 icosahedral triangles can corresponds to amino-acids but not to stopping sign. Could it be that one of the additional codons in 24 corresponds to stopping sign and two exotic amino-acids Pyl and Sec appearing in biosystems explained by the icosahedral model in terms of a variant of the genetic code. There indeed exists even third exotic amino-acid! N-formylmethionine (see <http://tinyurl.com/jsphvgt>) but is usually regarded as as a form of methionine rather than as a separate proteinogenic amino-acid.
3. Recall that the problem related to the ico-tetra harmony is that it does not contains the chords of what might be called classical harmonies (the chords assignable to major and minor scales). If 24 chords of bio-harmony correspond to toric harmony, one could obtain these chords if the chords in question are chords obtainable by the proposed construction.

But is this construction consistent with the representation of 64 chords by taking to each chord one note from 3 disjoint groups of 4 notes in which each note belongs to 16 chords. The maximum number of chords that note can belong to would be  $5+5+6=16$  as desired. If there are no common chords between the 3 harmonies the conditions is satisfied. Using for instance 3 toric representations the number would be  $6+6+6=18$  and would require dropping some chords.

4. The earlier model for tRNA as fusion of two icosahedral codes predicting  $20+20=40$  tRNA codons. Now tRNAs as fusion of two harmonies allows two basic options depending on whether both harmonies are icosahedral or whether second harmony is toric. These options would give  $20+20=40$  or  $20+24=44$  tRNAs. Wikipedia tells that maximum number is 41. Some sources however tell that there are 20-40 different tRNAs in bacterial cells and as many as 50-100 in plant and animal cells.

## 2. A more detailed model for toric harmonies

One can consider also more detailed model for toric harmonies.

1. The above discussed representation in terms of frequencies assigned with nucleotides depending on their position requires the decomposition of the notes to 3 disjoint groups of 4 notes. This means decomposition of 12 vertices of Hamiltonian cycle to 4 disjoint groups such that within given group the distances between the members of group are larger than one unit so that they cannot belong to same triangle. There are  $Bin(12, 4) \times Bin(8, 4)$  decomposition to 3 disjoint groups of for vertices, where  $Bin(n, k) = n!/(n-k)!k!$  is binomial coefficient.
2. Once the Hamiltonian cycle has been fixed and is one assumes that single step along cycle corresponds to quint, one knows what the notes associated with each vertex is and given the note of the 12-note scale one knows the number  $0 \leq n < 12$  of quint steps needed to obtain it. For instance, for the proposed grouping  $\{C, C\sharp, D, D\sharp\}$  and its two transposes by 2 hole steps one can assign 4 integers to each group. The condition is that within each group the notes labelled by the integers have minimum distance of 2 units between themselves.
3. One could try to understand the situation in terms of the symmetries of the system.



- (a) Could the triplet  $\{C, E, G\sharp\}$  and its four translates be interpreted as  $Z_3$  orbits. Could suitable chosen members from 4 disjoint quartets quite general form  $Z_3$  orbits.

**Remark:** Particle physicists notes the analogy with 4 color triplets formed by u and d quarks having spin 1/2.  $Z_4$  would correspond to spin and color spin and  $Z_3$  to color.

- (b)  $Z_4$  acts as symmetries of the tessellation considered and these symmetries respect distances so that their action on a quartet with members having mutual distances larger than unit creates new such quartet. Could the triplet  $\{C, E, G\sharp\}$  and its four translates by an  $n$ -multiple of half note,  $n = 0, 1, 2, 3$  correspond to an orbit  $Z_4$ ?

Could the groups of 4 notes quite generally correspond to the orbits of  $Z_4$ ? This can be true only if the action of non-trivial  $Z_4$  elements relates only vertices with distance larger than one unit.

4. The group of isometries of the toric triangulation acts as symmetries.  $Z_{24} = Z_6 \times Z_4$  is a good candidate for this group.  $Z_6$  corresponds to the rotations of around given point of triangulation and should leave the tessellation invariant. The orbit of given triangle defining the set of DNA codons coding the amino-acid represented by the orbit would correspond to orbit of subgroups of  $Z_{24}$ . Only orbits containing orbits containing 1, 2, 3, 4 or 6 triangles are allowed by the degeneracies of the genetic code. These numbers would correspond to degeneracies that is the numbers of codons coding for given amino-acid. All these numbers appear as degeneracies.

### 3. What one can say about toric Hamiltonian cycles?

First some basic notions are in order. The graph is said to be equivelar if it is a triangulation of a surface meaning that it has 6 edges emanating from each vertex and each face has 3 vertices and 3 edges [A23]. Equivelarity is equivalent with the following conditions;

1. Every vertex is 6-valent.
2. The edge graph is 6-connected.
3. The graph has vertex transitive automorphism group.
4. The graph can be obtained as a quotient of the universal covering tessellation (3,6) by a sublattice (subgroup of translation group). 6-connectedness means that one can decompose the tessellation into two disconnected pieces by removing 6 or more vertices
5. Edge graph is  $n$ -connected if the elimination of  $k < n$  vertices leaves it connected. It is known that every 5-connected triangulation of torus is Hamiltonian [A39] (see <http://tinyurl.com/y7cartk2>). Therefore also 6-connected  $(6, 3)_{p=2, q=2}$  tessellation has Hamiltonian cycles.
6. The Hamiltonian cycles for the dual tessellation are not in any sense duals of those for the tessellation. For instance, in the case of dodecahedron there is unique Hamiltonian cycle and for icosahedron has large number of cycles. Also in the case of  $(6, 3)$  tessellations the duals have different Hamilton cycles. In fact, the problem of constructing the Hamiltonian cycles is NP complete.

Can one say anything about the number of Hamiltonian cycles?

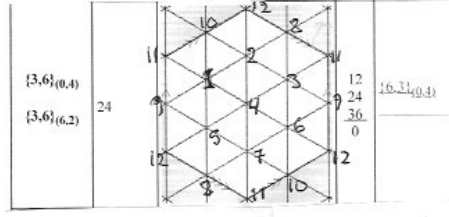
1. For dodecahedron only 3 edges emanates from a given vertex and there is only one Hamiltonian cycle. For icosahedron 5 edges emanate from given vertex and the number of cycles is rather large. Hence the valence and also closely related notion of  $n$ -connectedness are essential for the existence of Hamilton's cycles. For instance, for a graph consisting of two connected graphs connected by single edge, there exist no Hamilton's cycles. For toric triangulations one has as many as 6 edges from given vertex and this favors the formation of a large number of Hamiltonian cycles.

2. Curves on torus are labelled by winding numbers  $(M, N)$  telling the homology equivalence class of the cycle.  $M$  and  $N$  can be any integers. Curve winds  $M$  ( $N$ ) times around the circle defining the first (second) equivalence homology equivalence class. Also Hamiltonian cycles are characterized by their homology equivalence class, that is pair  $(M, N)$  of integers. Since there are only  $V = 12$  points, the numbers  $(M, N)$  are finite. By periodic boundary conditions means that the translations by multiples of  $2e_1 + 2e_2$  do not affect the tessellation (one can see what this means geometrically from the illustration at <http://tinyurl.com/y7xfmc>). Does this mean that  $(M, N)$  belongs to  $Z_2 \times Z_2$  so that one would have 4 homologically non-equivalent paths.

Are all four homology classes realized as Hamiltonian cycles? Does given homology class contain several representatives or only single one in which case one would have 20 non-equivalent Hamiltonian cycles?

It turned out that there exist programs coding for an algorithm for finding whether given graph (much more general than tessellation) has Hamiltonian cycles. Having told to Jebin Larosh about the problem, he sent within five minutes a link to a Java algorithm allowing to show whether a given graph is Hamiltonian (see <http://tinyurl.com/y7y9tr5t>): sincere thanks to Jebin! By a suitable modification this algorithm find all Hamiltonian cycles.

1. The number  $N_H$  of Hamiltonian cycles is expected to be rather large for a torus triangulation with 12 vertices and 24 triangles and it is indeed so:  $N_H = 27816!$  The image of the tessellation and the numbering of its vertices are described in figure below (see **Fig. 6.1**). Incide matrix  $A$  characterizes the graph: if vertices  $i$  and  $j$  are connected by edge, one has  $A_{ij} = A_{ji} = 1$ , otherwise  $A_{ij} = A_{ji} = 0$  and is used as data in the algorithm finding the Hamiltonian cycles.



**Figure 6.1:** The number of the vertices of  $(V, F) = (12, 24)$  torus tessellation allowing path  $(0, 1, 2, 3, 4, 6, 5, 8, 10, 7, 11, 9, 0)$  as one particular Hamiltonian cycle.

The cycles related by the isometries of torus tessellation are however equivalent. The guess is that the group of isometries is  $G = Z_{2,refl} \rtimes (Z_{4,tr} \rtimes Z_{n,rot})$ .  $Z_{n,rot}$  is a subgroup of local  $Z_{6,rot}$ . A priori  $n \in \{1, 2, 3, 6\}$  is allowed.

On basis of [A23] I have understood that one has  $n = 3$  but that one can express the local action of  $Z_{6,rot}$  as the action of the semidirect product  $Z_{2,refl} \times Z_{3,rot}$  at a point of tessellation (see <http://tinyurl.com/ya6g9kwe>). The identity of the global actions  $Z_{2,refl} \times Z_{3,rot}$  and  $Z_{6,rot}$  does not look feasible to me. Therefore  $G = Z_{2,refl} \rtimes (Z_{4,tr} \rtimes Z_{3,rot})$  with order  $ord(G) = 24$  will be assumed in the following (note that for icosahedral tessellation one has  $ord(G) = 120$  so that there is symmetry breaking).

$Z_4$  would have as generators the translations  $e_1$  and  $e_2$  defining the conformal equivalence class of torus. The multiples of  $2(e_1 + e_2)$  would leave the tessellation invariant. If these arguments are correct, the number of isometry equivalence classes of cycles would satisfy  $N_{H,I} \geq N_H/24 = 1159$ .

2. The actual number is obtained as sum of cycles characterized by groups  $H \subset Z_{12}$  leaving the cycle invariant and one can write  $N_{H,I} = \sum_H (ord(H)/ord(G)) N_0(H)$ , where  $N_0(H)$  is the number of cycles invariant under  $H$ .

What can one say about the symmetry group  $H$  for the cycle?

1. Suppose that the isometry group  $G$  leaving the tessellation invariant decomposes into semi-direct product  $G = Z_{2,refl} \rtimes (Z_{4,tr} \rtimes Z_{3,rot})$ , where  $Z_{3,rot}$  leaves invariant the starting point of the cycle. The group  $H$  decomposes into a semi-direct product  $H = Z_{2,refl} \rtimes (Z_{m,tr} \times Z_{3,rot})$  as subgroup of  $G = Z_{2,refl} \rtimes (Z_{4,tr} \times Z_{3,rot})$ .
2.  $Z_{n,rot}$  associated with the starting point of cycle must leave the cycle invariant at each point. Applied to the starting point, the action of  $H$ , if non-trivial - that is  $Z_{3,rot}$ , must transform the outgoing edge to incoming edge. This is not possible since  $Z_3$  has no idempotent elements so that one can have only  $n = 1$ . This gives  $H = Z_{2,refl} \rtimes (Z_{m,tr})$ .  $m = 1, 2$  and  $m = 4$  are possible.
3. Should one require that the action of  $H$  leaves invariant the starting point defining the scale associated with the harmony? If this is the case, then only the group  $H = Z_{2,refl}$  would remain and invariance under  $Z_{refl}$  would mean invariance under reflection with respect to the axis defined by  $e_1$  or  $e_2$ . The orbit of triangle under  $Z_{2,refl}$  would consist of 2 triangles always and one would obtain 12 codon doublets instead of 10 as in the case of icosahedral code.

If this argument is correct, the possible symmetry groups  $H$  would be  $Z_0$  and  $Z_{2,refl}$ . For icosahedral code both  $Z_{rot}$  and  $Z_{2,refl}$  occur but  $Z_{2,refl}$  does not occur as a non-trivial factor of  $H$  in this case.

The almost exact  $U \leftrightarrow C$  and  $A \leftrightarrow G$  symmetry of the genetic code would naturally correspond to  $Z_{2,refl}$  symmetry. Therefore the predictions need not change from those of the icosahedral model except that the 4 additional codons emerge more naturally. The predictions would be also essentially unique.

4. If  $H$  is trivial  $Z_1$ , the cycle would have no symmetries and the orbits of triangles would contain only one triangle and the correspondence between DNA codons and amino-acids would be one-to-one. One would speak of disharmony. Icosahedral Hamiltonian cycles can also be of this kind. If they are realized in the genetic code, the almost exact  $U \leftrightarrow C$  and  $A \leftrightarrow G$  symmetry is lost and the degeneracies of codons assignable to 20+20 icosahedral codons increase by one unit so that one obtains for instance degeneracy 7 instead of 6 not realized in Nature.

What can one say about the character of toric harmonies on basis of this picture.

1. It has been already found that the proposal involving three disjoint quartets of subsequent notes can reproduce the basic chords of basic major and minor harmonies. The challenge is to prove that it can be assigned to some Hamiltonian cycle(s). The proposal is that the quartets are obtained by  $Z_{rot}^3$  symmetry from each other and that the notes of each quartet are obtained by  $Z_{4,tr}$  symmetry.
2. A key observation is that classical harmonies involve chords containing 1 quint but not 2 or no quints at all. The number of chords in torus harmonies is  $24 = 2 \times 12$  and twice the number of notes. The number of intervals in turn is 36, 3 times the number of the notes. This allows a situation in which each triangle contains one edge of the Hamiltonian cycle so that all 3-chords indeed have exactly one quint.
3. By the above argument harmony possesses  $Z_2$  symmetry or no symmetry at all and one has 12 codon doublets. For these harmonies each edge of cycle is shared by two neighboring triangles containing the same quint. A possible identification is as major and minor chords with same quint. The changing of the direction of the scale and the reflection with respect to the edges the Hamiltonian cycle would transforms major chords and minor chords along it to each other and change the mood from glad to sad and vice versa.

The proposed harmony indeed contains classical chords with one quint per chord and for  $F, A, C^\sharp$  both minor and major chords are possible. There are 4 transposes of this harmony.

4. Also Hamiltonian cycles for which  $n$  triangles contain two edges of Hamiltonian path ( $CGD$  type chords) and  $n$  triangles contain no edges. This situation is less symmetric and could correspond to a situation without any symmetry at all.
5. One can ask whether the classical harmonies corresponds to 24 codons assignable to the toric harmony and to the 24 amino-acids being thus realizable using only amino-acids. If so, the two icosahedral harmonies would represent kind of non-classical exotics.

### Appendix: Some facts about toric tessellations

Genus  $g = 1$  (torus) is unique in that it allows infinite number of tessellations as analogs of planar lattices with periodic boundary conditions.  $g = 0$  allows only Platonic solids as tessellations and  $g > 1$  allows very few tessellations. The article [A23] gives a nice review about toric tessellations.

1. Toric tessellations correspond to tessellations of plane by periodic boundary conditions. Torus tessellation allows a universal covering identifiable as counterpart of infinite lattice in plane. There are infinite number of coverings of given tessellation labelled by two integers  $(m, n)$  since the homology group of torus is  $Z \times Z$ . The tessellation is obtained by dividing  $Z \times Z$  by its normal subgroup. Also the rotation group  $Z_6$  acts as group leaving the tessellation invariant and correspond to the rotation leaving invariant the lattice cell consisting of 6 vertices around given vertex.
2. The tessellation is called decomposable if there is a  $k$ -sheeted covering map (map corresponds to a collection of charts) characterized by the subgroup of the isometries of the covering of the tessellation which corresponds to a sub-tessellation. This subgroup is characterized by a pair  $(p, q)$  of integers being generated by the translation  $pe_1 + qe_2$  and  $2\pi/6$  rotation. The unit vectors can be chosen to be  $e_1 = (1, 0)$  and  $e_2 = (1, \sqrt{3})/2$  for triangular tessellation (presumably this tessellation is regular tessellation with the conformal equivalence class of torus fixed by the angle between  $e_1$  and  $e_2$ ). Line reflection transforms  $(3, 6)_{p,q}$  to  $(3, 6)_{q,p}$  (see Fig 1 of <http://tinyurl.com/ya6g9kwe>). The tessellation is invariant under reflections - regular - if  $pq(p - q) = 0$ . The peculiar looking form of the conditions follows from the identity  $(3, 6)_{q,p} = (3, 6)_{p+q, -q}$  (also  $p = 0$  or  $q = 0$  is possible) Note that the tessellation  $(3, 6)_{2,2}$  is invariant under reflection and thus non-chiral.
3. The number  $V$  of vertices of the triangular tessellation is given by  $V = p^2 + q^2 + pq$ . The regular tessellation  $(p, q) = (2, 2)$  has 12 vertices and is the interesting one in the recent case. It is the smallest regular tessellation. For given  $(p, q)$  one can have several non-equivalent pairs  $(p, q)$  defining combinatorially non-equivalent tessellations. My interpretation is that they correspond to different conformal equivalence classes for torus: the intuitive expectation is that this should not affect the topology of tessellation nor Hamiltonian cycles. For  $(6, 3)_{p,q} = (6, 3)_{2,2}$  with  $s$  ( $V = 12, F = 24$ ) there are  $1+6=7$  combinatorially non-equivalent tessellations: one non-chiral and 6 chiral ones.

Quite generally, the tessellations with  $V$  vertices with  $V \bmod 4 = 0$  (as in the case of  $V = 12$ ) allow one map (chart consisting of faces) with isotropy group of order 2 and 6 maps with isotropy group of order 4. These variants are labelled by an  $SL(2, Z)$  matrix  $(a, b; 0, c)$  with determinant equal to  $V = ac$ . For  $V = 12$  one has decompositions  $12 = 1 \times 12$ ,  $12 = 2 \times 6$ ,  $12 = 3 \times 4$ .  $-c < b < a - c$  is unique modulo  $a$ . In the recent case one has  $ac = 12$  allowing  $(a, c) \in \{(1, 12), (2, 6), (3, 4)\}$  and pairs obtained by permuting  $a$  and  $c$ . These matrices need not define combinatorially different tessellations since modular transformations generate equivalent matrices.

### 6.5.4 Icosa-tetrahedral and icosadodecahedral bioharmonies as candidates for genetic code

Both the icosatetrahedral [L31] and icosadodecahedral harmony to be discussed below can be considered as candidates for bio-harmony as also the harmony involving fusion of 2 icosahedral harmonies and toric harmony [L112]. The basic reason is that the third harmony corresponds to doublets. One cannot exclude the possibility of several equivalent representations of the code.

### Icosa-tetrahedral harmony

Icosahedral harmonies can be characterized by a subgroup of icosahedral isometries  $A_5$  having 60 elements. If reflections are included the isometry group, one as  $A_5 \times Z_2$  with 120 elements. The group of symmetries is  $Z_6, Z_4$ , or  $Z_2$ . There are two choices for  $Z_2$  and the interpretation has been that  $Z_2$  correspond to either reflection or rotation by  $\pi$ .  $A_5$  however allows also  $Z_2 \times Z_2$  as subgroup. AAs correspond to orbits of the symmetry group and DNA codons coding for the AA correspond to triangles (3-chords) at the orbit. In purely icosahedral model one obtains 20+20+20 codons. A fusion with tetrahedral harmony gives 64 codons.

1.  $Z_6$  gives rise to 3 AAs coded by 6 codons each (leu,se,arg) and 2 AAs coded by 2 codons: the choice of the doublet would require additional conditions. One option is ile doublet.
2. Depending on whether one includes reflection or not, one can have either  $Z_4 \subset A_5$  ( $60 = 4 \times 15$ ) or  $Z_4 = Z_{2,rot} \times Z_2 \subset A_5 \times Z_2$ . I have assumed that  $Z_4 = Z_{2,rot} \times Z_2$  but the recent argument suggests the first option. This does not have any implications for the earlier model. Icosahedral  $Z_4$  gives rise to 5 AAs coded by 4 codons each ( $5 \times 4 = 20$ ). This leaves 11 AAs and 3 "empty" AA formally coded by stop codons.
3. Icosahedral  $Z_2$  gives rise to 10 doublets. These 4-plets would correspond to (phe, tyr, his, gln, asn, lys, asp, glu, cys, stop-doublet) This leaves (stop,trp) double and (ile,met) doublet with broken  $Z_2$  symmetry.

The fusion with tetrahedral code with 4- codons and 4 AAs should explain these 4 AAs. Tetrahedral isometries form group  $S_3$  and reduce to group  $Z_3$  for tetrahedral cycle.

- (a) One could argue that ile-triplet and met correspond to 3-element orbits with 1-element orbit. (stop,trp) would be formed by  $Z_2$  symmetry breaking from trp doublet and there is no obvious mechanism for this.
- (b) If one tetrahedral face is fixed as a face shared with icosahedron, the symmetry group of tetrahedral cycle reduces to  $Z_1$ . This would give 4 singlets identifiable as (ile,met) and (stop,trp) symmetry broken doubles. Since ile appears also in doublet, tetrahedral 1-orbit and icosahedral 2-orbit must have a common doubled triangle identifiable as the common face of icosahedron and tetrahedron. The doubling of the common triangle replaces ile-doublet with ile-triplet. This option looks rather reasonable.

### Dodecahedral harmony

Dodecahedral harmony correspond to the unique Hamilton cycle at dodecahedron. Dodecahedral harmony as 20 notes and 12 5-chords. If one assumes that the octave divides to 20 notes, this brings in mind "eastern" view about harmony.

The obvious objection against dodecahedral harmony is that dodecahedral faces are pentagons so that dodecahedral chords would be 5- rather than 3-chords so that the correspondence between chords and DNA codons would be lost. The situation changes if 3 notes - 3-chord - determine the 5-chord completely and one can assign a unique 3-chord to each pentagon. This is indeed the case!

1. 3-edges meet in every dodecahedral vertex (this makes the dodecahedral cycle unique apart from rotations) and each edge pair in the vertex belongs to same pentagon (in the case of icosahedron there are 5 edges per vertex so that this is not true). Therefore each pentagon must contain at least 2 edges of Hamilton's cycle.

The cycle must visit all vertices of pentagon, and the visit to the vertex means that the cycle shares at least one edge with pentagon. Since all vertices of the pentagon must be visited, there are two options. For option a) given pentagon shares with the cycle disjoint 2-edge with 3 vertices and 1-edge with two vertices. For option b) the pentagon shares with the cycle 4-edge with 5 vertices.

2. The numbers  $n_a$  of pentagons with 4-edges and  $n_b = 12 - n_a$  2-edge+ 1-edge (making 3 edges) can be deduced easily. Cycle has 20 edges. Pentagon of type a) shares 3 edges with

the cycle and the edge is shared by 2 pentagons. This gives  $3n_a/2$  edges. Pentagon of type b) shares 4 edges with the cycle. This gives  $2n_b = 2(12 - n_a)$  edges. The total number of edges is  $3n_a/2 + 2n_b = 20$ , which gives  $n_a = 8$  and  $n_b = 4$ . Dodecahedral Hamilton's cycle can be found from web (see <http://tinyurl.com/y5woajcb>). The structure is as deduced here.

For case a) the 3-chords correspond naturally to the 3 vertices of the 2-edge shared with the cycle. Therefore it is possible to assign unique 3-chords to the dodecahedral harmony and to obtain connection with codons in this case. One however obtains also 12 2-chords: could they have some genetic counterpart?

What about 5-chords for pentagons of type b)? Hamiltonian cycle can be oriented and this induces orientation of the pentagons. One can say that the first vertex in the 4-edge is the vertex at which cycle arrives to the pentagon and identify the 3-chord as the first three vertices. It turns out that for the replacement of quint cycle this is not actually necessary.

### Is icoa-dodecahedral harmony consistent with the genetic code?

One must check whether icoa-dodecahedral harmony is consistent with the degeneracies of the genetic code.

1. A fusion of 2 icosahedral harmonies and 2 copies of dodecahedral harmony would be in question. As in the case of icosahedral harmony already discussed, the two icosahedral harmonies would have symmetry groups  $Z_6$  and  $Z_4$  and give the codons coding for 3 6-plets and 1 doublet + 5 4-plets + two copies of dodecahedral harmony.
2. Can the model predict correctly the numbers of codons coding for AAs? It is known that dodecahedral Hamilton cycle divides dodecahedron to two congruent pieces related by  $Z_2$  symmetry (see <http://tinyurl.com/yy6pcogt>). Also the Hamiltonian cycle defining the common boundary has  $Z_2$  symmetry. A good guess is that these  $Z_2$ 's corresponds to reflection symmetry and rotation by  $\pi$  but I am not able to exclude  $Z_4 \subset G_0$ , where  $G_0$  consists of 60 orientation preserving isometries. In this case some orbits - presumably all 3 of them - could contain 4 pentagons. This is not consistent with the condition that one has doublets and singlets.

If the second symmetry corresponds to reflection, it can be excluded by simply assuming that reflections change the orientation of the cycle.

3. Rotation by  $\pi$  has two fixed points corresponding to opposite poles so that one has 5 2-orbits and 2 1-orbits giving 12 triangles for each copy. Two copies of dodecahedral harmony would give  $5+5=10$  doublets and  $2+2=4$  singlets. A possible interpretation would be as (ile,met) and (stop,trp).

Consider now objections against dodecahedral harmony.

1. Why two copies of dodecahedral code? What distinguishes between them? If imirror symmetry leaves the cycle invariant apart from orientation the copies could be mirror images and consist of same faces. The second option is that they related by a rotation?
2. The number of dodecahedral AAs is 24 rather than 20. Could the additional 4 AAs as orbits have interpretation as AAs in some sense. Could the "empty" AAs coded by stop codons be counted as AAs exceptional in some sense. In TGD framework one can consider the possibility that although AA is "empty", there is analog of AA as physical signature for the end of protein telling what stopping codon it corresponds. The magnetic body of protein is a good candidate.

Genetic code has several slightly differing variants. Could the 2 additional exotic AAs Pyl and Sec correspond in some situations to the additional AAs?

3. Essential for the bio-harmony as a fusion of harmonies is that one can select from each orbit single face as a representative of the AA it codes - kind of gauge choice is in question - and that the orbits corresponding to different AAs can be chosen to be disjoint. Otherwise codons

belonging to the orbits of different Hamilton cycles can code for the same AA if the AA can be chosen to be in intersection. If not, the same codon can code for 2 different AAs - this can indeed occur in reality [L120]!

The condition that orbits of different cycles do not intersect seems quite stringent but has not been proven. But what if it is actually broken? Indeed, in the case of icosahedral harmony with  $Z_1$  symmetry tetrahedron and icosahedron could have common a doubled face the breaking of this condition would geometrically explain why ile belongs to both icosahedral and tetrahedral orbit.

Ile is the problem also in the case if ico-dodecahedral harmony. Dodecahedral singlet codes for ile as also icosahedral doublet. Could one talk about doubling of ile face so that it corresponds to a pair of triangle and pentagon (in 1-1 correspondence with triangle as chord).

4. The two copies of the dodecahedral code should correspond to 5 doublets and 2 singlets each. One expects that together they give rise to  $10+2+10+2=24$  faces. Do they? Mirror symmetry and rotation by  $\pi$  act as symmetries of the cycle so that neither can map the two cycles to each other. Dodecahedral (equivalently icosahedral) rotations give rise to new equivalent cycles. The action on pentagons corresponds to the action on vertices of icosahedron so that it is easy to understand what happens.

Each symmetry corresponds to a rotation around some axis and has opposite icosahedral vertices at this axis as fixed points. Hence any two cycles obtained in this manner have 2 common pentagons. This means reduction  $24 \rightarrow 22$  unless one interprets the situation in terms of doubled faces? Could the disappearing doublet correspond to stop-doublet? What about the remaining stop of the vertebrate code pairing with trp? Why does second singlet correspond to empty AA and not something else such as exotic AA.

5. There is also further problem. Suppose that an intersection of orbits takes place at single triangle. Suppose that one cannot choose this triangle to be "AA" triangle for both orbits. In this case it is not clear to which AA the codon codes. This kind of phenomenon actually takes place in some cases and is known as homonymy [L120]. It is associated with the deviations of the code from the vertebrate code and involves exotic AAs Pyl and Sec. Codons can serve as a stop codon or code for an exotic AA.

Clearly, the notion of bio-harmony involves many unclear aspects but my strong feeling is that there is very beautiful mathematics involved.

## 6.6 Appendix

### 6.6.1 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 taking  $X$  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  $CM = CEG$  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

$$k \rightarrow k_{inv} = (2 \times k(X) - \Delta k_{inv}) \bmod 12 . \quad (6.6.1)$$

**Table 6.7** 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 6.8** 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.

|   |   |           |    |    |    |    |    |    |    |    |   |
|---|---|-----------|----|----|----|----|----|----|----|----|---|
| 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 6.7:** Inversion of the scale leaving  $C$  (and also  $F\sharp$ ) invariant.

|       |       |         |        |        |        |        |         |          |         |
|-------|-------|---------|--------|--------|--------|--------|---------|----------|---------|
| 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 6.8:** 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 6.9:** 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 6.10:** 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 6.11:** Pairs “X” and “iX” of columns give the chords of the bio-harmonies and their inversions depicted in figures ??, ??, ??.

### 6.6.2 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 chords defined as the minimal distance between triangles representing them vanishes. Some general comments are in order.

1. 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.
2. 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.
  - (a) 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  $M = N^2$   $20 \times 20$ -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  $20 \times 20$ -D incidence matrix.
  - (b) 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  $8 \times 24$ . Remarkably, the magic number 24 of also stringy mathematics appears.
  - (c) If the transitions can be restricted to single triplet of cycles, one must calculate 6  $20 \times 20$ -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  $60 \times 60$  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.
3. For the extended genetic code the most natural assumption is that the extension of the code to icoso-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  $C6 = CGA$ .
4. 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.

### 6.6.3 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

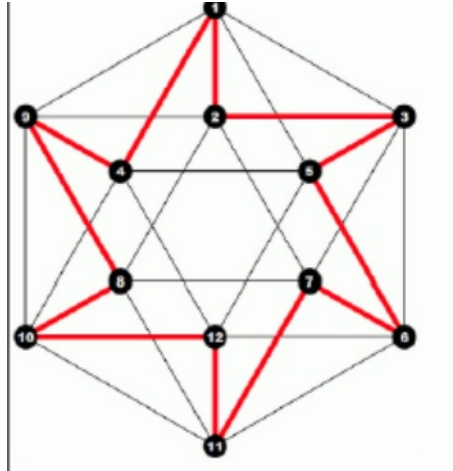
??, ??, and ?? extended by adding chords  $Bb$ ,  $Gm$  and  $G7$  and associated  $Bb6$  representing stopping codon and punct in tetra- icosahedral code and Sec or Pyl in their unfused variants. These three harmonies correspond to groups of 20, 20, and 24 DNA codons at orbits of  $Z_6$ ,  $Z_4$ , and  $Z_2$  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.

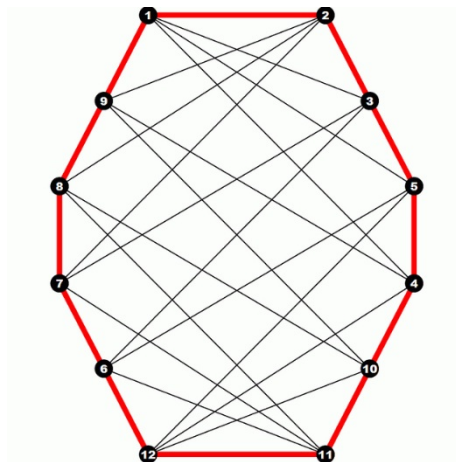
Faug, A6, Dm, G6, G6, G6, Em, G6, Cm, G6, F6, Faug, F+m, Dm, G6, G6, Gaug, G+m, Cm, F6, Dm, Dm, F+m, Dm, F6, F6, B-m, C+6, B-m, F6, Dm, G6, G6, Gaug, G+m, Cm, Gaug, G6, Dm, B-m, F6, Faug, A6, G6, Gaug, G+m, Cm, F6, Faug, F6, Cm, F6, G6, Gaug, Gaug, B6, Gaug, G6, Gaug, Em, Gaug, Em, A6, F+m, B-m, F6, 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.

#### 6.6.4 Illustrations of icosahedral Hamiltonian cycles with symmetries

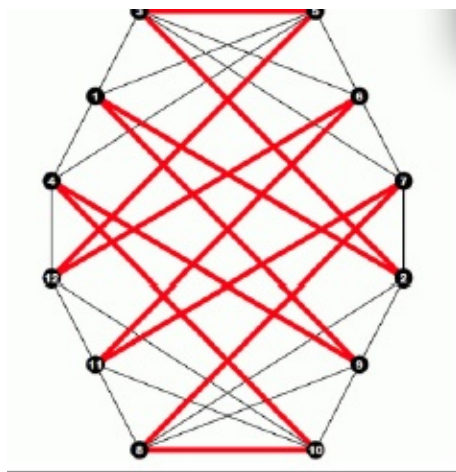
The figures below illustrate the Hamiltonian cycles involved. Quite generally, the  $Z_n$  symmetry acts by a shift by  $12/n$  quints along the cycle and the orbits of chords consist of at most  $n$  chords of same type as the reader is encouraged to verify.



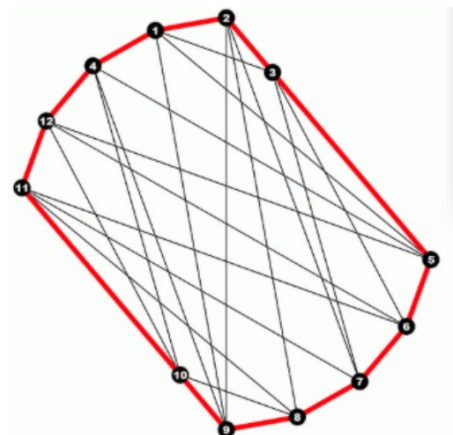
**Figure 6.2:**  $(n_0, n_1, n_2) = (2, 12, 6)$  Hamiltonian cycle with 6-fold rotation symmetry acting shifts generated by a shift of 2 quints.



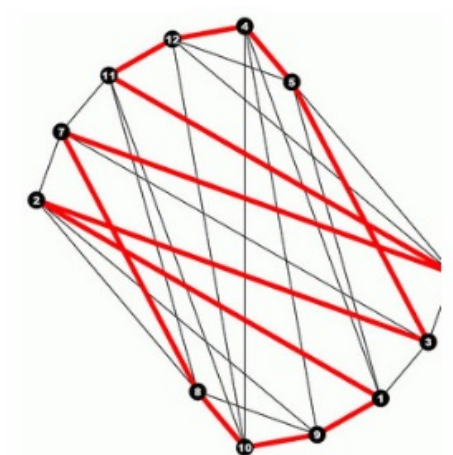
**Figure 6.3:**  $(n_0, n_1, n_2) = (0, 16, 4)$  Hamiltonian cycle with 4 reflection symmetries generated by reflections in vertical and horizontal directions.



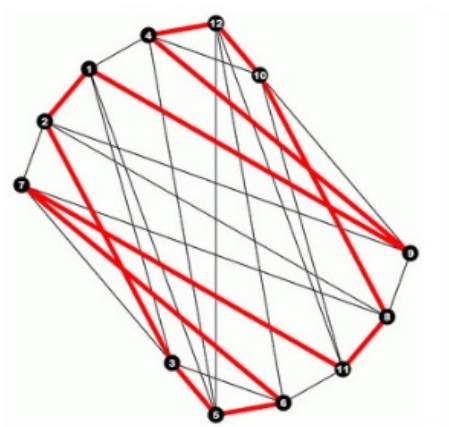
**Figure 6.4:**  $(n_0, n_1, n_2) = (4, 8, 8)$  Hamiltonian cycle with 4 reflection symmetries.



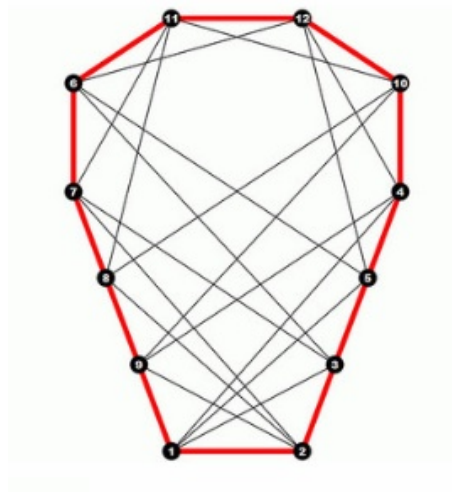
**Figure 6.5:**  $(n_0, n_1, n_2) = (0, 16, 4)$  Hamiltonian cycle with 2-fold rotational symmetry realized as 6-quint shift along the cycle.



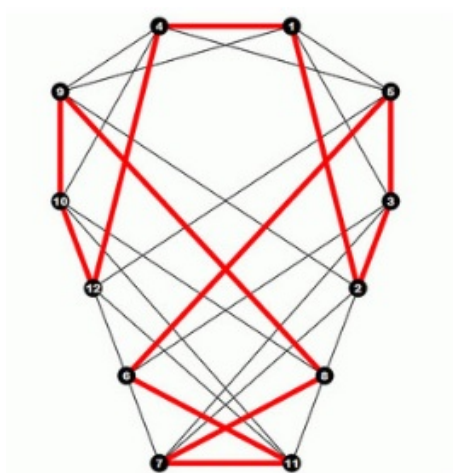
**Figure 6.6:**  $(n_0, n_1, n_2) = (2, 12, 6)$  Hamiltonian cycle with 2-fold rotation symmetry.



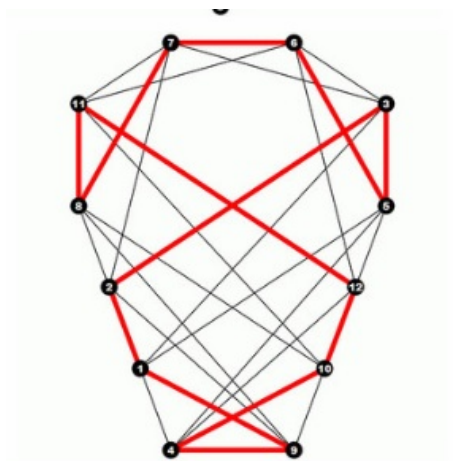
**Figure 6.7:**  $(n_0, n_1, n_2) = (4, 8, 8)$  Hamiltonian cycle with 2-fold rotation symmetry.



**Figure 6.8:**  $(n_0, n_1, n_2) = (2, 12, 6)$  Hamiltonian cycle with 2-fold reflection symmetry realized as horizontal reflection



**Figure 6.9:**  $(n_0, n_1, n_2) = (2, 12, 6)$  Hamiltonian cycle with 2-fold reflection symmetry.



**Figure 6.10:**  $(n_0, n_1, n_2) = (4, 8, 8)$  Hamiltonian cycle with 2-fold reflection symmetry.

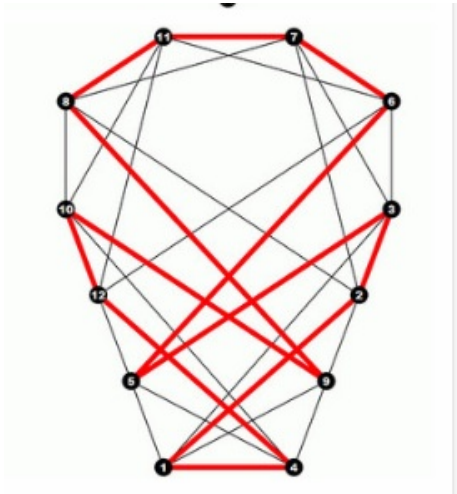


Figure 6.11:  $(n_0, n_1, n_2) = (2, 12, 6)$  Hamiltonian cycle with 2-fold reflection symmetry.

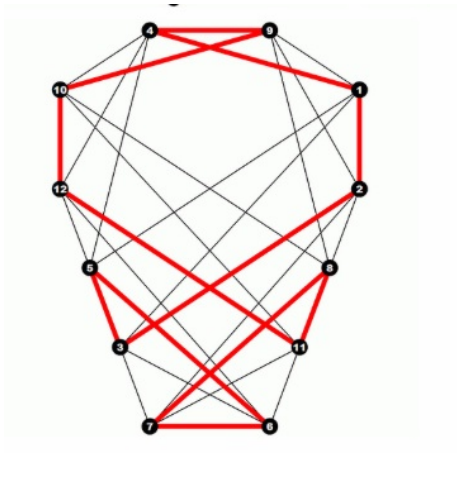


Figure 6.12:  $(n_0, n_1, n_2) = (2, 12, 6)$  Hamiltonian cycle with 2-fold reflection symmetry.



## Chapter 7

# An Overall View about Models of Genetic Code and Bio-harmony

### 7.1 Introduction

During last years kind of brain storming period has occurred in the model of bio-harmony [L31]. A lot of ideas, some of them doomed to be short lived, have emerged, and it seems that now it its time for a thorough cleanup and integration with the general ideas of TGD inspired quantum biology.

TGD leads to 3 basic realizations of genetic code: this is now relatively well established part of TGD inspired quantum biology. One can also consider 3 realization also for bio-harmony. The question is which of them is the realistic one or whether several options can be considered.

#### 7.1.1 3 basic realizations of the genetic code

In TGD Universe there are at least 3 realizations of the genetic code.

Besides biochemical realization one has a realization in terms of dark nuclei realized as dark proton sequences and possibly in terms of more general sequences involving effective dark neutrons. The states of 3 dark protons defining the dark codon have multiplet decomposition  $64 + 64 + 40 + 20$  corresponding to dark variants of DNA, RNA, tRNA, and amino-acids (AA). I will denote these dark variants by DDNA, DRNA, DtRNA, and DAA.

If one allows also dark analogs of neutrons by allowing negatively charged color bonds between protons, the number of code letters doubles: this could relate to the recently constructed Hachimoji DNA [I17] (see <http://tinyurl.com/y2mcjb4r>) discussed from TGD viewpoint in [L144].

Dark photon 3-chords assignable to the realization of bio-harmony with the note scale identified as Hamilton cycle on a polytope with triangular faces gives a third realization coupling dark and ordinary representations together. I have proposed 3 realizations in terms of icosahedral and tetrahedral [L31], icosahedral and toric [L112], and icosahedral and dodecahedral [L144] geometries (for the latter 5-chords would effectively reduce to 3-chords).

If there is DDNA-DNA, DRNA-RNA, DAA-AA pairing, the negative charges of DNA, RNA, and tRNA nucleotides finds explanation in terms of positive charge of dark proton sequence. For AAs the situation is not clear since the charge per unit length for amino-acids varies and depends on pH. DAA-AA pairing would require that dark analogs of neutrons are present in the dark proton sequence.

#### 7.1.2 3 models of bioharmony

There are now 3 models of bioharmony [L31, L112, L144] making very similar predictions. Harmony for given graph is defined as a Hamiltonian cycle connecting neighboring points and going through all points of the graph without self-intersections. Scale is identified by assigning notes to the

vertices and faces correspond to the chords of the harmony obtained in this way. Bio-harmonies are fusions of 3 or 4 sub-harmonies.

1. The original proposal - icoso-tetrahedral bio-harmony - is based on the fusion of 3 icosahedral harmonies with symmetry groups  $Z_6$ ,  $Z_4$  and  $Z_2$  permuting the triangles of given orbit of  $Z_n$ . Given icosahedral harmony corresponds to an imbedding of 12-note scale as a Hamilton cycle at icosahedron. The 12 vertices of icosahedron are identified as the notes of 12-note scale and 20 triangular faces define the 3-chords of the harmony.

The distance between nearest vertices is assumed to correspond to quint that is scaling of the frequency by  $3/2$ . Each cycle defines a collection of 20 3-chords defining an icosahedral harmony. Octave equivalence is used to map the 12 frequencies obtained to single octave. There is however a slight inconsistency since 12 quint corresponds to slightly more than 7 octaves as already Pythagoras realized. The addition of tetrahedron to icosahedral harmony is interpreted as an addition of one vertex adding one note which should be very near to one of the 12 notes.

Icosahedral harmonies are characterized by a symmetry group  $Z_n$ ,  $n = 6, 4, 2, 1$ ,  $n = 1$  corresponds to chaotic cycles, which might serve as correlate for dis-harmony and might relate to the correlates of emotions: at the level of genetic code is AA would be coded by single DNA codon.

Icosahedron decomposes to orbits of  $Z_n$  consisting of triangles or equivalently chords. The chords can be classified further by the frequency ratios correlating with the emotional effect. One has the orbits  $3 \times 6 + 2 = 20$  for  $Z_6$ ,  $5 \times 4 = 20$  for  $Z_4$  and  $10 \times 2$  for  $Z_2$ .  $Z_6$  harmony is unique but there are 3  $Z_4$  and even more  $Z_2$  harmonies for which  $Z_2$  can correspond to rotation by  $\pi$  or reflection. This can be understood as breaking of symmetry splitting the  $Z_6$  orbits to pieces. This gives  $60 = 2 + 20 + 20$  3-chords. The numbers of chords at give orbit rather neatly correspond the numbers of DNA codons coding for given AA.

4 chords and DNAs and AAs are however missing. Tetrahedral harmony would add  $3 + 1 = 4$  chords:  $Z_3$  would the symmetry group instead of  $Z_4$ . This would be due to the symmetry breaking due to gluing of one-tetrahedral face with icosahedral face, which is however counted as separate face and corresponds to 1-triangle orbit under  $Z_3$  permuting its vertices. This gives 64 3-chords corresponding to codons of genetic code.

$3 + 1$  decomposition would naturally correspond to (*ile, ile, ile, met*) 4-plet coded by codons *AUX*. The numbers of codons coding given AA identified as orbit of  $Z_n$  come out almost correctly. The only exception is trp-stop doublet for which doublet decomposes to stop and singlet. One must understand the reason for this symmetry breaking - it might just the need to have stop codon and this could be arranged if there is no tRNA coupling to this codon. Note that for some code variants stop codon UAG corresponds to Pyl and UGA to Sec.

Since music generates and expresses emotions, the interpretation would be in terms of moods. Even molecules would have moods.

2. Also icoso-dodecahedral and icosahedral-toric harmonies contain the  $Z_6$  and  $Z_4$  icosahedral harmonies ( $20_1$  and  $20_2$ ) so that one must only add the missing 10 doublets and  $3+1$  codons assigned to tetrahedron in icoso-tetrahedral case.

The dodecahedral harmony with 6 chords arranged in doublets is unique from the uniqueness of the Hamiltonian cycle [L144]. The icoso-dodecahedral harmony would give  $20_1 + 20_2 + 12_1 + 12_2 = 64$ . 12 decomposes into 6  $Z_2$  doublets so that one has 12 doublets. The realization of scale for dodecahedral harmony would in 20 powers of rational scaling  $x$  such that  $x^{20}$  is as near to a power of two as possible [L144].  $x = 2^{1/20}$  would correspond to the Eastern variant of well-tempered scale.

There are objections against icoso-dodecahedral harmony. Chords are 5-chords rather than 3-chords. The 5-chords of dodecahedral harmony however turn out to be equivalent to 3-chords as far as information content is considered [L144]. The number of vertices for dodecahedron is 20, not 12, but one could argue that dodecahedron corresponds to Eastern harmony having micro-intervals. Two copies of the dodecahedral harmony are needed. What could distinguish between these copies will be discussed later. Also  $3+1$  is missing.

3. The icosahedral-toric harmony [L112] decomposes as  $20_1 + 20_2 + 24 = 64$  involving torus with 24 triangles and 12 vertices. Toric harmony has  $Z_{24}$  as isometries and gives 12 doublets. One could argue that the fusion of icosahedral and toric harmonies is geometrically un-natural. One must be however cautious if the geometric realization is in extension of rationals. Also now  $3+1$  is missing.

The considerations in the sequel suggests that the ico-tetra option is the most realistic if not unique.

### 7.1.3 About the geometric interpretation of icosahedral and other symmetries

The geometric interpretation of icosahedral and possible other geometries is a challenge. The 60-element group  $A_5$  of rotations - alternating group of 5-letters - acts as orientation preserving isometries of icosahedron.

1. Since Galois group is central in adelic physics, and all finite groups can appear as Galois groups, one can ask whether icosahedral group and tetrahedral groups could act as Galois group for some extension of rationals relevant for biology. Going to web gives an affirmative answer [A34] (see <http://tinyurl.com/y4qsea6h>)! Icosahedral symmetry appears as Galois group of the general quintic equation! The lowest order polynomial equation not allowing closed expressions for the roots.

Galois theory (see <http://tinyurl.com/y6e955ke>) allows to understand the situation in terms of the discriminant defined as product  $D = \prod_{i < j} (r_i - r_j)^2$ , where  $r_i$  are the roots of the irreducible polynomial considered.  $S_n$  is the symmetry group in the generic case and odd permutations of  $S_n$  change the sign of  $D$ . If  $D$  is square of rational number in the field  $K$  considered (which can be also extension of rationals now), Galois group reduces to alternating group  $A_5$ .

**Remark:** For octahedron and its dual cube the group is  $S_4$  and can be realized as Galois group of  $4^{th}$  order polynomials. For tetrahedron the group is  $A_4$  and can be also realized as Galois group of  $4^{th}$  order polynomials for which discriminant is square in  $K$ .

2. Icosahedral and dodecahedral geometries having the same isometry group are common in biology, and one can wonder whether there could be a geometric realization - perhaps at the level of magnetic body. This might somehow relate also to the frequent appearance of Golden mean involving  $\sqrt{5}$  in biology and Golden angle related to the fifth root of unity.
3.  $M^8 - H$  duality provides besides the usual formulation of TGD also a formulation in complexified  $M^8$  identified as complexified octonions [L88]. The associativity of the tangent or normal space of space-time surface is assumed as a dynamical principle and implies quaternionicity. Quaternions have  $SO(3)$  as automorphism group analogous to Galois group and have the finite isometry groups of Platonic solids as finite subgroups.

Could quaternionicity give a connection with the geometric picture? In adelic physics discretizations of space-time points as points with coordinates in the extension of rationals are in central role. Could discretizations contain orbits of the Platonic isometries as quaternionic Galois groups? This could also give to the geometric picture although icosahedral symmetries are not obvious in the geometry of say DNA.

4. Is the genetic code really unique as its dark nucleus realization and the fact that the isometry groups of Platonic solids are finite subgroups of quaternionic isomorphisms suggests? Could any Galois group give rise to an analog of bioharmony and of genetic code? Could the recent genetic code correspond to a first step in the process going beyond the solvable polynomial equations?

What about toric code? The group of toric isometries is  $Z_{24}$  and 24 is one of the magic number of mathematics, and dimension 24 is crucial in bosonic string model. Could  $Z_{24}$  correspond to the Galois group for 24:th roots of unity defining 24-D algebraic extension of rationals. We cannot sensorily imagine higher dimensions but can do this cognitively. I have

proposed that the ability to imagine higher dimensions could be due to the possibility of higher-dimensional extensions of rationals and p-adics.

Could one realize the icosahedron and 24-torus as imagined object in the algebraic extension of rationals? Could the  $n$ -dimensional discrete geometric objects assignable to  $n$ -dimensional extensions of rationals have quite generally this kind of representations as a generalized Platonic solid in algebraic extension. Could they define cognitive harmonies as Hamiltonian cycles? Could one imagine also cognitive variant of genetic code whereas as sensory/biological variant of genetic code would be forced by dark proton physics?

#### 7.1.4 Mistracks

In the attempts to understand the connection with standard realization of the genetic code I have also considered the possibility that the frequencies of 3-chord might be mapped to their sum in the interactions. This possibility was considered in the model of homonymy [L120]. In the light of afterwisdom this proposal looks ad hoc.

Also a proposal for how 12-note scale could quite concretely correspond DNA codons was discussed [L123]. The idea was to assign notes with individual letters of the codon such that the note depends on the position of the letter whereas the model of harmony assignment the chord to the entire codon represented as entangled state of 3 dark protons. It is now clear this proposal very probably cannot realize all possible harmonies and is in conflict with the general model which as such fixes the correspondence between chords and codons without any additional assumptions.

## 7.2 Interactions between various levels

One challenge is to understand how the various realizations of the genetic code interact with each other. There are DX-DY interactions, DX-Y interactions and X-Y interactions and in living matter they should occur in long length scales so that they should be mediated by dark photons.

1. How dark photon triplets assumed to be generated by dark nucleon sequences interact with ordinary DNA? Here one can bring in rather stable ideas of TGD inspired view about quantum biology. Dark matter in TGD sense represents long length scale quantum coherence and bio-chemistry short scale coherence. The interaction is therefore between long and short scales.
2. There are two ways to interact: frequency resonance and energy resonance. Frequency resonance mediates long length scale interactions and if DX-X pairing exists, the exchange of dark photon triplets - 3-chords - allows long range DX-DY interactions. DX-X interaction by energy resonance is short range interaction so that X-(DX-DY)-Y interaction would give rise to long range interaction between X-Y as interaction induced by dark level (MB).
3. DX-X interaction involves energy resonance and transformation of dark photons to ordinary photons with the same energy. Bio-photons would be an outcome of the transition  $h_{eff} \rightarrow h$ . Also the reversal of this transition and more general transitions  $h_{eff,1} \rightarrow h_{eff,2}$  are of course possible.

Bio-photons have a universal energy spectrum corresponding to molecular and atomic transition energies. This is possible if they result from dark cyclotron photons if the condition  $h_{eff} = h_{gr} = GMm/v_0$  introduced originally by Nottale and implying that the cyclotron energy does not depend on the mass of the charged particle producing the dark cyclotron photons.

### 7.2.1 The independence of the interaction energy on frequency

Dark matter as a hierarchy phases labelled by  $h_{eff}/h_0 = n$  identifiable as a dimension of extension of rationals implies evolutionary hierarchy:  $n$  serves as a kind of IQ. This strongly suggests that ordinary matter is controlled by dark matter at MB and mimics its behavior.

Evolution would not proceed by change and necessity but would be a process controlled and guided by MB. MB would be an active intentional agent guiding the evolution. Situation in biology

would be much like that in modern technological society where intentional technical progress leads to more and more refined products. How could this be realized at the level of basic bio-molecules? One should also understand how genetic code evolves gradually to a more refined form.

1. The selection of basic bio-molecules having energy resonance with their dark variants mediated by dark photon 3-chords by change would be extremely in-effective process. MB should have mechanisms of tuning the energies of dark photons to achieve energy resonance.

This is achieved if the value of  $h_{eff}$  at the flux tubes mediating the interaction can be controlled. Since the length of flux tube is proportional to the  $h_{eff}$  by Uncertainty Principle, the variation of  $h_{eff}$  would mean variation of the length  $L$  of the flux tube: a kind of motor action of MB. Cyclotron frequencies are proportional to the value of monopole magnetic field  $B$  at flux tube and by flux quantization one has  $B \propto 1/S$ ,  $S$  the area of flux tube cross section (which for monopole flux tubes is closed 2-surface). The variation of the thickness/area of the flux tube, second motor action of MB, would allow to vary cyclotron frequencies.

2. The ideal situation concerning the coupling to ordinary matter would be that same chemical transition with fixed energy for given molecule could couple to several frequencies. This would be achieved if the cyclotron energy is constant.

The condition that the cyclotron energies in a coupling to a given molecule do not depend on the frequency requires that  $h_{eff,i}$  at flux tube  $i$  compensates this dependence. MB can vary the value of  $B$  to vary frequencies and the value of  $h_{eff,i}$  to keep energy unaffected. The areas  $S$  and length  $L$  of flux tubes are varied so that the volume remains unaffected.  $B \propto 1/S$  and  $L \propto h_{eff}$  by Uncertainty Principle.  $E_c \propto h_{eff}B = \text{constant}$  implies that  $L/S$  is constant.  $S$  increases like  $S \rightarrow x^2S$  and  $L \rightarrow x^2L$  in the scaling changing  $f_c \rightarrow f_c/x^2$ . The magnetic energy  $E_{magn} = B^2SL \propto L/S$  of the flux tube is not changed. Kind of energy criticality would be in question - one would have a large number of flux tube configurations with the same energy and volume ideal for control purposes. Quantum criticality is actually basic dynamical principle of quantum TGD allowing to predict the spectrum of various coupling parameters.

3. Besides cyclotron frequencies Josephson energies are central in TGD based model of nerve pulse and EEG. Josephson energy  $E_J = ZeV$  and cyclotron frequency  $f_c = ZeB/m$  do not depend on  $h_{eff}$ . An attractive possibility is that cyclotron photons couple to Josephson junctions meaning that they become Josephson photons and then transform to ordinary photons inducing molecular transitions.
4. In the case of bio-harmony the frequencies would be rational multiples of basic frequency and by separating common numerator they are certain integer multiples  $f_i = n_i f_0$  of a basic frequency  $f_0$ . The integers  $n_i$  have decomposition to products of powers of certain primes:  $n_i = \prod p_i^{k_i}$  and each of  $p_i$  appears as some maximal power  $k_{i,max}$ . If one has  $n = \prod_i p_i^{k_{i,max}} n_0$  one can obtain  $h_{eff,i} = h_{eff}/n_i$ . In this manner one would obtain the desired independence of  $E_{c,i}$  on  $f_i$ . For Pythagorean scale only primes  $p = 2$  and  $p = 3$  would be involved.

All codons coding for given AA could have same coupling energy. Unless the values of Planck constants and frequencies associated with flux tubes coupling to given codon are fixed, one could have same transition energy for all letters but this is an unrealistic condition. Transition energies are naturally different and can code for letters if not even codons. For this option only the correct combination of frequencies and values of  $h_{eff,i}$  allows resonant coupling.

The 3-chords associated with different harmonies would naturally correspond to the same energy. The physics of emotions would not be directly visible at the level of chemistry: chemist would certainly agree with this. The values of Planck constants would characterize the frequencies: I have indeed speculated that nucleotides could be labelled by values of  $h_{eff}$ . Number theory would be essential for the understanding life at the level of genes: Galois groups would characterize the nucleotides. Galois groups code for complexity at the level of dark matter so that the behavior guided by the MB of molecule would depend on the  $IQ = n = h_{eff}/h_0$  of MB.

### 7.2.2 The independence of cyclotron energy on frequency and Nottale hypothesis

Is the independence of interaction energy on frequencies consistent with  $h_{gr} = GMm/v_0$  hypothesis [E1] [K100, K78, K12]? Here one might encounter difficulties. The division by  $n_i$  should change one of the parameters appearing in the formula. The interpretation has been  $m$  corresponds to the dark proton mass at the end of the flux tube connecting it to large mass  $M$ . If so  $m$  cannot be varied.

Could  $M$  be varied?

1. The parameter  $v_0 \simeq 2^{-11}$  can be varied by powers of two, which do not affect the notes identified by octave equivalence.
2. Could  $M$  correspond to atomic or molecular mass in good approximation equal to sum of atomic numbers  $A$  of atoms involved? The divisors of the total atomic number  $A_{tot}$  would define the allowed integers  $n_i$  characterizing the frequencies of Pythagorean scale in the model of bio-harmony. One must have  $h_{gr}/h > 1$  with requires  $M > \hbar/Gm = 1.3 \times 10^{19} m_p v_0$ . For  $v_0 = 2^{-11}$  this corresponds to  $M > \hbar/Gm = 6 \times 10^{15} m_p$ . The scale of a water blob with  $A = 20$  containing this number of protons is about  $70 \mu$ , which is of order cell size. One can wonder how  $A_{tot}$  could be kept as divisible by  $n_i$  characterizing the frequencies of the Pythagorean scale. The problem is that an addition of one proton spoils the divisibility conditions completely.
3. The solution of the problem could be based on a more precise view about  $h_{eff}$  [L143]. The understanding of the variation of Newton's constant - too large to be due to experimental errors - led to the realization of the meaning of the fact that space-time surfaces can be regarded simultaneously coverings of  $n_2$ -fold  $M^4$  and  $n_1$  fold  $CP_2$  and that one has  $n = n_1 n_2$  in  $h_{eff}/h_0 = n$  and  $n_1$  would have interpretation as the number of flux tubes which are parallel in  $M^4$  and can be even disjoint. This would give  $h_{gr} \propto n_1$  and the factors of  $n_1$  should correspond to the integers characterizing the notes of the 12-note scale. One could perhaps say that effectively single proton is replaced with  $n_1$  protons located at different flux tubes so that also proton mass becomes  $n_1 m$ . One would have effectively a Bose-Einstein condensate like state of  $n_1$  protons (at different flux tubes).
4. In the Pythagorean representation of octave the notes correspond to powers  $(3/2)^k$ ,  $k = 0, 1, \dots, 11$ , if  $(3/2)^{12} \simeq 2^7$  is not included. The corresponding integers are  $3^k 2^{11-k}$ . Only powers of primes  $p = 2$  and  $p = 3$  are involved and one just have  $n_1 \propto 3^{11} 2^{11}$ . If one increases the number of octaves involved to 14 to get a representation for chords needed to avoid the mapping of two dark codons to same 3-chords, one must have  $n \propto 3^{23} 2^{23} = 6^{23}$ . One can consider also simpler representations using integers expressible in terms of powers of primes  $p = 2, 3, 5$  but one must give up exact quint cycle in this case. Interestingly, a good guess for the standard value  $h$  of  $h_{eff}$  is as  $h = 6h_0$  [L62, L115].
5. Small p-adic primes  $p = 2$ ,  $p = 3$  and perhaps also  $p = 5$  (Golden Mean) are expected to be of special importance in TGD inspired biology [K69].  $p = 2$  seems to appear everywhere and there is also support for  $p = 3$  in biology [I52, I53] (see <http://tinyurl.com/ycesc5mq>): great evolutionary leaps seem to correspond to time scales coming in powers of 3.
6. The branching of the flux tube bundle to  $n_i$  sub-bundles  $N_i = n/n_i$  could correspond to the reduction  $h_{eff} \rightarrow h_{eff}/n_i$ . This could be seen as reduction of  $h_{eff}$ . One can also consider phase transitions reducing  $n$  to  $n/n_i$ .

## 7.3 Homonymy of the genetic code

In the following I will discuss briefly the basic facts about genetic code at Wikipedia level with emphasis on the poorly understood aspects of the code. There are two interesting phenomena: synonymy and homonymy. Synonymy means several names for AA or tRNA codon so that several RNAs are mapped to the same AA or tRNA codon: the understanding of the genetic code is the understanding of synonymy.

Homonymy means that the same RNA codon can correspond to several tRNAs or even AAs. A general TGD based view about homonymy differing from that discussed in [L120] based on the recent understanding of the interaction between various representations of the genetic code is described below.

### 7.3.1 Variations of the genetic code

There exists also as many as 31 genetic codes (see <http://tinyurl.com/ydeeyhjl>) and an interesting question is whether this relates to the context dependence. Mitochondrial codes differs from the nuclear code and there are several of them. The codes for viruses, prokaryotes, mitochondria and chloroplasts deviate from the standard code. As a rule, the non-standard codes break U-C or A-G symmetries for the third code letter. Some examples are in order (see <http://tinyurl.com/puw82x8>).

1. UUU can code Leu instead of Phe and CUG can code Ser rather than Leu. In bacteria the GUG and UUG coding for Val and Leu normally can serve as Start codons.
2. UGA can code to Trp rather than Stop: in this case the broken symmetry is restored since also UGG codes for Trp.
3. There is variation even in human mitochondrial code (see <http://tinyurl.com/puw82x8>). In 2016, researchers studying the translation of malate dehydrogenase found that in about 4 per cent of the mRNAs encoding this enzyme the UAG Stop codon is naturally used to encode the AAs Trp and Arg. This phenomenon is known as Stop codon readthrough (see <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5133446/>).
4. There is also a variant of genetic code in which there are 21st and 22nd AAs Sec and Pyl coded by Stop codons. UGA can code for Sec and Stop in the same organism. UAG can code for Pyl instead of Stop and introduces additional breaking of A-G symmetry for the third letter (UAA to Stop and UAG to Pyl).

### 7.3.2 Wobble base pairing

Wobble base pairing (see <http://tinyurl.com/y73se8vs>) emerges from the observation that the number of tRNAs pairing with mRNAs is smaller than 45 and considerably smaller than that of mRNAs. The needed minimum number of tRNAs is 32. Therefore the RNA-tRNA pairing cannot be 1-1 and some mRNA codons must correspond to several tRNA codons.

**Remark:** One could ask whether mRNAs code for tRNAs just like DNAs code for AAs. Homonymy for mRNA-tRNA pairing implies that the pairing can be many-to-1 only in given context.

1. According to the standard code, the first two bases of mRNA codon corresponds to two last bases of tRNA anti-codon and obey standard code. Wobble base pairing hypothesis applies to the pairing of the 3rd mRNA base to the 1st base in tRNA anticodon. At the level of chemistry the hypothesis is that the position of the first tRNA anticodon base pairing with the third mRNA base is variable and allows it to pair with several bases appearing as 3rd base in mRNA. This homonymy would be due to “wobbling” of the position of the first tRNA anticodon.
2. In the original model for wobble base pairing tRNA bases contain besides standard A, C, G, U also inosine I as a modification of G obtained by dropping  $\text{NH}_2$  from the 6-cycle of G. It has turned out that there are actually variants of C and 5 variants of U (see <http://tinyurl.com/y73se8vs>). The large amount of homonymy for tRNAs forces to ask whether chemistry alone really dictates the genetic code.
3. The first tRNA letter is assumed to be spatially wobbling so that the association of tRNA with RNA is not unique and mRNA-tRNA pairing involves both synonymy and homonymy as the two tables for the pairing of the 1st 5' anticodon base of tRNA and 3rd 3' codon base of mRNA show. In the second column bold letters for mRN bases allow to read the

standard pairing with tRNA codons in the first column and non-bold letters allow to deduce the non-standard behavior.

4. The first table (see <http://tinyurl.com/y73se8vs>) represents the original Watson-Crick proposal.

- (a) The pairings of the 3rd letter of mRNA codon to the 1st letter of tRNA anti-codon are following.

- $U \rightarrow G$ .
- $G \rightarrow U$
- $\{A, C \text{ or } U\} \rightarrow I$ .

The 2nd and 3rd tRNA letters A and C are paired with the 1st and 2nd mRNA letters in the canonical manner. There are only 3 tRNA letters, which implies that the number of tRNAs is smaller than maximal.

- (b) There is single 1-to-many pairing:  $U \rightarrow \{G, I\}$  giving rise to 2-fold homonymy.

5. Revised pairing rules (see <http://tinyurl.com/y73se8vs>) are more complex since the number of tRNA bases is larger (U has 5 variants and C has 2 variants). All mRNA letters have 1-to-many pairing. Even if one counts the variants of U as single U there is 4-fold homonymy for U and homonymies for other codons. For A one has 9-fold homonymy.

These variations do not induce variation in  $DNA \rightarrow AA$  pairing if the AA associated with the homonyms of tRNA are identical. This seems to be the case almost always since the variation of the genetic code is surprisingly small. This raises the question whether there is some mechanism eliminating to high degree the expected effects of homonymy in  $mRNA \rightarrow tRNA$  pairing.

## 7.4 TGD view about homonymies

One should understand the homonymies of the genetic code [L120]. One can imagine homonymies at the level of DDNA-3-chord and DRNA-3-chord correspondences and between RNA-AA and RNA-tRNA correspondences.

### 7.4.1 Homonymies for DRNA-3-chord correspondence

It is possible that homonymies are present already at the dark photon level in the sense that the sub-harmonies have common chords.

1. Are the icosahedral orbits for different symmetry groups  $Z_6$ ,  $Z_4$ ,  $Z_2$  disjoint? If they contain common triangles, the outcome is homonymy for dark codons unless one can scale the 12-note scales with respect to each other (different keys) to avoid common chords.

This question finds an answer from the tables of [L31] representing the chords. If the two scales considered contain 3-chords with the same frequency ratios this can happen.  $Z_6$  harmony contains chords of same type with whole note intervals:  $C_x, D_x, E_x, \dots, x = m, 6, 9$  coding the frequency ratios as is done in popular music. If second harmony contains several types such that they are not separated by a multiple of whole note interval, at least one common chord is unavoidable also for shifted harmonies.

2. From the tables 7.2 and 7.3 of Appendix one finds that for  $Z_6$  and 2  $Z_4$  harmonies this is indeed the case and they have 2-chords involving 2 quints in common: 6-orbit and 4-orbit containing  $x = 9$  3-chords have 2 common chords. One has homonymy at dark level. If entire orbits are mapped to the same AA there would be 8 AAs in the same multiplet. Some DDNA and DRNA codons are mapped to the same 3-chord of dark photons. This problem is shared by all 3 models of bio-harmony.



3. For the unique  $Z_6$  harmony and 3  $Z_{2,rot}$  (table 7.4 of Appendix) of harmonies common chords can be avoided by shifting the latter harmonies by a half-note. The reason is that the chords of same type are now separated by a multiple of whole note interval. For  $Z_{2,refl}$  harmonics (table 7.5 of Appendix) the chords of same type are separated by odd number of half-notes so that common chords are unavoidable since 3-chords of the same type appear. There are also common chords with  $Z_4$  harmony.
4.  $Z_6$  and  $Z_{2,rot}$  harmonies possess no common chords by a shift by odd number of half notes.  $Z_4$  and  $Z_{2,rot}$  and  $Z_4$  and  $Z_6$  possess at least 2 common chords.  $Z_{2,refl}$  possesses more common chords with  $Z_4$  and  $Z_6$ .

The fusion of  $Z_6$ ,  $Z_4$ , and  $Z_{2,rot}$  harmonies with 2 common chords between in  $Z_6 \cap Z_4$   $Z_4 \cap Z_{2,rot}$  seems to be best that one can achieve. This would give  $1 \times 2 \times 3 = 6$  harmonies altogether unless one obtains new harmonies by relative shifts of the key.

How to solve the problem?

1. The above described homonymies involving 6-plets involve either 6-plet or 2-plet as second multiplet so that these deviations cannot be due to homonymy at the level of DRNA-3-chord correspondence.
2. Should one take seriously the puzzle that teased Pythagoras and led him to seriously consider that the structure of the Universe based on rationals has serious flaw in it. 12 quints give slightly more than 7 octaves: one has  $(3/2)^{12} = 129.746337890625$  rather than  $(3/2)^{12} = 128$  so that one obtains slightly more than octave under octave equivalence.

Why not represent notes as powers of algebraic number  $2^{1/12}$  and this is indeed done in practice (in rational approximation of course) but very musical people notice the difference and dislike this representation. There should be something deep in the representation of the scale in terms of rationals as TGD indeed predicts. Note that a strict resonance is not required, it represents only the optimal situation.

3. Repeating the quint cycle gives slightly displaced chords: one can of course do this several times [L144]. Could these slightly displaced chords represent DDNA and RNA codons as 3-chords otherwise mapped to the same chords? This would also mean that the corresponding DNAs and RNAs correspond to 3-chords with at least one note differing only slightly. This kind of notes is shared by 5 chords in icosahedral harmony. The addition of second quite cycle means that the integers  $n_i = 2^k 3^{23-k}$  characterize the notes of the 3-chords and  $2^k 3^{23-k}$  and  $2^{k+12} 3^{11-k}$  represent the nearby notes.
4. The minimal modification would replace only minimum number of notes in the problematic chords with new ones. A stronger modification would replace the problematic chords with displaced variants with notes in the second quint cycle. One could also do the same for all chords and say that the number of codons for non-problematic dark codons is doubled.

One could also consider the doubling of each letter of the codon so that each chord would be replaced with 8 almost copies except in the case of homonymic AAs. A non-homonymic AA coded by  $n$  RNAs would be coded by  $8n$  3-chords. If the frequency differences are small enough this is not seen at the level of transition energies of AAs: this must be the case for non-homonymous AAs. For homonymous RNAs the energy differences must be seen and remove the homonymy. This DRNA-3-chord homonymy would be analogous to the RNA-tRNA homonymy.

5. One can consider the problem from a different perspective. For Hachimoji DNA [I17] (see <http://tinyurl.com/y2mcjb4r>) the number of DNA letters seem to double so that codon is replaced with 8 codons. An explanation based on the Pythagorean dilemma was discussed in [L144]. In the model it was however assumed that the doubling of dark DNA and DNA is real being due to the possibility of having also negatively charged color bonds between dark protons so that dark proton is effectively dark neutron (this might happen even in ordinary nuclear physics in nuclear string model [K65]). The Pythagorean double covering of 3-chords could describe the doubling of codons. The doubling would not occur for the codons for which one has the homonymy - a prediction, which could be perhaps tested.

### 7.4.2 The map DRNA-DtRNA by 3-chords

The map  $64 \rightarrow 40$  for DRNA-DtRNA inducing the corresponding map for  $RNA - tRNA$  is not unique since there are many ways to reduce 64 to 40. Could this relate to tRNA-RNA homonymy? Consider icosahedral code  $20 + 20 + 20 + 4 = (3 \times 6 + 2) + (5 \times 4) + (10 \times 2) + (3 + 1)$  as example.

1. Suppose  $Z_2$  is the divisor group (also  $Z_4$  and  $Z_3 \subset Z_6$  can be considered) so that the orbit can split to two and two tRNAs are associated with given amino-acid coded by  $n$  codons. At the first step one can take  $20_1 + 20_2 + 20_3 + 4 \rightarrow 20_1 + 10_2 + 10_3 + 4 = 44$ . Also  $10_1 + 20_2 + 10_3 + 4$  and  $10_1 + 10_2 + 20_3 + 4$  can be considered. Since  $Z_n$  has  $Z_2$  as subgroup, the simplest manner to achieve  $20_k = 10_k$  is to divide all orbits to 2  $Z_2$  cosets. This can be carried out in 3 ways.
2. One must get rid of 4 tRNAs. This can be achieved in several ways. In  $20_1 = 3 \times 6 + 2$  one could have  $6 + 2 \rightarrow 3 + 1$ : there are 3 alternatives. In  $20_2 = 5 \times 4$  one could have  $5 \times 4 \rightarrow 3 \times 4 + 2 + 2$  (10 ways). In  $20_3 = 10 \times 2$  one can take two 2:s to 1 (45) ways.
3. Could all these maps be realized and could they correspond to different maps at the level of dark codons? If the independence of resonances energies on frequencies is true with an appropriate choice of  $h_{eff,i}$ , it would seem that in all these cases same chemical tRNA is possible.

### 7.4.3 Homonymies for RNA-AA correspondence

There are two basic types of homonymies involving bio-molecules.

1. RNA-AA correspondence can vary somewhat and there are 31 variants of genetic code. RNA-tRNA homonymies are common and wobble phenomenon could be regarded as such homonymy. This homonymy is poorly understood.

I made the first attempt to understand homonymies in [L120] but failed to realize one absolutely essential feature. Despite RNA-tRNA homonymies there are practically no RNA-AA homonymies. They might be completely absent for given genetic code. There must be a simple explanation for this.

2. In TGD framework the genetic code is replaced with 3 codes. There is DRNA-DtRNA code mapping 64 DRNA codons to 40 DtRNA codons and  $DtRNA - DAA$  code mapping 40 DtRNA codons to 20 DAAs. The composition of these codes gives DRNA-DAA code inducing the RNA-AA code.

The highly non-trivial fact is that one has what mathematician would call commuting triangle:  $RNA-tRNA-AA = RNA-AA$  for given code. All the homonymies of RNA-tRNA code are possibly completely compensated for given  $RNA - AA$  code. This must have simple explanation and once one has made this question, one also knows its answer in TGD framework.

3. For Hamiltonian cycles the  $n(A)$  codons coding for given AA corresponds to orbit of a fixed codon at the orbit having symmetry group  $Z_{n(A)}$ . Genetic code maps the codons at the orbit to the AA corresponding to the orbit and replaces the symmetry group  $Z_n$  with trivial group  $Z_n/Z_n = Z_1$ .

*Remark:* There are 6 chaotic icosahedral Hamiltonian cycles with symmetry group  $Z_1$  so that therefore 20 amino-acids each coded by single codon. Could one interpret the 20 amino-acids with the chaotic representation of chaotic icosahedral Hamiltonian cycle?

For RNA-tRNA correspondence similar process is possible. Now one replaces  $Z_n/Z_k$  where  $k$  is factor of  $n$ .

Consider icosahedral code as an example.  $k = 2$  is simplest choice since it divides  $n = 6, 4, 2$  for icosahedral codes but not for tetrahedral code for which one has  $n = 3$ : (*ile, ile, ile, met*) would naturally correspond to the 2 orbits under tetrahedral  $Z_3$ . This symmetry appears only for icosahedral option. For other options one can explain it as

an outcome of symmetry breaking for doublets and (ile,ile) and symmetry broken (ile,met) would have ile in common. This looks un-natural.

One can indeed construct  $64 \rightarrow 40$  map for DRNA and DtRNA codons by replacing some orbits with their  $Z_2$  cosets but this map is not completely unique. This is possible for all code candidates, which all contain  $Z_6$  and  $Z_4$  symmetric icosahedral harmonies giving rise to amino-acids corresponding to 3 6-orbits and one 2-orbit for  $Z_6$  symmetry and 5 4-orbits with  $Z_4$  symmetry. The remaining orbits are 3-orbit and 1-orbit for tetrahedral symmetry broken to  $Z_3$  and 2-plets for  $Z_2$  orbits.

There are however codes for which RNA-AA correspondence is non-standard. As explained above, the simultaneous replacement  $UUC\text{-}Leu \rightarrow UUC\text{-}Phe$  and  $UUG\text{-}Leu \rightarrow UUG\text{-}Ser$  can take place. Also  $AUG\text{-}met \rightarrow CUG\text{-}met$  and  $GUG\text{-}met \rightarrow GUG\text{-}met$  can occur.

A general explanation could be as follows. If the two homonymous amino-acids - Phe and Leu and Leu and Ser in the first example and met and Leu and Val in the second example- have very nearly same transition energy, and if the 3-chords correspond transition energies of AA irrespective of frequencies, homonymy becomes possible.

This problem can be avoided if the tRNA pairing second AA with the RNA codon is not present. Both options might be realized in the same organism. It could also happen that second AA is so far from energy resonance that it is only rarely translated.

#### 7.4.4 Homonymies for RNA-tRNA correspondence

Could the possibility of several harmonies/moods with different chords increase the number of tRNA codons from the minimal value 40? Are these homonymies forced by necessity or do their reflect freedom of MB to choose? Do dialects emerge already at the molecular level and do they have some practical advantage?

1. Could the possibility of several moods demand more than the minimal number of tRNAs. Harmonies correspond to different collections of triplets  $(n_1, n_2, n_3)$  characterizing the chord.

It was however already noticed that the variation of the Planck constants  $h_{eff} \rightarrow h_{eff}/n_i$  associated with the flux tubes can modify the cyclotron energies. This would mean that the emotions are not directly seen at the level of molecular transitions as bio-chemist would certainly argue. If energy resonance couples dark photons to ordinary matter it could be possible to guarantee the coupling energy does not depend on the values of frequencies of the 3-chord at flux tubes. This would suggest that there is no motivation to increase the number of tRNAs for the lack of required resonance energies.

2. Could a large number of tRNAs as mediators of RNA-AA pairing be something chosen intentionally by MB rather than being forced by chemical limitations. Could surplus of different tRNAs be a safer option when some tRNAs are not produced. In natural languages there is large number of dialects and new are born all the time.

No hard-wired correspondence would exist at chemical level. MB would be to some degree creative and able to build tRNAs from the stuff that it happens to find from the lab! Biology could be creative already at RNA-tRNA level and this flexibility could emerge from the intelligence coded by  $h_{eff} = n$ : the larger the number of factors of  $n$  the higher the intelligence of the system would be.

This flexibility might also explain the homonymy at RNA-AA level and different genetic codes as a formation of dialects.

## 7.5 About the details of the genetic code based on bio-harmony

TGD suggests several realizations of music harmonies in terms of Hamiltonian cycles representing the notes of music scale, most naturally 12-note scale represented as vertices of the graph used. The most plausible realization of the harmony is as icosahedral harmony [L31] (see <http://tinyurl.com/yad4tqwl> and <http://tinyurl.com/yyjpm25r>).

1. Icosahedron (see <http://tinyurl.com/15sphzz>) has 12 vertices and Hamiltonian cycle as a representation of 12-note scale would go through all vertices such that two nearest vertices along the cycle would differ by quint (frequency scaling by factor  $3/2$  modulo octave equivalence). Icosahedron allows a large number of inequivalent Hamiltonian cycles and thus harmonies characterized by the subgroup of icosahedral group leaving the cycle invariant. This group can be  $Z_6$ ,  $Z_4$ , or  $Z_2$  which acts either as reflection group or corresponds to a rotation by  $\pi$ .
2. The fusion of 3 icosahedral harmonies with symmetry groups  $Z_6$ ,  $Z_4$  and  $Z_2$  gives  $20+20+20=60$  3-chords and  $3+1+5+10=19$  orbits of these under symmetry group and almost vertebrate genetic code when 3-chords are identified as analogs of DNA codons and their orbits as amino-acids. One obtains counterparts of 60 DNA codons and  $3+1+5+10=19$  amino-acids so that 4 DNA codons and 1 amino-acid are missing.
3. The problem disappears if one adds tetrahedral harmony with 4 codons as faces of tetrahedron and 1 amino-acid as the orbit of the face of tetrahedron. One obtains 64 analogs of DNA codons and 20 analogs of amino-acids. I call this harmony bio-harmony. The predicted number of DNA codons coding for given amino-acid is the number of triangles at the orbit of given triangle and the numbers are those for genetic code.
4. How to realize the fusion of harmonies? Perhaps the simplest realization that I have found hitherto is based on union of tetrahedron of 3 icosahedrons obtained by gluing tetrahedron to icosahedron along its face which is triangle. The precise geometric interpretation of this realization has been however missing and I have considered several variants. I have proposed that the model could explain the two additional amino-acids Pyl and Sec appearing in Nature. There is also a slight breaking of symmetries: ile 4-plet breaks into ile triplet and met singlet and trp double breaks into stop and trp also leu 4-plet can break in leu triplet and ser singlet (see <http://tinyurl.com/puw82x8>). This symmetry breaking should be understood.

### 7.5.1 Why 3 icosahedral harmonies and 1 tetrahedral harmony?

The following argument suggests a more detailed solution of these problems than proposed earlier.

1. The copies of icosahedron would differ by a rotation by multiples of  $2\pi/3$  ( $Z_3$ ) around axis through the common triangular face. This face unlike the other faces remains un-affected. Also tetrahedron remains un-affected so that it is counted only once.  
If the 3 copies of the icosahedral common face are counted as separate (this is important!), one obtains  $20+20+20$  faces from icosahedron. If also tetrahedral shared faces is counted as separate, tetrahedron gives 4 faces: 64 codons altogether as required. One obtains 19 orbits from the 3 icosahedra and 1 orbit from tetrahedron: 20 orbits as counterparts of amino-acids altogether.
2. But can one really counter the 4 common faces as separate? One must do so. Could these faces be interpreted as somehow special codons? Maybe as stop codons or start codons for the vertebrate genetic code which also corresponds to the realization of DNA, RNA, tRNA, and amino-acids as dark proton triplets so that DNA sequences would correspond to dark proton sequences. Could the shared codons be assigned with various modifications of the vertebrate code involving also exotic amino-acids Pyl and Sec.
3. Consider first the tetrahedral face. If the common face is removed from the 4-face orbit of tetrahedron, the orbit has only 3 faces and correspond to an amino-acid coded by 3 DNA codons. ile is the only such amino-acid and the interpretation could be that one ile corresponds to the 3 tetrahedral faces and met acting as start codon to the fourth shared face.
4. Also 3 icosahedral amino-acids corresponding to orbits containing the shared face can lose 1 codon each. To make this more concrete, one can look for the deviations from the vertebrate code.

- (a) There are 10 doublets if the doublet UAA, UAG acting as stop codons is counted as doublet coding for stop regarded formally as amino-acid.
  - (b) The second member in the doublet UGA, UGG coding for tyr in code table could correspond to a common face and act as a stop codon.
  - (c) For the modifications of genetic code UAG coding for stop can code for Pyl and UGA coding for stop can also code for Sec. UGA can also code for trp so that there would not be any symmetry breaking in this case. Could UAG and UGA correspond to common faces for two icosahedra?
  - (d) There is also third icosahedral shared face. CUG coding for leu can also code for ser. Could this correspond to the third exceptional codon associated with the icosahedral part of the code?
5. If the answers to the questions are affirmative, all basic deviations from the vertebrate code can be understood. The translation of the codons associated with shared face would be unstable for some reason.
- (a) 3-chord representation is more fundamental than the chemical one. This could mean that the chords associated with the shared faces are very near to each other so that the correspondence between 3-chord representation and chemical representation of codons becomes unstable if based on triple resonance.
  - (b) The proposal has indeed been that the 13th vertex implied by tetrahedron corresponds to a note very near to one of the notes of 12-note scale - this note is necessary since the 12-note scale defined by quints gives 12th note slightly more than octave under octave equivalence as discovered already by Pythagoras.

If this picture is correct, the symmetry breaking of the genetic code would be due to the presence of the face common to icosahedron and tetrahedron and reflect the problem discovered already by Pythagoras. The rational number based Pythagorean scale defined by quints is special: people with absolute pitch prefer it over the well-tempered scale involving powers of irrational number  $2^{1/12}$  requiring extension of rationals.

### 7.5.2 Could stop codons correspond to dissonant 3-chords?

One can approach the situation also from the point of view of harmony - or rather, dis-harmony: could dissonance 3-chords act as stop codons. The 3-chords of icosahedral harmonies can be classified to three groups depending on whether the triangle representing the chord contains 0, 1, or 2 sides [L31]: in other words, whether the chord contains 0, 1, or 2 quints. The harmonies can be labelled by the triplet  $(n_0, n_1, n_2)$  telling the numbers of chords with 0, 1, and 2 quints.

1. The unique  $Z_6$  harmony necessarily present in the bio-harmony has  $(2, 12, 6)$ . It has two augmented chords (transposes of  $C_{aug} = CDG\sharp$ ) containing two major thirds and defining the 3-chord of a harmony assignable to triangle). This beautiful chord to which finnish tangos so often end, cannot be regarded as dissonance.
2. The 2  $Z_4$  harmonies have  $(n_0, n_1, n_2) = (0, 16, 4)$  and  $(4, 8, 8)$ . For the latter harmony one has genuine dissonances since the highest and lowest note of 3-chord are separated by major or minor third. The chords with 0 quints labelled by script "ex1", "ex2", ..., "ex6" (for the notation see [L31]) are dissonances in this sense. "ex7" and "ex8" ( $CDF\sharp$  and  $CDG\sharp$ ) cannot be regarded as dissonances in this sense.
3. The 3  $Z_{2,rot}$  harmonies have  $(0, 16, 4)$ ,  $(2, 12, 6)$ , and  $(4, 8, 8)$ . Both 2-plets and 4-plets contain 2 dissonances.
4. There are 3  $Z_{2,refl}$  harmonies with  $(2, 12, 6)$  and 1 with  $(4, 8, 8)$ . These harmonies have genuine dissonances. Interestingly,  $(2, 12, 6)$  corresponds to a doublet for which only the second member corresponds to dissonance.

5. For tetrahedral harmony single step should correspond to  $1/4$ th of octave (using suitable power of  $3/2$  as a rational approximation) so that the notes at the vertices of tetrahedron should correspond to  $CE\flat F\sharp$  defining  $C_{dim}$ . This does not appear in the icosahedral code table as 0-quint chord. Although the triangles of tetrahedron and icosahedron would be shared in some sense, the chords cannot be same. This support the idea that ile triplet and met are coded by tetrahedral faces.

The chords containing 0 quints appearing in  $Z_4$  and  $Z_2$  harmonics can be regarded as dissonant. The minimization of dissonance would give a fusion of the unique  $Z_6$  harmony (2, 12, 6), unique  $Z_4$  harmony (0, 16, 4) and unique  $Z_{2,rot}$  harmony (0, 16, 4). Bio-harmony would be unique and contain no dissonances. Recall however that the proposal is that bio-harmonies serve as correlates for moods realized even at the level of basic bio-molecules.

For other options one would have dissonant chords.  $Z_{2,refl}$  harmony (2, 12, 6) has only single dissonant chord. Since stop codons would naturally correspond to dissonances, this observation raises some questions.

1. Could the dissonant chord of  $Z_{2,refl}$  harmony (2, 12, 6) correspond to the triangle shared by tetrahedron and icosahedron? Could this correspond to (stop, trp) pair with stop coded by dissonant chord "ex"7 ( $CDF\sharp$  defining part of D7 chord). This would fix the code to contain  $Z_6$  harmony (2, 12, 6), unique  $Z_4$  harmony (0, 16, 4) and unique  $Z_{2,refl}$  harmony (2, 12, 6). There would be single dissonance coding for stop in stop, trp doublet.
2. The doublet coding for stop should formally code for amino-acid. One cannot realize this doublet as a doublet of dissonances with "ex" $n$ , with  $n \in \{1, \dots, 6\}$  for single bio-harmony. The second member of this doublet could however correspond to the shared triangle.

This tentative picture should be of course checked. There are also cycles without any symmetries. Could these chaotic cycles be interpreted as disharmonies.

### 7.5.3 How could the representations of genetic code as dark 3-chords and nucleotide triplets relate?

One of the poorly understood aspects of the model is how the various representations of the code relate.

#### Frequency coding of nucleotides is not possible

Frequency coding of nucleotides would look natural but it is easy to see that it is in conflict with bio-harmony.

1. The representations as dark proton triplets and dark photon triplets do not involve decomposition to ordered triplet of letters as the ordinary chemical representation does. Dark protons are entangled and one cannot order them and there is no obvious ordering of the frequencies of dark photons.

This is not a problem for the correspondence between dark proton triplets and dark photon triplets and one can even imagine assignment of dark cyclotron photons with 3 parallel flux tubes acting as wave guides. This could mediate the interaction between dark variants of basic biomolecules with same value of  $h_{eff}$  as frequency resonance.

2. The interaction between ordinary DNA/RNA/tRNA and its dark variant should involve the transformation of dark photon triplet associated with flux tube triplet emanating from dark bio-molecule to ordinary photons (possibly bio-photons) and energy resonance would be involved. Is the energy resonance involved with the formation of the dark-ordinary pairs or with the sustainment of these pairings? The example of benzene suggests sustainment.
3. The assumption that energy resonance is involved with dark-ordinary pairing indeed leads to problems. The first guess would be that ordinary photon triplet somehow carries information about the position of nucleotide in the codon. The 4 nucleotides would correspond to 4 frequencies with frequency scale depending on the position inside the codon. There are indeed

12 frequencies in the 12-note scale so that 3 frequency scales with 4 frequencies associated with each of them would give 64 combinations of frequencies.

Frequency coding of nucleotides however leads to a problem. The first two letters of the codon are known to determine the amino-acid coded by it to a high degree since the third letter typically distinguishes between 1 or 2 amino-acids only, and labels codons at the orbit of DNA codon defining amino-acid. Therefore for DNA codons coding same amino-acid the first two frequencies should be same. This is not the case for bio-harmony for the simple reason that the frequencies of 3-chords along the orbit defining amino-acids are different. Only the frequency ratios defining the type of the chord are same along the orbit.

The frequency ratios determine the correspondence so that the correspondence can be only between *entire* dark and ordinary codons, and cannot be reduced to correspondence between frequencies and letters. Holism does not reduce to reductionism.

### **Does the impossibility of frequency coding of nucleotides lead to problems with the models of replication and transcription?**

This becomes a potential problem in the model for DNA replication and transcription to RNA.

1. The basic picture about bio-catalysis in TGD framework is following. U-shaped magnetic flux tubes emanate from the reactants and can reconnect to form a pair of flux tubes connecting the reactants. The shortening of the flux tube pair by a reduction of  $h_{eff}$  brings the reactants together and liberates the energy needed to kick the reactants over the potential wall making the reaction rate extremely low otherwise.

The U-shaped flux tubes or flux tube triplets would be associated with dark codons of dark DNA accompanying DNA strand, and would be formed as the flux tube pair(s) connecting the strands split by the reversal of reconnection. The  $h_{eff}$  associated with resulting U-shaped flux tubes associated with replicating strands would increase requiring metabolic energy. They would get longer and could act as tentacles scanning the environment to spot similar flux tubes assignable to nucleotides or codons by resonance.

2. In the standard picture one assumes that nucleotides defining the letters of the codons appear as non-correlated molecules in the environment, and that each codon is built by a stepwise process in which letters attach to it. The letters can respond only to single frequency and cannot "know" which position to attach to. The frequency coding is not consistent with the idea that dark photon triplet assigned with the dark codon gives rise to energy resonance with the letters one by one.

Could the triple resonance occur as single step and attach all 3 nucleotides in single step? Or could the triple resonance be a collective frequency resonance with dark codon already attached to the ordinary codon in the environment. Ordinary-dark pairing by energy resonance would sustain rather than generate DNA strand since otherwise the Coulomb repulsion due to the large negative charge of DNA does not allow stability.

3. The problem is that it is nucleotides seem to appear in the environment rather than codons. Could the nucleotides of the environment actually form loose codons connected to dark codons by long flux tubes with large value of  $h_{eff}$ ? Could the reduction of  $h_{eff}$  bringing nucleotides together induce the reduction of flux tube lengths giving rise to ordinary codon? If the reduction of  $h_{eff}$  for flux tubes occurs nucleotide-by nucleotide, one would have consistency with the standard picture. The simplest picture is following.

Dark codons are paired with the loose variants ordinary codons. The opening of DNA double strand leads to the splitting of the flux tube pairs connecting the ordinary codons of strands to U-shaped flux tubes, which reconnect with U-shaped flux tubes coming dark codons paired with loose ordinary codons. The reduction of  $h_{eff}$  d pairs nucleotides of loose codons with those of ordinary codons.

4. The pairs of dark codons and loose codons would be analogous to tRNA molecules. One can imagine even pre-tRNA molecules with loose coupling of RNA and amino-acid so that

replication and transcription would be very similar topological processes. Also RNA transcription and translation of RNA to amino-acids would rely on similar mechanism. The only difference would be that only the second - active - strand would form U-shaped flux tubes connecting with dark RNA codons.

### What about remote DNA replication

This model could also explain remote replication of DNA for which Montagnier *et al* have reported evidence [I36]. Also remote transcription is predicted to be possible. I have already earlier considered a model of remote replication [K131] in an article written together with Peter Gariaev who has reported this kind phenomenon already earlier. I have discussed the findings of Montagnier *et al* in [L15].

1. The experiment involves two vessels, call them A and B. A contains genes and B only nucleotides - at least according to the standard picture. There is irradiation using 7 Hz frequency not far from the lowest Schumann frequency having a nominal value of 7.8 Hz. What happens is that the replicas of genes appear in B. It is also reported that the DNA generates em radiation possibly responsible for the information transfer.
2. The proposed model for the ordinary DNA replication generalizes easily to describe also remote replication. The new element would be that the U-shaped flux tubes from A would extend to B - here 7 Hz radiation could be essential - , would be parallel to each other, and have same average length, which is natural if they have same value of  $h_{eff}$ . Also the experimental arrangement could favor parallel flux tubes. In B the dark codons paired with loose codons formed from ordinary nucleotides would be present, and their U-shaped flux tubes would reconnect with those coming from A. Remote replication could take place: here it is essential that the U-shaped flux tubes are parallel and have very nearly the same length.

The TGD interpretation would be that the Earth's magnetic body is involved and generates quantum coherence in the length scale at least the size of the system studied. The reported em radiation would naturally relate to the dark photon triplets representing the codons.

### Is ZEO needed to understand the replication?

In TGD one must give up thinking in terms of standard ontology of bio-chemistry in which the process is a kinetic process governed by differential equations for the populations of molecules and proceeding in step-wise manner nucleotide by nucleotide. ZEO suggests temporal holism - at least at the level of single dark codon, which cannot be built building brick by building brick.

1. An open question is in which time scale this temporal quantum holism holds true: in the time scale of addition of single codon or in the time scale of replication of gene or something else? In the following the possibility that temporal holism holds in the time scale for the pairing of dark codons.
2. In ZEO one could have state function reduction in which initial state corresponds to dark codon plus population of nucleotides and final state to dark codon paired with the ordinary codon formed from 3 nucleotides in energy resonance with the codon formed from nucleotides. What matters are only the initial and final states.
3. If "big" state function reduction (BSFR) is in question, the final state would correspond to a superposition of deterministic time evolutions leading from the outcome of the reduction to geometric past, possibly but not necessary to a state in which nucleotides do not form codon paired with the dark codon.
4. The process would create strong correlations between the position of nucleotides of the codon and between the positions of codon and its dark variant and therefore a generation of entanglement. Unitary evolutions followed by "small" state function reductions (SSFRs) would generate a state as a superposition of the states satisfying the criteria of the desired final state and other states and BSFR would select the desired final state. It could be followed by BSFR returning the original arrow of time but doing nothing for the state.



## 7.6 How to compose beautiful music of light in bio-harmony?

The topic of this section is the detailed definition of the notion of bio-harmony [L39, L40, L156]. A sequence of 3-chords of bio-harmony defines a music piece: what rules guarantee that this piece is beautiful? This question is interesting because the chords of bio-harmony correspond to DNA codons.

### Bio-harmony as a realization of genetic code

TGD leads to a notion of bio-harmony in terms of icosahedral and tetrahedral geometries and 3-chords made of light assigned to the triangular faces of icosahedron and tetrahedron [L39, L40, L156]. Bio-harmonies are associated with the so-called Hamiltonian cycles, which go through every vertex of Platonic solid once. For icosahedron the number of vertices is 12, the number of notes in 12-note scale. The 64 codons of bio-harmony represented as light 3-chords formed by dark photon triplets are formed from 3 20-chord harmonies associated with icosahedron and the unique 4-chord harmony associated with tetrahedron.

The surprise was that vertebrate genetic code emerged as a prediction: the numbers of DNA codons coding for a given amino acid are predicted correctly. DNA codons correspond to triangular faces and the orbit of a given triangle under the symmetries of the bio-harmony in question corresponds to DNA codons coding for the amino acid assigned with the orbit.

Codon corresponds to 6 bits: this is information in the usual computational sense. Bio-harmony codes for mood: emotional information related to emotional intelligence as ability to get to the same mood allowing to receive this information. Bio-harmony would be a fundamental representation of information realized already at molecular level and speech, hearing and other expressions of information would be based on it. For emotional expression at RNA level possibly involved with conditioning at synaptic level see [L113].

### About generalizations of the notion of bio-harmony

One can consider several generalizations for the notion of bio-harmony.

1. All Platonic solids, in particular tetrahedron, cube, octahedron and dodecahedron are possible and one can consider the possibility that they also define harmonies in terms of Hamiltonian cycles. Dodecahedron would have 5-chords (pentagons as faces) as basic chords and there is only single harmony. Same mood always, very eastern and enlightened as also the fact that scale would have 20 notes.

Also octahedron gives 3-chords (triangular faces) whereas cube gives 4-chords (squares as faces). One can of course speculate with the idea that DNA could also represent this kind of harmonies: sometimes the 3N rule is indeed broken, for instance for introns.

2. Galois confinement [L174] allows the possibility to interpret dark genes as sequences of  $N$  dark photon triplets as higher level structures behaving like a single quantal unit. This would be true also for the corresponding dark photon sequences consisting of  $3N$  dark photons representing the gene in bio-harmony as an analog of a music piece consisting of 3-chords and played by transcribing it to mRNA.

Basic biomolecules (DNA, RNA, tRNA, amino acids) would have names represented as a sequence of light 3-chords representing a piece of music and dark biomolecules with the same name could recognize and communicate with each other in  $3N$ -resonance. Dark-ordinary communications could transform dark  $3N$ -photon to single bio-photon so that resonance would be possible when the sum of energies coincides with a transition energy of the ordinary biomolecule. The resonance condition would very effectively select survivors in the fight for survival.

3. The picture can be viewed even more generally. Any discrete structure, defining graph, in particular cognitive representation providing a unique finite discretization of space-time surface as points with the coordinates of the 8-D embedding space coordinates in the extension of rationals, defines harmonies in terms of Hamiltonian cycles. Could also these harmonies make sense? The restrictions of the cognitive representations to 2-D partonic 2-surfaces would

define something analogous to bio-harmony as Hamiltonian cycle of 2-D graph (Platonic surfaces solids can be regarded as 2-D graphs). The interpretation as representations of Galois groups and the notion of Galois confinement is possible although one loses the symmetries of the Platonic solids allowing to identify genetic code.

During years I have indeed considered some modifications of the original bio-harmony base on the fusion of 3 icosahedral harmonies and tetrahedral harmony in particular so called  $E_8$  harmony and toric harmony [L58, L112] but the overall conclusion [L140] is that the original model is the most plausible candidate.

### The challenges of the model

The model of bio-harmony is far from complete and this article discusses a more detailed definition. Also the question about the rules defining beautiful music by posing rules on chord sequences are considered. These aesthetic rules are also rules for the corresponding DNA and amino-acid sequences.

1. The fusion of the three harmonies having symmetry groups  $Z_n$ ,  $n = 6, 4, 2$  has been considered but not in the required detail. The Hamiltonian cycles of icosahedron are fixed only modulo isometries of icosahedron preserving the shape of the cycle, scalings of the cycle by a power of quint forming group  $Z_{12}$  leaving the cycle of invariant but inducing transposition (change of the key), and the change of the cycle orientation possibly related to minor-major dichotomy correlating with joyful-sad dichotomy. For a single icosahedral cycle these transformations do not change anything but for the fusion of 3 cycles realized at the same icosahedron the situation changes, and the number of harmonies increases dramatically.

Are all combinations of icosahedral harmonies allowed or are there some natural restrictions on them? I have considered this question but it seems that there is no good reason for posing any restrictions. The spectrum of harmonies determined by dark genetic codons and therefore the spectrum of emotions at the molecular level would be surprisingly rich.

2. Is it possible to reproduce the basic harmonies of the western music based on the 12-note system which inspired icosahedral harmonies? In particular, can one understand the chords C, F, G of C-major scale? By octave equivalence the nearest neighbors of the Hamiltonian cycle are related by quint scaling frequency by factor  $3/2$  scaling C to G. The 3-chords containing at least one cycle edge contain quint (C → G) and quint is the basic aspect of bio-harmony. For harmonies with opposite orientation quints become perfect fourths (C → F) and FCG corresponds to transposition of F by two quints.

For a single icosahedral harmony the chord-pairs analogous to C-F or C-G do not appear in any obvious manner. If the 3 icosahedral harmonies are related by quint scalings (FCG) the analogs of these chord pairs become natural. Could this be the solution to the problem?

3. What are the rules producing aesthetically satisfying music? I experimented with the ultraconservative assumption that only chord pairs containing common quint are allowed: the result was not ugly but it was boring. Already the transitions of CFG major scale are too radical for this option!

An attractive idea is that the sequence of 3-chords is continuous in some sense. Could the sense be strictly geometric: could chord pairs be nearest neighbors in some sense. For Option I nearest neighbors have a common edge (3 nearest neighbours). For Option II they have a common vertex (10 nearest neighbors). These options do not allow all 3-chord pairs and thus not all possible DNA pairs and all possible amino-acid pairs. A more abstract definition identifies the nearest neighbors with the orbits of nearest neighbors for Option I or II under the symmetry group  $Z_n$  ( $n = 6, 2$ ). Codon is replaced with the codons coding for the same amino-acid. For Option II this allows to have all possible chord pairs and therefore DNA and amino-acid pairs.

4. Also the role of tetrahedral harmony and its relation to start and stop codons is interesting. One wants also to understand why the genetic code at the bio-chemical level is not quite complete and why there are several variants of it.

| Symmetry     | $\#(class)$ | $\#(repr)$ |
|--------------|-------------|------------|
| $Z_6$        | 1           | 8          |
| $Z_4$        | 2           | 12         |
| $Z_{2,rot}$  | 3           | 24         |
| $Z_{2,refl}$ | 5           | 24         |

**Table 7.1:** The number  $\#(class)$  of equivalence classes of Hamiltonian cycles and the number  $\#(repr)$  of representatives in the class for icosahedral Hamiltonian cycles. If the orientation is not taken into account the number of representatives reduces to  $\#(repr)/2$

### 7.6.1 About bio-harmonies

The set of allowed 3-chords define music harmony. The 12-note scale is essential for the western view about harmony. The TGD inspired geometric model for music harmony identifies bio-harmony as a fusion of 3 icosahedral harmonies with 12-note scale represented geometrically as a Hamiltonian cycle at icosahedron and 1 tetrahedral harmony represented as a unique Hamiltonian cycle of tetrahedron. Each icosahedral harmony has 20 3-chords identifiable as triangular faces of the icosahedron whereas tetrahedral harmony 4 3-chords. This gives  $20+20+20+4=64$  chords - the number of genetic codons.

#### Symmetries of icosahedral harmonies

There are 3 types of icosahedral harmonies with symmetries characterized by a subgroup of icosahedral isometries, which is  $Z_6$ ,  $Z_4$  or  $Z_2$  acting either as a rotation by  $\pi$  or as a reflection. The orbits of triangles are identified as counterparts of amino-acids coded by the DNA codons assigned with the triangles of the orbit.

1. For  $Z_6$  given triangle gives rise to 3 6-orbits with 6 triangles and 1 2-orbit:  $Z_3$  subgroup of icosahedral group permutes the 3 6-orbits and acts trivially to 2-orbit.
2. For  $Z_4$  there are 5 4-orbits and  $Z_5$  permutes these orbits.
3. For  $Z_2$  there are 10 2-orbits and  $Z_{10}$  permutes them.  $Z_2$  can act either as reflections or rotations.

There are also 6 cycles without any symmetries perhaps identifiable as dis-harmonies. They will not be considered in the sequel. For them the number of amino-acids coded by codon would be one.

**Table 7.1** summarizes the numbers of equivalence classes of cycles and under icosahedral rotation group for various symmetry groups as well as the numbers of representatives in the class. These numbers allow to deduce the number of bio-harmonies by fixing one of the icosahedral harmonies, most naturally the  $Z_6$  harmony for which one has only one class.

Remarkably, the combination of 3 icosahedral cycles with symmetries  $Z_k$ ,  $k = 6, 4, 2$  with the tetrahedral Hamiltonian cycle gives 64 codons and the model correctly predicts the numbers of DNA codons coding for a given amino acid. Could there be a connection between music and genetic code? Could one speak of bio harmonies as correlates of emotions at the molecular level?

The natural expectation is that the symmetries  $Z_n$  of a given harmony leave the ratios of frequencies of 3-chords invariant. This is true if the edge connecting nearest neighbors along Hamiltonian cycle corresponds to a quint that is scaling of frequency by  $3/2$  and projection to the basic octave (octave equivalence). Therefore the chords at the orbit of a given chord coding for the same amino-acid are replaced by a scaling by power of  $3/2$  so that the scalings are mapped to unitary rotations.

The factors of 12 include indeed 6, 4, and 2 so that the 12-element group of scalings modulo octave equivalence can be mapped to  $Z_{12}$  rotations. There is however a problem with rational quintus due to the fact that - as already Pythagoras found -  $(3/2)^{12} = 129.746\dots$  does not correspond exactly to  $2^7 = 128$ . One reason for introducing icosahedron could be that this brings additional note allowing to get rid of the problem. One can also construct the notes by powers of  $2^{1/12}$  applied

to the basic frequency but now the frequencies are not rational. Furthermore, people with absolute pitch favor rational frequency ratios, which suggests that rational numbers and roots of unity assignable with adelic physics as physics of cognition are really important.

### Fusion of 3 icosahedral harmonies and tetrahedral harmony to bio-harmony

There is quite a large number of icosahedral Hamiltonian cycles and therefore of bio-harmonies. Although the isometries of icosahedron and their transpositions do not matter for given icosahedral harmony, they matter when one has 3 icosahedral harmonies. A simple example from physics helps to understand this: although rotations are symmetries of an N-particle system the rotations of a single particle are not symmetries anymore and represent new degrees of freedom.

1. Bio-harmony assigns to the same icosahedron 3 Hamilton cycles with symmetries  $Z_k$ ,  $k = 6, 4, 2$ . This means assigning to the same icosahedron 3 Hamiltonian cycles giving rise to 3 representations of 12-note scale each giving 20 chords so that one 20+20+20 chords coding 3 classes of amino acids. Tetrahedron gives the remaining 4 chords.

There are  $N_i$ ,  $i = 1, 2, 3$  cycles corresponding to  $Z_{k(i)}$ ,  $k(i) = 6, 4, 2$ : for the values of  $N_i$  and detailed 3-chord contents of icosahedral harmonies see [L31]. From the table **Table 7.1** one has for  $(Z_6, Z_4, Z_{2,rot})$   $\#(class) = (\#(class)_1, \#(class)_2, \#(class)_3) = (1, 2, 3)$  giving 6 different classes and  $(Z_6, Z_4, Z_{2,refl})$   $(\#(class)_1, \#(class)_2, \#(class)_3) = (1, 2, 5)$  giving 8 different classes. This gives  $N = 14$  different icosahedral Hamiltonian cycles.

The numbers of representatives for given equivalence class are for both  $(Z_6, Z_4, Z_{2,rot})$   $(Z_6, Z_4, Z_{2,refl})$   $\#(repr) = (2, 12, 24)$ .

2. The 3 cycles go through all points of the icosahedron. This means that for each point of icosahedron there are 3 cycles going through that point. There can be however situations in which there are common edges. 5 edges arrive at given icosahedral vertex. There are 3 cycles entering and leaving the vertex: this makes 6 cycle edges. There is necessarily one edge shared by two cycles. If the edge is shared by 3 cycle edges, one edge has no cycle edge. This kind of situation - 3-edge - is achieved by performing a suitable  $Z_5$  rotation for the third cycle.

Do all bioharmonies have 3-edges? Could 3-edges have a special role concerning bio-harmony and music experience? Could they define chords with preferred quints such as chords C, F, G in C major scale? The bio-harmonies having chord(s) with 3-edge could give rise to simple CFG type harmonies. Fusion of 3 icosahedral harmonies differing by quint scalings gives a CFG type situation, and one could assign all these 3 types of chords with a triangle with 3-edge. Geometrically the chord progression would reduce to a repetition of the same triangle! Allowing also the triangle at the other side of the 3-edge, the chord progression involving only these 2 triangles consists of 3+3=6 chords.

3. One can assume that the 3 Hamiltonian cycles start at the same almost arbitrarily chosen vertex of the icosahedron. As a special case one can assume that it corresponds to the same basic note (C). Since  $Z_6$  allows only a single cycle, it is natural to fix it: the fact this cycle has 2 orientations gives degeneracy factor 2.

The other other cycles are determined apart from the rotation group  $Z_5$  leaving the base point invariant. Therefore the  $Z_4$  and  $Z_2$  harmonies give rise to an additional  $5^2 = 25$ -fold degeneracy of bio-harmonies  $N \rightarrow 25N$ . If the cycles are required to have a common first edge besides the base point, one does not obtain the degeneracy factor. This argument shows that common edges are possible and the vertices associated with them are definitely special.

Fixing the cycle types and the  $Z_6$  cycle one can calculate the number of bioharmonies for a given equivalence classes as the number  $\#(repr(Z_4))\#(repr(Z_2))$  One obtains  $12 \times 24$  representatives for both choices of  $Z_2$ . For  $r$   $Z_2 = Z_{rot}$  the total number of bioharmonies is

$$N(harmony, rot) = 2 \times 2 \times 12 \times 3 \times 24 = 2^7 \times 3^2$$

$$N(harmony, refl) = 2 \times 2 \times 12 \times 5 \times 24 = 2^7 \times 3 \times 5 \ .$$

The first factor of 2 comes from the two orientations for the fixed  $Z_6$  cycle.

4. The transpositions realized as scalings along the Hamiltonian cycle define 1-to-1 map of icosahedral vertices which is however not an isometry but preserves the harmony. This gives a degeneracy factor  $12^2$  and one has

$$N(\text{harmony}, \dots) \rightarrow 12^2 \times N(\text{harmony}, \dots) .$$

The formula for the total number of bioharmonies is

$$\begin{aligned} N(\text{harmony}) &= N(\text{harmony}, \text{rot}) + N(\text{harmony}, \text{refl}) = 2^{14} \times 3^3 , \\ N(\text{harmony}, \text{rot}) &= 2^{11} \times 3^4 , \\ N(\text{harmony}, \text{refl}) &= 2^{11} \times 3^3 \times 5 . \end{aligned} \tag{7.6.1}$$

$$\tag{7.6.2}$$

### How to understand the tetrahedral code and symmetry breaking of the perfect code?

The precise understanding of the relationship between tetrahedral and icosahedral codes has been a long standing challenge and I have considered several scenarios. The geometric idea has been that tetrahedron is somehow glued to icosahedron along on face and selects a unique codon of the icosahedron defining the basic chord. As found, another manner to fix this chord as a chord to which one can assign 3 cycle edges. There might be other faces with the same property.

One can get information about the situation by looking at the code table.

1. There are 10 unbroken icosahedral  $Z_2$  doublets containing (stop, stop) plus 1 symmetry broken doublet (stop, tyr). What could cause the symmetry breaking? The energy resonance condition associated with the pairing of dark mRNA codons with dark tRNA codons could explain the presence of stop codons: translation would stop when no tRNA in energy resonance is found.

Dark 3-photon representing the dark stop codons could not couple to tRNA codon in energy resonance since there would not be tRNA with cyclotron resonance energy triplet resonating with that of dark stop codon. This would be the case for the (punc, punc) doublet and also for punc member of (puc, trp) doublet. The mimicry of dark level by biochemical level would not be complete. For the variants of the code it would be even less complete.

2. From the table one learns that both  $Z_6$  and  $Z_4$  codons are realized completely for the vertebrate code. This leaves only one conclusion: (ile, ile, ile, met) must correspond to a  $Z^4$  symmetry breaking for tetrahedral rather than icosahedral 4-plet. The AGG coding for met, which is unique in the sense that it serves as a mark for the beginning of genes, would correspond to a tetrahedral face.

The failure of energy resonance could force the splitting of unbroken tetrahedral ile 4-plet to (ile, ile, ile, met). Fourth codon in  $Z_4$  4-plet would be in energy resonance with tRNA associated with met. Note that icosahedral code gives rise to  $4+5+10=19$  amino-acids and met provides the 20<sup>th</sup> amino acid. Symmetry breaking would be necessary to mark the starting and stopping points of transcription and translation.

3-chords also depend on the icosahedral harmony and for some icosahedral harmonies energy resonance could fail so that the emotional state of at dark matter level would reflect itself at the biochemical level. The number of icosahedral harmonies is (1, 2, 3, 5) for ( $Z_6, Z_4, Z_{\text{rot}}, Z_{2, \text{refl}}$ ). For  $Z_4$  and  $Z_2$  the failure of energy resonance is possible.

**Remark:** I must confess that many earlier texts about the problem contain a stupid error. I have considered the proposal that (ile, ile, ile, met) could correspond to symmetry broken icosahedral 4-plet. Vertebrate code has however 5 unbroken 4-plets corresponding to (val, pro, thr, ala, gly) as also 3 unbroken 6-plets (leu, ser, arg)! For vertebrate code the symmetry breaking can therefore occur only for icosahedral  $Z_2$  doublets and tetrahedral  $Z_4$  4-plet.

### Variations of the genetic code

There exists also as many as 31 genetic codes (see <http://tinyurl.com/ydeeyhjl>) and an interesting question is whether this relates to the context dependence. Mitochondrial codes differ from the nuclear code and there are several of them. The codes for viruses, prokaryotes, mitochondria and chloroplasts deviate from the standard code. As a rule, the non-standard codes break U-C or A-G symmetries for the third code letter.

In the proposed framework the failure of energy resonance conditions could be at the level of tRNA. The dark tRNA analog of RNA could be in energy resonance with "wrong" amino acid.

Some examples are in order (see <http://tinyurl.com/puw82x8>).

1. UUU can code Leu instead of Phe (symmetry breaks for Phe doublet) and CUG can code Ser rather than Leu (symmetry breaks for leu 6-plet). In this case it seems that the "problem" is at the level of tRNA. The dark RNA codon could couple with a "wrong" amino acid.
2. In bacteria the GUG and UUG coding for Val and Leu normally can serve as Start codons. In this case symmetry breaking for  $Z_4$  4-plet would be in question. The problem could be also at tRNA level. Note however that both tetrahedral codons and icosahedral  $Z_4$  codons have the same symmetry group. Could tetrahedral codons correspond to a different frequency scale and correspond to Leu and Val 4-plet instead of symmetry broken ile 4-plet.
3. UGA can code to trp rather than punc: in this case the broken symmetry would be restored since also UGG codes for trp. Both codons for (trp,trp) doublet would be in resonance: this supports the explanation for the emergence of the third stop codon.
4. There is variation even in human mitochondrial code (see <http://tinyurl.com/puw82x8>). In 2016, researchers studying the translation of malate dehydrogenase found that in about 4 per cent of the mRNAs encoding this enzyme the UAG Stop codon is naturally used to encode the AAs trp and arg. This phenomenon is known as Stop codon readthrough [I32]. Also this phenomenon could be understood at tRNA level.
5. There is also a variant of genetic code in which there are 21st and 22nd AAs Sec and Pyl coded by Stop codons. UGA in (punc,trp) doublet can code for Sec and punc in the same organism. UAG can code for (punc,punc) doublet Pyl instead of punc and UAG. This introduces additional breaking of A-G symmetry for the third letter of codon. Energy resonance at the level of tRNA could explain these deviations from the vertebrate code.

Peter Gariaev has introduced the notion of homonymy of genetic code meaning that the same codon can code for several amino-acids and the coding depends on context. I have considered this phenomenon from the TGD point of view in [L120]. Resonance could explain this phenomenon.

Dark mRNA codon could be in frequency resonance with dark tRNAs coding for different amino acids. The fraction of particular synonymous amino-acid produced in translation would naturally depend on how well the energy resonance condition is satisfied. Homonymy could also reduce to the level of tRNA: this happens if the coupling of the tRNA analog of RNA codon has energy resonance with several amino-acids.

### 7.6.2 How to produce beautiful bio-music?

Music expresses and produces emotions and harmonies in music correspond to emotions. Chemical representation of the genetic code should be the same irrespective of the emotional state of the gene represented at the magnetic body in terms of dark proton triplets also representing genetic codons and by music of light represents 3-chords of light with frequency ratios determined by one of the bio-harmonies.

This is achieved naturally. The correspondence between the chords of harmony and DNA and amino-acids does not depend on what vertex of icosahedron the base note (C for definiteness in the sequel) corresponds to. It also depends only on the shape of the Hamiltonian cycle invariant

under isometries of the icosahedron. Furthermore, transpositions of the scale by power of  $3/2$  plus projection to the basic octave do not affect the Hamiltonian cycle and therefore leave the correspondence with DNA codons and amino acids invariant.

The sequences of 3-chords would correspond to sequences of DNA codons mapped to sequences of amino-acids. Genes would be like music pieces. These music pieces would also serve as kind of names of passwords in 3N-fold resonance in communications between dark variants of basic biomolecules and between them and ordinary basic biomolecules. They would be like theme songs of TV series catching the attention or names essential for symbolic dynamics at the level of the basic biomolecules. The basic biomolecules in the same emotional state - that is having the same bio-harmony - could resonate and therefore couple.

What the rules for a beautiful bio-music could be? Could these rules select particular bioharmonies and/or particular DNA sequences as allowed chord progressions and allow a deeper understanding of why particular genes are selected? Note that the condition that the chords of bio-harmony define 3N-resonances assignable to transitions of the basic biomolecules could lead to the selection of both harmony and biomolecules. A weaker condition is that ordinary biomolecules couple only to the sum of frequencies appearing in 3N-frequency assignable to dark codon.

### Are beautiful chord sequences continuous in some sense?

The original model discussed in [L31, L140] started from a very conservative idea for what harmonic change of chord could be. The two chords should have at least a single quint. This fails for the chords with no quints. The resulting music pieces were also boring which is not a surprise: for instance, the transitions between basic chords C, F, G of C major scale are not possible.

This suggests that one should not start from music but from geometry. Let us consider isohedral geometry for simplicity and the proposed picture for the bio-harmonies.

1. Continuity in some sense is a natural requirement. The natural definition of continuity is that the sequence of 3-chords of progression should define a sequence of neighbouring triangles at the icosahedron. But how should one define neighborhood?
2. Concerning the notion of nearest neighbor, there are 3 options to consider.

**Option I:** The strong form of continuity is that neighboring triangles have at least one common edge. This allows 4 different chord pairs. This would mean 4 possible DNA codon pairs for a given Hamiltonian cycle. For bio-harmony the symmetry of icosahedral harmony determined by  $Z_n$  ( $n = 6, 4, 2$ ) can change and one would have  $4+4+4=12$  codon pairs. This kind of correlation for codon sequences would have been observed.

**Option II:** For a weaker option the neighboring triangles would have at least 1 common vertex. A given triangle would have  $4+3+2+1=10$  neighbors ("1" corresponds to the triangle itself as a neighbor). This would give  $10+10+10=30$  possible codon pairs.

Tetrahedral harmony gives further pairs but since one triangle of tetrahedron should correspond to a fixed triangle of icosahedron, this can change the situation for only a single chord. It is known that the minimum of 32 two codons are needed to code amino acids. The optimum situation very probably not reached for all bio-harmonies (if any), would be that the amino acid associated with the next codon can be any aminoacid. It should be easy to demonstrate by studying a sample of genes or more general DNA codon sequences to find that this prediction is wrong.

**Option III:** For the weakest option the nearest neighbors would correspond to triangles at the orbits of the nearest neighbors in the sense of **Option II** or perhaps even **Option I** under the symmetry group  $Z_n$  of a given cycle. For instance, the transitions which would not change the codon would be replaced with all codons coding for the same amino-acid. The notion of nearest neighbor would reduce to the level of amino-acids: only the transitions to codons coding for the same amino-acid would be possible.

For the generalization of **Option I**  $Z_6$  cycle would give 4 orbits of which several must be identical so that there are no problems.  $Z_4$  cycle would give 4 orbits with 4 codons so that one amino acid is missing. For the  $Z_2$  option one obtains only 4 2-orbi so that 6 amino-acids are missing.

For the generalization of **Option II** 10+10+10 nearest neighbours would be replaced with their orbits. For the  $Z_6$  cycle there are nearest neighbor 10 orbits and since there are only 4 orbits, there are no problems. For the  $Z_4$  cycle one there are 5 4-orbits so that the minimal degeneracy of a given orbit is 2.

For the  $Z_2$  cycle there are 10 2-orbits, and this number is obtained unless some 2-orbit occurs more than once. The 10 nearest neighbor triangles must correspond to different amino-acids: whether this is possible for all bioharmonies, remains an open question. In any case, it is plausible **Option III** can produce all possible codon pairs although this need not be the case for all bioharmonies. Could preferred bioharmonies be selected by the condition that all codon pairs are possible?

### What about melody?

Melody is also an important part of music. A rough rule of thumb is that a beautiful melody tends to contain notes of the chord accompanying it. Dissonance is of course what makes music really interesting. This can be understood as a resonant coupling of the notes of the melody with the notes appearing in the accompanying chords.

Can one apply this picture to the music of light? Could the dark 3-photon states bound to a single unit by Galois confinement tend to decay to ordinary 3-photon states (bio-photons) and could melody represented as a sequence of single photon states couples resonantly to these photons? Could melody correspond to as sequence dark photons 1-plets decaying to ordinary bio-photons coupling to the decay products of dark photon triplets representing genetic codons?

### Summary

The basic results of the article are a precise definition of bio-harmony allowing to obtain the analogs of ordinary simple harmonies as special cases and a proposal that the 3-chord sequence defines a beautiful music piece if it corresponds to a continuous sequence for icosahedral faces. In principle this criterion allows bio-harmonies for which all possible codon pairings appear in chord sequences but some bio-harmonies might be excluded.

## 7.7 Is genetic code part of fundamental physics in TGD framework?

### 7.7.1 3 basic realizations of the genetic code

Topological Geometroynamics (TGD) proposes 3 basic realizations of the genetic code [L140]. The first realization is the standard chemical realization. The second realization is in terms of dark proton sequences (dark nuclei) with proton triplet representing a codon. Ordinary DNA strands would be accompanied by dark magnetic flux tubes carrying the dark proton triplets. Also RNA, amino-acids and tRNA would have dark proton analogs.

The third realization is in terms of dark photon triplets and involves the notion of bio-harmony described in terms of icosahedral and tetrahedral geometries with 3-chords of light (perhaps also sound) assigned to the triangular faces of icosahedron and tetrahedron. 12-note scale is realized as a Hamiltonian cycle for icosahedron with the step between nearest neighbor vertices for the cycle realised as quin (scaling of frequency by factor  $3/2$ ). The 3-chords correspond to the triangular faces of the icosahedron. Also tetrahedral realization of 4-note scale is necessary in order to obtain genetic code. DNA codons correspond to triangular faces and the orbit of a given triangle under the symmetries of the bio-harmony corresponds to DNA codons coding for the amino acid assigned with the orbit. Vertebrate genetic code emerges as a prediction.

The 3-chords of dark photon triangles are assigned with the triangular faces of icosahedron and tetrahedron [L31, L140, L171] such that their corners are labelled by the notes of the 12- and 4-note scales realized as a icosahedral and tetrahedral Hamiltonian cycles, which are closed paths connecting vertex to neighboring vertex and going through every vertex once.

Genetic code corresponds to a fusion of tetrahedral harmony with 4 chords and of 3 icosahedral harmonies with 20 3-chords having as group of symmetries  $Z_6$ ,  $Z_4$  and  $Z_2$  -  $Z_2$  can correspond



either to reflection or rotation by  $\pi$ . There are also 6 disharmonies without any symmetries ( $Z_1$ ) with single DNA codon coding for single amino-acid. There is a considerable number of different icosahedral harmonies and the 3 icosahedral harmonies can be in different key so that a large number of bio-harmonies is possible [L171]. The details of the model of bio-harmony are not completely fixed. In particular, the understanding of stop codons is not completely satisfactory. The small deviations from the vertebrate code (say bacteria and mitochondria) could be understood as being due to the incomplete mimicry of the dark code by chemical code in accordance with the idea that the mimicry has gradually evolved more complete.

Dark photon 3-chords mediate interaction between various realizations. Both dark proton and dark photon triplets would be dynamical units analogous to protons as color confined states of 3 quarks and in the adelic vision the notion of color confinement is replaced with Galois confinement [L171, L224]. Also genes could be seen as Galois confined states of 3N dark protons and dark photons. 3N-photon exchange would be realized as 3N-fold frequency - and energy resonance (mere energy resonance) between dark levels with the same value (different values) of  $h_{eff}$ . The possibility to modify the value of  $h_{eff}$  for flux tube makes it possible to have for a given codon single resonance energy [L224, L222, L223].

There are several questions relating to the bio-harmony.

1. The gluing of icosahedron and tetrahedron along the face looks ugly in the original model. Why both icosahedron and tetrahedron and why the gluing? The recent progress with  $M^8-H$  duality [L165, L166] suggests an answer. The tessellations (honeycombs) of hyperbolic 3-space  $H^3$  appear at the fundamental level and induce sub-tessellations of the magnetic flux tubes. One of these honeycombs- tetrahedral-icosahedral honeycomb (TIH)- involves all Platonic solids with triangular faces - tetrahedron, octahedron, and icosahedron. Could genetic code relate to TIH?

Cognitive representation [L101, L148, L152] as a set of points of space-time surface in the space of complexified octonions  $O_c$  with points having  $O_c$  coordinates in extension of rationals associated with the polynomial defining the space-time surfaces are central for both quantum TGD and TGD inspired theory of cognition leading to adelic physics [L97]. The cognitive representation is mapped to  $H = M^4 \times CP_2$  by  $M^8 - H$  duality [L165, L166].

Could the genetic code be realized at the level of fundamental physics as a TIH in  $H^3$  emerging as a cognitive representation [L101, L148, L152, L174] for the space-time surfaces in  $M^8$  and by  $M^8 - H$  duality also in  $H = M^4 \times CP_2$ . If so, the biological realization could be only one particular realization of the code.

2. Why there should be 3 icosahedral harmonies and one tetrahedral harmony? There is a partial answer to this question. The correspondence with 64 dark proton triplets representing codons and triangles requires 3 icosahedral harmonies. What distinguishes stop codons from other codons? It turns out that stop codons could be dark proton triplets for which the corresponding triangle does not exist in TIH realization! The lack of dark proton triplet would mark the end of the gene.

It should be possible to unify various TGD inspired models of genetic code to a single unified description. Is the time ripe for this?

1. The realizations in terms of dark protons and dark photons are related: dark photon 3N-plets would be emitted by dark proton 3N-plets in 3N-proton cyclotron transitions. In the 3N-resonance interaction with DNA, RNA, amino-acids, and tRNA the dark photon 3N-plet would transform to ordinary photons (bio-photons). Energy resonance could select the basic information molecules.
2. How the dark level interacts with the ordinary matter? Music expresses and creates emotions. Light 3-chords for a given bio-harmony could therefore represent an emotional state of MB (emotions as sensory perceptions of MB?). Fourier transform in terms of frequencies represents non-local holistic information and emotional information indeed is holistic information. Codons as units of 6 bits would represent ordinary temporarily local, reductionistic information.

Each emotional state corresponds to a particular collection of 3-chords as allowed chords of the bio-harmony and therefore the resonance occurs with different biomolecules or induces different transitions of these bio-molecules. Could this serve as a universal mechanism of bio-control? Could epigenesis as a control of DNA transcription rely on this mechanism? As a matter of fact, the model described in this article emerged from an attempt to understand epigenesis in the TGD framework.

3. Is it possible to unify all models of the genetic code to single model so that the representation of a codon as dark proton triplet is assigned to a representation as an "activated" triangle of icosahedron or tetrahedron of TIH containing at it vertices dark protons defining the same codon as the triangle as 3-chord for a given icosahedral harmony. Could these "activated" triangles be selected faces of TIH. Could genes correspond to sequences of these icosahedron-tetrahedron pairs at magnetic flux tubes?

In the sequel the questions raised above are discussed.

### 7.7.2 Genetic code and hyperbolic tessellations

Why 3 different icosahedral harmonies with symmetries  $Z_6$ ,  $Z_4$ , and  $Z_2$  plus one (there is only one) tetrahedral harmony is needed to get  $3 \times 20 = 60 + 4$  chords in correspondences with 64 codons of the genetic code?

#### Hyperbolic tessellations and genetic code?

What comes into mind, are fundamental lattice like structures - tessellations - having as basic building bricks icosahedron and tetrahedron - at least these. This would make sensical to speak about gluing of tetrahedron to icosahedron, which looks a strange operation in the original formulation of the model.

1. Platonic solids correspond to finite tessellations at 2-sphere or equivalently 3-D solid polyhedrons in 3-D space Euclidian space  $E^3$ . Maybe one could answer the question by increasing dimension and by studying 3-D polyhedrons of 4-D space defining tessellations of the hyperbolic space  $H^3$ .

By  $M^8 - H$  duality [L165, L166], these tessellations appear at the fundamental level TGD as cognitive representations since the 3-D mass shells with the geometry of  $H^3$  appear naturally in the solutions of dynamical equations as algebraic equations at the level of  $M^8$  identifiable as real section of complexified octonions  $O_c$ . The dynamics reduces to the associativity of the normal space of the space-time surface determined as a root for the real part of an octonionic polynomial obtained as an algebraic continuation of a real polynomial. Real part is defined in quaternionic sense by decomposing octonion to two quaternions in the same manner as a complex number is decomposed to its real and imaginary parts.

The algebraization of the octonionic counterpart of Dirac equation forces its identification as the counterpart of momentum space version of the ordinary Dirac equations and the identification of  $M^8$  as an analog of momentum space so that space-time surface is analog of Fermi ball.

2. The tessellations of  $H^3$  are analogs of lattices in an Euclidian momentum space  $E^3$ . In adelic physics they define cognitive representations providing unique discretizations of space-time surface both at the level of  $M^8$  and  $H$ .  $M^8 - H$  duality maps tessellations to their analogs of  $H = M^4 \times CP_2$ . Contrary to my long held belief, Uncertainty Principle forces the map to be instead of a direct identification an inversion for  $M^4 \subset M^8 \rightarrow M^4 \subset H$  [L165, L166]. Mass hyperboloids correspond in  $H$  to light-cone proper time constant sections of space-time surface: light-cone proper time defines Lorentz invariant cosmic time.
3. The tessellations of  $H^3$  can have several different analogs of unit cells glued together along their 2-D faces. The positive curvature of sphere forces Platonic solids as tessellations of 2-sphere to be closed and be finite.  $H^3$  as a negative curvature space does not allow a closure. This implies a large number of tessellations as infinite analogs of regular solid polyhedra.

Both icosahedron, octahedron and tetrahedron have triangular faces so that they might allow gluing together for the simplest tessellations. Also more complex tessellations are possible.

### Details about hyperbolic tessellations

Consider now in more detail some tessellations of  $H^3$  possibly relevant for the bio-harmony [L31, L140, L171] involving icosahedral and tetrahedral geometries.

Some basic concepts and notations are necessary to help the reader to understand the Wikipedia articles, which give detailed explanations and illustrations.

1. Regular polytopes are tessellations consisting of single polytope. There are subtle differences between tessellations and honeycombs: tessellations are more general than honeycombs. These differences are not relevant for what follows so that I will use both terms interchangeably.
2. Schläfli symbol [A11] <https://cutt.ly/7jagV1T> ( $p, q, r, \dots$ ) characterizes regular polytopes in both Euclidian spaces and hyperbolic spaces locally but does not tell anything about the object globally. For a 3-D regular polytope ( $p, q, r$ ) in 4-D space (say tessellation of  $H^3$  the faces have  $p$  vertices,  $q$  identical faces meet at given vertex, and  $r$  identical 3-cells meet along given edge. For instance,  $(3, 5, 3)$  characterizes a regular tessellation having icosahedron as fundamental cells with 3 icosahedrons meeting along given edge.
3. Vertex figure [A15] <https://cutt.ly/yjagMQn> represents the neighboring vertices as seen from a given vertex. Formally it is defined by contracting all edges emanating from the vertex to their middle points and connecting these points by lines along faces. For a  $n$ -D polytope ( $p, r, s, \dots$ ) the vertex figure is  $n-1$ -D polytope ( $r, s, \dots$ ). For instance, for icosahedron  $(3, 5)$  the vertex figure is  $(5)$  telling that 5 edges meet at vertex. For the regular honeycombs in  $H^3$  the vertex figure is a regular polyhedron. For instance, for  $(3, 5, 3)$  it is  $(5, 3)$  identifiable as dodecahedron. Second notation for the vertex figure is as the list of numbers of edges meeting at the vertices of the face: For icosahedron this list is 3.3.3.3.3 telling that the faces of the edge figure has 5 vertices at which edges meet.
4. Edge figure [A15] (<https://cutt.ly/djag9Q9>) is the vertex figure of the vertex figure of the polytope. For  $D$ -dimensional polytope it is polytope of dimension  $D-2$ . For a regular polytope ( $p, q, r, \dots, s$ ) the edge figure is  $(r, \dots, p)$ : for Platonic solids  $(r, s)$  edge figure is  $()$  telling that two faces meet along a given edge. For the regular polytope  $(r, s, p)$  the edge figure tells the number of identical 3-cells meeting at given edge. For cubic lattice it is 4. For semiregular honeycombs the 3-cells need not be identical.
5. The notion of dihedral angle (see <https://cutt.ly/vjs20BI>) is very useful in trying to understand whether a given tessellation of  $E^3$  and  $H^3$  is possible. Dihedral angle is defined as the angle between the faces of the polytope meeting along a given edge. For tetrahedron it is  $120^\circ$ , for octahedron  $90^\circ$  and for icosahedron  $138.19^\circ$ . Since at least 3 polyhedra must meet at a given edge, the sum of these angles must be smaller than 360 degrees in  $E^3$ . This prevents icosahedral tessellations in  $E^3$ .

In  $H^3$  negative curvature allows the sum to be larger than  $360^\circ$  (think of polygons at a saddle surface as a visualization) so that 3 icosahedra might meet at a given edge as indeed occurs for  $(3, 5, 3)$  tessellation. The sum of the dihedral angles of T, O, and I assignable to tetrahedral-icosahedral honeycomb in  $H^3$  is  $348.19^\circ$  and smaller than  $360^\circ$  but rather near to it.

6. An important notion is Coxeter group [A3] (<https://cutt.ly/FjdEJeG>) acting as the symmetry group of the honeycomb. Coxeter group is generated by reflections meaning that honeycombs can be generated by reflections in suitable mirror planes. Honeycomb is constructed kaleidoscopically: a concretization of Leibniz's monadology is in question. Coxeter group and therefore also the honeycomb is characterized by Coxeter diagram [A2] (<https://cutt.ly/SjdEZiH>) having as its nodes the mirrors and connected by edges labelled by the dihedral angles  $\phi = \pi/n$  between the mirror planes. The value of  $n$  is written explicitly to the diagram except when it is the minimal value  $n = 3$ . For instance, the

sequence  $[(5,3,3,3,3)]$  characterizing tetrahedral-icosahedral honeycomb in  $H^3$  tells that the dihedral angles between the 5 mirror planes are  $(\pi/5, \pi/3, \pi/3, \pi/3, \pi/3)$ .

Consider now honeycombs in hyperbolic space  $H^3$ .

1. The simplest tessellations - regular honeycombs - of  $H^3$  consist of icosahedra and dodecahedra having the same isometry group. That 3 of the 4 most symmetric honeycombs in  $H^3$  have icosahedral symmetries whereas the fourth has cubic symmetries, is a highly encouraging sign. These 4 regular honeycombs are icosahedral honeycomb  $\{3, 5, 3\}$  with 3 icosahedrons meeting along edge; order-5-cubic honeycomb  $\{4, 3, 5\}$  with 5 cubes (rather than 4 as in  $E^3$ ) meeting along a given edge; and dodecahedral honeycombs of order 4 (5) with 4 (5) dodecahedra meeting along edge. In all these cases the sum of the dihedral angles is larger than  $360^\circ$  so that the negative curvature of  $H^3$  is essential for the existence of these honeycombs.
2. What about the combinations of Platonic solids having triangles as faces - tetrahedron, octahedron, and icosahedron? From Wikipedia article [L192] (<https://cutt.ly/cjaheWC>) one learns that there exists honeycombs of  $H^3$  characterized by Schläfli symbol  $\{(3, 3, 5, 3)\}$  and Coxeter group with symbol  $[(5, 3, 3, 3)]$  consisting of reflections and generating the honeycomb. The regular honeycombs are characterized by 3 integers (say  $(3, 5, 3)$ ) and the meaning of the code is not quite clear to me but must reflect the fact that the honeycomb is semiregular.

Tetrahedron corresponds to  $(3,3)$  and icosahedron to  $(3,5)$  and octahedron  $(3,4)$  as a rectified tetrahedron obtained by contracting edges to their middle points and expanding vertices to faces, has symbol  $r(3, 3)$ . Perhaps  $(3,3)$  in  $(3,3,5,3)$  refers to Coxeter group both tetrahedron and its rectification and  $(3,5)$  in  $(3,3,5,3)$  to icosahedron. The last "3" tells that 3 identical solid icosahedra, tetrahedra, or octahedra meet at given edge.

In particular, the tetrahedral-icosahedral honeycomb (TIH) is a compact uniform but not a regular honeycomb, having icosahedra, tetrahedra, and octahedra, all of which have triangular faces, as analogs of unit cells [A8, A6, A14] (see <https://cutt.ly/xhBwTph>, <https://cutt.ly/lhBwPRc>, and <https://cutt.ly/0hBwU00>). The Wikipedia article [L192] contains beautiful illustrations of these honeycombs.

One can wonder why "tetrahedral-icosahedral honeycomb" does not involve octahedron. This is said to reflect the fact that only tetrahedral and icosahedral cells of the tessellation are regular 3-cells. All these polyhedra are regular as Platonic solids, and it remains unclear to me what the lacking regularity of the octahedron as 3-cell means in the recent context.

For TIH  $\{(3, 3, 5, 3)\}$  the vertex figure is rhombicosidodecahedron (RID) [A10] (<https://cutt.ly/yjahitS>) discovered already by Kepler. Kepler talked about Harmonices Mundi and I cannot but smile as I recall how I read as a young man a book having fun with Kepler's medieval belief on celestial harmonies and laughed also! Maybe the celestial harmonies are making a glorious comeback!

RID is an Archimedean solid [A1] (<https://cutt.ly/njahaGN>) having 60 vertices corresponding to 12 disjoint pentagons and 20 disjoint triangles with 60 vertices both. RID has as faces 20 triangles assignable to icosahedron, 12 pentagons assignable to dodecahedron plus 30 squares - 62 faces altogether. RID is obtained by radially scaling the distance of icosahedral and dodecahedral faces from origin but keeping the area of the spherical faces the same: this yields squares as additional faces. Triangles and pentagons have only squares as edge neighbors.

Edge figure tells the number of edges meeting at given edge. For TIH it is 3. Regular and single-ringed Coxeter diagram uniform polytopes to which also TIH belongs have a single edge type. Therefore icosahedron, tetrahedron, and octahedron must meet at given edge. That vertex figure contains 3 types of faces (triangles, and squares, and pentagons) presumably reflects this. Recall that the sum of the dihedral angles of T, O, and I is  $348.19^\circ$ .

One can try to build a more concrete picture about how the Platonic solids are glued together along their triangular faces in the icosahedral-tetrahedral honeycomb.

1. Must to make this concrete, one can regard Platonic solid as a kind of mini Earth with two other Platonic solids glued to its surface like mountains. In all cases one has Platonic analog of a planar lattice of triangles at this mini Earth. To minimize typing call the 3 different Platonic solids T, O, and I.
2. Due to the symmetries one expects that for O and I the triangles correspond to different Platonic solids if they are edge neighbors. For T this is not possible since all faces are edge neighbours. All 6 2+2 configurations of B and C are however related by a rotational symmetry. This already gives a rather satisfactory picture about what the situation looks like at the surface of each mini Earth (I cannot avoid the analogy with inner planets, the living Earth as the largest one would correspond to I!).
3. The radius  $R$  of circumscribed inner or outer sphere gives an idea about the size scales of these Platonic solids when the edge length  $a$  is the same for them as it is in the recent case. The following gives the radii of the outer sphere.

$$\begin{aligned}
 \text{tetrahedron} \quad \frac{R_{T,out}}{a} &= \sqrt{\frac{1}{2}} \quad , & \frac{R_{T,in}}{a} &= \sqrt{\frac{1}{24}} \\
 \text{octahedron} \quad \frac{R_{O,out}}{a} &= \sqrt{\frac{3}{4}} \quad , & \frac{R_{O,in}}{a} &= \sqrt{\frac{1}{6}} \quad , \\
 \text{icosahedron} \quad \frac{R_{I,out}}{a} &= \frac{1}{2} \sqrt{\phi \sqrt{5}} \quad , \phi = \frac{(1+\sqrt{5})}{2} \quad , & \frac{R_{I,in}}{a} &= \frac{\sqrt{3}}{12} \sqrt{3+\sqrt{5}} \quad .
 \end{aligned} \tag{7.7.1}$$

4. The ratios of the outer radii are given by  $R_{I,out} : R_{O,out} : R_{T,out} = \sqrt{\phi \sqrt{5}} : \sqrt{\frac{3}{4}} : \sqrt{\frac{1}{2}} \simeq 1.9021 : 0.8660 : 0.7071$ . The ratios of the inner radii are given by  $R_{I,in} : R_{O,in} : R_{T,in} = \sqrt{\phi \sqrt{5}} : \sqrt{\frac{3}{4}} : \sqrt{\frac{1}{2}} \simeq .756 : 0.408 : 0.2041$ . That icosahedron has the largest size, is natural since the total solid angle defined as a sum of the solid angles of the 20 triangles is  $4/\pi$  and the contribution of an individual triangle is smallest for I and largest for the 4 triangles of T.

### Could TIH allow to unify the models of genetic code?

Does this picture help to say anything interesting about the model of bio-harmony and even to unify the models of genetic code?

1. tessellations define in a natural manner discretizations of MB defining cognitive representations suggested to relate to the geometric representations for the states of the brain at MB and more generally, for the states of various parts of the biological body at MB. There is evidence for an effective hyperbolic geometry of brain realized in a statistical sense [J75] (<http://tinyurl.com/ybghux6d>): functionally similar neurons are near to each other in this effective hyperbolic geometry. This evidence is discussed from TGD point of view in [L167]: one ends up with a proposal that the MB of the brain provides a geometric representation for the statistical aspects of the brain - kind of abstraction? Information from the brain would be sent by dark Josephson radiation from similar neurons to positions of MB near to each other. This model could generalize to other parts of organism. MBs could form a kind of abstraction hierarchy representing more and more abstract data about the state of organism.
2. Could the icosahedral-tetrahedral tessellation allow a justification for the fusion of 3 icosahedral harmonies with the tetrahedral harmony? Why does the octahedral harmony disappear? Octahedral harmony would mean 6 additional notes assignable to the vertices of octahedron and 8 3-chords and this does not fit with facts.

**Remark:** In the Wikipedia article about TIH it is said that octahedrons of TIH are not regular, unfortunately in the sense that I do not understand. Note also that tetrahedral and octahedral harmonies are unique because there is only a single Hamiltonian cycle.

3. Geometrically the tessellation means identification of the neighbouring faces, which gives a justification for the strange looking proposal of gluing tetrahedron to icosahedron in order to

fuse 3 icosahedral and one tetrahedral harmony. If also the 3-chords associated with the faces are identified, one can ask whether only icosahedral and tetrahedral harmonies are needed and the chords of the octahedral harmony are determined by them.

2 3-chords of tetrahedral harmony are the same as those for icosahedral harmony but the 2 3-chords associated with the 2 T-O faces are independent. This would give 62 independent chords (amusingly, 62 happens to be the number of faces of RID).

One of the tetrahedral chords is necessary since purely icosahedral harmony allows to get only 19 amino-acids identified as the orbits of the chords under the symmetries of a particular icosahedral harmony with 20 chords: one additional chord is needed for the missing amino-acid. Since two icosahedral triangles facing the tetrahedron "eat" 2 further tetrahedral chords, this leaves 1 tetrahedral chord from 4: 3 chords as tetrahedral codons are missing. Could the 3 missing tetrahedral 3-chords correspond to the ordinary DNA codons acting as stop codons? Could the stop codons lack a representation as dark photon triplets or could their frequencies be such that they do not allow 3-resonance with any tRNA?

4. How genes would be realized in the tessellation? Could dark genes correspond to flux tubes forming 1-D sub-tessellations of  $H^3$  induced to the flux tubes? Could gene correspond to a sequence of icosahedron-tetrahedron pairs such that neighboring codons are associated with icosahedron-tetrahedron pairs as cell-neighbors. Two subsequent icosahedrons would have a tetrahedron between them.

Could the tessellation induced from  $H^3$  to MB be dynamical involving an "activation" of a particular triangle as a codon inside each icosahedron and tetrahedron? Could dark genes at the flux tubes have these codons as induced dark codon sequences? Could "activation" mean that the triangle representing particular codon is accompanied by 3 dark protons at its vertices and representing the same genetic codon? The representations in terms of dark protons triplets, as triangles of icosahedron and tetrahedron, and as dark photon triplets would fuse to single representation. There could be a representation also for stop codons in terms of 3 dark protons but there would not be no triangle where to locate them so that coding would stop! The missing dark codon would signify the end of the gene.

This would give the long-sought connection between dark codons realized as dark triplets and dark codons realizing bio-harmony and dark codons realized as dark photon triplets generated in the cyclotron transitions of dark codons. An essential role would be played by Galois confinement [L171] stating that these triplets behave like dynamical units - just like 3 confined quarks forming a baryon. Galois confinement generalizes to the level of genes.

5. This proposal is of course one of the many variations of single theme developed during years. What is new that the proposal would make the roles of the icosahedral and tetrahedral geometries concrete, not at the level of bio-molecules but at the level of their MBs. A profound dramatic generalization of the notion of genetic code from biology to the level of fundamental physics is also suggestive. Even a hierarchy of genetic codes in various scales can be considered.

The interpretation of various harmonies as correlates of emotions implies that each icosahedral-tetrahedral unit of the tessellation would have its own varying emotional state expressed and affected by biochemical level via different interaction actions with ordinary biomatter realized in terms of dark photon N-resonance with targets depending on the emotional state [L224, L222, L223]. This could serve as a universal mechanism of bio-control by MB applying also to epigenesis.

There are still several open questions: in particular, what is the deeper reason for the fusion of just 3 icosahedral bio-harmonies. That the number of the dark codons is 64 is a partial reason but is this enough.

6. There are reasons to ask whether the cell membrane and microtubuli could provide a 2-D realizations of the genetic code [L224]. If genes are induced as 1-D sub-tessellations from that of MB, there is no reason to exclude 2-D or even 3-D induced tessellations.
7. I cannot avoid the temptation of mentioning the notion of memetic code [K46], which was my first idea about genetic code and proposed as a generalization of genetic code by starting

from a speculated hierarchy of Mersenne primes, whose members would come as  $M(n+1) = M_{M(n)}$ ,  $M_n = 2^n - 1$ ,  $M(2) = 2$ . This gives the Mersenne primes  $M(2) = M_2 = 3$ ,  $M(3) = 2^3 - 1 = 7$ ,  $M(4) = M_7 = 2^7 - 1$ ,  $M(5) = M_{127} = 2^{127} - 1$ . It is not known whether the hierarchy continues.  $M_7$  would correspond to the ordinary genetic code and  $M_{127}$  to memetic code with codons realizable as sequences of 20 codons.

Could memetic code be realized by TIH? Could one consider a planar or cylindrical subtessellation with a width of 20 tetrahedral-icosahedral pairs? If the size assignable to single pair is that of DNA codon - 1 nm roughly - the width would be about 20 nm which might relate to the radial scale of the microtubuli.

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## 7.8 Galois groups and genetic code

Galois groups, in particular simple Galois groups acting on cognitive representations consisting of points, whose coordinates in a number theoretically preferred coordinate system of octonions belong to EQ, play a fundamental role in the TGD view of cognition [L174]. The TGD based model of genetic code [L31, L170] involves in an essential manner the groups  $A_5$  (icosahedron ( $I$ )), which is the smallest non-abelian simple group, and  $A_4$  (tetrahedron ( $T$ )). Genetic code has as building bricks Hamiltonian cycles of  $I$  and  $T$ . Genetic code relates to information and therefore to cognition so that the interpretation of these symmetry groups as Galois groups is suggestive.

The most recent step of progress was the realization that genetic code can be represented in terms of icoso-tetrahedral tessellation of a hyperbolic 3-space  $H^3$  [L192] and that the notion of genetic code generalizes dramatically. Also octahedron ( $O$ ) is involved with the tessellation but plays a completely passive role. The question why the genetic code is a fusion of 3 icosahedral codes and of only a single tetrahedral code remained however poorly understood.

The progress in the understanding of the role of Galois groups inspired by a summary of inverse Galois problem [A40] (<https://cutt.ly/jmjpyDS>) in TGD framework [L189] made it possible to answer this question. The proposal is that the symmetry groups of the  $I$ ,  $O$ , and  $T$  can be identified as Galois groups.

Icosa-tetrahedral tessellation can be replaced with its 3-fold covering replacing  $I/O/T$  with the corresponding symmetry group acting as a Galois group. Octahedral codons can be regarded as icosahedral and tetrahedral codons so they do not contribute to the code.  $T$  has only a single Hamiltonian cycle and its 3-fold covering behaves as a single cycle.  $I$  has only a single Hamiltonian cycle and its 3-fold covering behaves effectively as a single cycle.

### 7.8.1 Could the symmetries of icoso-tetrahedral realization of the genetic code correspond to Galois symmetries?

Abelian groups  $Z_p$ ,  $p$  prime, are simple and the alternating group  $A_5$  with order 60 is the smallest non-Abelian simple group. All groups  $A_n$ ,  $n \geq 5$  are simple and have  $n!/2$  elements.  $A_5$  corresponds to the icosahedral group isomorphic with the symmetry group of the dodecahedron.

The TGD based model of genetic code [L31, L170, L192] involves in an essential manner the groups  $A_5$  (icosahedron) and  $A_4$  (tetrahedron). Simple groups play a fundamental role in the TGD view of cognition. Could this mean that genetic code represents the lowest level of an infinite cognitive hierarchy?

### The TGD inspired model of genetic code, cognition, and Galois groups

TGD based model of bioharmony [L31, L170, L192] provides a model of genetic code as a fusion of 3 icosahedral Hamiltonian cycles and the unique tetrahedral Hamiltonian cycle (what "fusion" precisely means is far from clear and I have considered several options).

Icosahedral Hamiltonian cycles is a non-self-intersecting path at icosahedron connecting nearest points of icosahedron going through all 12 points of the icosahedron. It is interpreted as a

representation of a 12-note scale with a scaling by quint assigned to a given step along the cycle. For a given Hamiltonian cycle, the allowed 3-chords of icosahedral harmony are identified as chords defined by the triangular faces of the icosahedron.

**Remark:** In the sequel I will use the shorthands IH, OH, and TH for icosahedral, octahedral, and tetrahedral harmonies. Also the notation  $I/O/T$  will be used for icosahedron/octahedron/tetrahedron unless there is a danger of confusing them with their symmetry groups with identical shorthand notations.

Galois groups are essential for cognition in the TGD framework. In particular, simple groups as primes for groups are also primes for cognition [L174]. Genes represent information and Galois groups are crucial for cognition in the TGD framework. Genes would correspond to sequences of 3-chords of bioharmony. This raises several questions.

Could genetic code relate to Galois group  $A_5$  as the smallest simple non-abelian Galois group (and also to the fact that the only polynomials of order smaller than 5 are generically solvable)? Could genetic code correspond to the lowest level in a hierarchy of cognition and of analogs of genetic code?

The order  $n = 60$  for  $A_5$  suggests a fusion of 3 icosahedral codes to give  $20+20+20 = 60$  codons.

1. 3 Platonic solids, - icosahedron ( $I$ ), tetrahedron ( $T$ ), and octahedron ( $O$ ) - which have triangles as faces so that one can consider the possibility of constructing a lattice like structure by gluing these Platonic solids together along their faces. Hyperbolic space  $H^3$  indeed allows icosahedron-tetrahedron tessellation, which also involves  $O$ 's. I have proposed that this allows a realization of genetic code and also of genes [L192]. The notion of gene generalizes so that genes can also be 2- or 3-D lattice-like structures.
2.  $A_5$  has  $A_3 = Z_3$  as a subgroup and  $I(\text{icosahedron})$  corresponds to  $A_5/Z_3$ . I has several Hamiltonian cycles having as a symmetry group  $Z_6, Z_4$  or  $Z_2$ .  $Z_2$  can act either as rotations or reflections.

**Q:** Could  $A_5$  as a Galois group as 3-fold covering of  $I$  make it possible to understand why the fusion of just 3 icosahedral codes is possible?

3. Tetrahedral group  $T$  corresponds to the alternating group  $A_4 = S_4/Z_2 = Z_4 \times Z_3$  with 12 elements and tetrahedron identification as  $A_4/Z_3$ . The tetrahedral Hamiltonian cycle (4-scale) is unique and has 4 3-chords. The 3-fold copy would correspond to  $A_4$ . Information about the unique Hamiltonian cycles of  $O$  and  $T$  can be found in [A24] (<https://cutt.ly/9m1MiV8>).

**Q:** Could the factor that there is only one tetrahedral cycle explain why only a single tetrahedron contributes?

4. Octahedral group  $O$  has 24 elements and is the wreath product of  $Z_3$  and  $Z_2^3$  and has also the decomposition  $O = S_2 \times S_4$ . Octahedron can be identified as  $O/Z_3$ . Also octahedral Hamiltonian cycle representing 8-scale with 8 chords is unique.

**Q:** Why don't octahedral codons contribute?

### A model of the genetic code based on ico-tetra-tessellation of hyperbolic 3-space

TGD leads to a proposal for a geometric representation of the genetic code in terms of ico-tetra-tessellation of the hyperbolic 3-space  $H^3$  (mass shell or light-cone proper time  $a = \text{constant}$  hyperboloids of  $M^4$ ) [L192]. Both  $I$ ,  $O$ , and  $T$  having triangular faces appear in the tessellation. Recall that the corresponding harmonies are denoted by IH, OH and TH.

I do not completely understand the details of the ico-tetra-tessellation. The following picture satisfies the constraints coming from the notion of harmony but I have not proven that it is correct. Here the help of a professional geometrician knowing about tessellations of  $H^3$  would be needed.

1. The analog of the discrete translational symmetry for lattices can be assumed: all  $I$ 's,  $O$ 's and  $T$ 's are equivalent as far as common faces with neighboring Platonic solids are considered.



2. The term icoso-tetrahedral tessellation suggests that all octahedral faces are glued to tetrahedral and icosahedral faces so that octahedral chords reduce to either icosahedral or tetrahedral chords. OH would not be an independent harmony. This requires that the number of common faces between two  $O$ :s vanishes:  $n_O^O = 0$ .
3.  $T$  shares at least 1 face with a given  $I$  so that the number of tetrahedral chords is reduced to at most 3 for given  $T$ . 4 purely tetrahedral faces (not shared with  $I$ ) are needed.  $I$  would have  $n_{IT} \leq 4$  purely tetrahedral faces in such a way that the total number of purely tetrahedral 3-chords is 4.

The simplest possibility is that  $I$  shares a common face with 2  $T$ :s. Each  $T$  shares 2 faces with  $O$  providing 2 purely tetrahedral 3-chords and shares the remaining 2 faces with distinct  $I$ :s. One would have  $n_T^I = 2$ ,  $n_T^O = 2$ ,  $n_T^T = 0$ .

Since each  $I$  defines independently 20 chords, 2  $I$ :s cannot have common faces. One would have  $n_I^T = 2$ ,  $n_I^I = 0$  and  $n_I^O = 18$  to give  $n_I^T + n_I^O + n_I^I = 2 + 18 + 0 = 20$ .

4. What remains to be fixed are the numbers  $n_O^I$  and  $n_O^T$  satisfying  $n_O^I + n_O^T = 8$ . The conditions  $n_O^T \geq 1$  and  $n_O^I \geq 1$  must be satisfied since both  $T$  and  $I$  share faces with  $O$ s.

Music comes to rescue here. The 8 3-chords of OH could define OH sub-harmony of IH. Analogously, the 4 3-chords of TH could define TH as a sub-harmony of OH.

Could IH sharing 18 3-chords with OH contain 2 transposed copies of OH plus 2 chords of TH? IH cannot of course contain the entire TH as a sub-harmony.

Could OH contain one copy of TH? This would give  $n_O^I = n_O^T = 4$ . Could the IH part of OH actually be TH as a sub-harmony of IH so that OH would reduce to 2 copies of TH?

To sum up, if the answers to the questions are positive, the incidence matrix  $n_i^j$ ,  $i, j \in \{I, T, O\}$ , telling how many faces  $i$  shares with  $j$  would be given by

$$\begin{bmatrix} n_I^I & n_I^O & n_I^T \\ n_O^I & n_O^O & n_O^T \\ n_T^I & n_T^O & n_T^T \end{bmatrix} = \begin{bmatrix} 0 & 18 & 2 \\ 4 & 0 & 4 \\ 2 & 2 & 0 \end{bmatrix} . \quad (7.8.1)$$

### 3-fold cover of the icoso-tetrahedral tessellation

The proposed model does not yet explain the fusion of 3 icosahedral Hamiltonian cycles. A 3-fold cover of the icoso-tetrahedral tessellation which replaces Platonic solids with their symmetry groups is highly suggestive. This raises a series of questions.

1. How could this representation relate to a possible interpretation in terms of the Galois groups  $I = A_5$  and  $O = S_2 \times S_4$  and  $T = A_4$ ?  $Z_3$  appears as a sub-group of all these groups and these Platonic solids are coset spaces  $I/Z_3$ ,  $O/Z_3$ , and  $T/Z_3$ .
2. Could one lift the icoso-tetrahedral tessellation to a 3-sheeted structure formed by the geometric representations of the Galois groups of this structure acting as symmetry groups? Platonic solids would be replaced with their symmetry groups acting as Galois groups.
3. Could the 3 different icosahedral Hamiltonian cycles correspond to different space-time sheets - roughly  $CP_2$  coordinates as 3-valued functions of  $M^4$  coordinates whereas 20 regions representing icosahedral vertices would correspond to different loci of  $E^3 \subset M^4$  just as one intuitively expects?
4. Same should apply to the tetrahedral and octahedral parts of the tessellation. But don't the 3 identical copies of the tetrahedral Hamiltonian cycle give  $64+8=72$  codons? How can one overcome this problem?

The following is a possible answer to these questions.

1.  $h_{eff} = 60h_0$  corresponds to 60-sheeted space-time (here also  $60k$ -sheeted space-time is possible if 60-D extension of  $k$ -dimensional extension is in question). For  $T$  and  $O$  an analogous picture would apply. One could say that the projections of  $I$  and  $O$  and  $T$  are in  $M^4$ . At each sheet one would have icoso-tetrahedral tessellation.
2.  $I$  has 3 types of Hamiltonian cycles with symmetry groups  $Z_6$ ,  $Z_4$ , and  $Z_2$  and can give 3 different copies. However, only a single copy of tetrahedral harmony appears in the model: otherwise the number of codons would be larger than 64. Could the 3 identical Hamiltonian cycles for  $T$  and  $O$  effectively correspond to a single Hamiltonian cycle?
3. The fusion of Hamiltonian cycles is analogous to a formation of many-boson states. For  $T$  and  $O$  all Hamiltonian cycles would be identical: one would have only one Hamiltonian cycle effectively. The 3-chords associated with the 3 octahedral and tetrahedral cycles are identical so that only single tetrahedral harmony would be present.

To sum up, the lift of the icoso-tetrahedral complex to that defined by the respective Galois groups could explain why just 3 icosahedral Hamiltonian cycles and effectively only 1 tetrahedral cycle.

## 7.9 MeshCODE theory from TGD point of view

Benjamin Goult has made an interesting proposal in the article *The Mechanical Basis of Memory the MeshCODE Theory* [J28] (<https://cutt.ly/WzlrMrM>) published in *Frontiers of Molecular Neuroscience* in 25 February 2021.

The proposal is that the cell or at least synaptic contacts realize mechanical computation in terms of adhesive structures consisting of hundreds of proteins known as talins, which act as force sensors. Talins are connected to integrins in the extracellular matrix, to each other, and to the actins in the cell interior.

This proposal does not conform with the TGD vision but inspires a series of questions leading to a rather detailed general vision for how magnetic body (MB) receives sensory input from biological body (BB) coded into dark 3N-photons representing genes with  $N$  codons and as a response activates same but differently realized genes, RNA or corresponding proteins as a reaction [L224, L31, L140, L170, L192]. This would mean a universal response function assigning to sensory input a unique response. Sensory input would code the response to it in terms of dark genes, which also generalize in TGD framework.

### 7.9.1 Some basic facts

The role of a protein known as talin [I11] ([https://en.wikipedia.org/wiki/Talin\\_\(protein\)](https://en.wikipedia.org/wiki/Talin_(protein))) is the topic of the article. Talin is associated with the cell-substratum contact and mechanically couples cytoskeleton and extracellular matrix (ECM) together. Adhesion units formed by integrin coupling to ECM, talin, and actin at cytoskeleton side form adhesion structures consisting of hundreds of adhesion units.

It is good to begin with by listing some basic definitions and facts.

1. Cytoskeleton [I2] (<https://en.wikipedia.org/wiki/Cytoskeleton>) consists of microfilaments (actin), intermediate filaments, and microtubules (MTs) which in neurons are called neurotubules. Neurons contain neurotubules [I8] (NTs) (<https://en.wikipedia.org/wiki/Neurotubule>) generated at MT organizing center (MTOC) and transferred to dendrites and axon, where they are parallel to the neuronal surface.

The cytoskeleton of an ordinary cell has as basic building bricks MTs and microfilaments and intermediate filaments. Both MTs and NTs are polarized. The + ends of MTs are at MTOC. + ends of NTs point towards the axon terminal and - end to the parent neuron. NTs in dendrites have mixed polarities.

2. ECM [I4] (<https://cutt.ly/5zNYtP6>) is a three-dimensional network consisting of extracellular macromolecules and minerals, such as collagen, enzymes, glycoproteins and hydroxyapatite that provide structural and biochemical support to surrounding cells. Cell adhesion, cell-to-cell communication and differentiation are common functions of the ECM.

3. Integrins [I5] (<https://cutt.ly/xzNYk7n>) are transmembrane receptors that facilitate cell-cell and cell-extracellular matrix (ECM) adhesion. Upon ligand binding, integrins activate signal transduction pathways that mediate cellular signals such as regulation of the cell cycle, organization of the intracellular cytoskeleton, and movement of new receptors to the cell membrane. The presence of integrins allows rapid and flexible responses to events at the cell surface (e.g. signal platelets to initiate an interaction with coagulation factors).
4. Actins [I1] (<https://cutt.ly/LzNYEo9>) are a family of globular multi-functional proteins that form microfilaments. It is found in essentially all eukaryotic cells, where it may be present at a concentration of over 100  $\mu\text{M}$ ; its mass is roughly 42-kDa, with a diameter of 4 to 7 nm. An actin protein is the monomeric subunit of two types of filaments in cells: microfilaments, one of the three major components of the cytoskeleton, and thin filaments, part of the contractile apparatus in muscle cells.

One can visualize talin as a spring between cytoskeleton and ECM. Talin couples directly to integrins at ECM side and either indirectly or directly to actin at cytoskeleton side. Talin's role is to be a rope in a "tug-of-war" between integrins at ECM and actin and it acts as a force sensor and could give rise to a molecular sense of touch based on force.

The part of talin subject to forces from the cellular interior and environment consists of 13 proteins domains which can be in two thermodynamically stable states analogous to the opposite magnetizations of ferromagnet and the domain exhibits hysteresis curve under a varying external force. The phases correspond folded and unfolded configuration looking like a straight bar. The two phases can be labelled by a bit and the proposal is that the talin conformations define 13 bits.

The domains are not identical so that each equilibrium state under varying external net force could correspond to a unique configuration in which domains are folded or unfolded. If so, talin would serve as a 13-bit force sensor of external forces with finite resolution corresponding to 13 octaves in linear scale. It will be found that the response could actually be determined by 6 bits and correspond to genetic codon.

The abstract of [I55] summarizes the functions of talin.

... Talin forms the core of integrin adhesion complexes by linking integrins directly to actin, increasing the affinity of integrin for ligands (integrin activation) and recruiting numerous proteins. It regulates the strength of integrin adhesion, senses matrix rigidity, increases focal adhesion size in response to force and serves as a platform for the building of the adhesion structure. Finally, the mechano-sensitive structure of talin provides a paradigm for how proteins transduce mechanical signals to chemical signals.

It is clear that talin does not look only a passive sensory receptor. That integrins are not necessary for talins to function implies that they have emerged before integrins in the evolution. It is clear that talins are essential aspect of multicellular life.

### 7.9.2 Could adhesion structures act as classical computers?

The proposal of the article [J28] relies on computationalism and suggests that talin could be more than a sensory receptor and adhesion structures could act as a computer. The structures formed by the adhesion units consisting of integrin-talin-actin triplets would serve as 13-bit units. Adhesion units would perform mechanical computation based on what authors call MESHcode.

One can argue that mechanical computation requires that adhesion units are isolated from the environment during the computation. This is in conflict with the role as force sensors. A weaker proposal would be that computation occurs only in the synaptic contacts which should be isolated during the computation. The same could take place also in the contacts between neurons and glial cells.

Concerning the synaptic level, a more realistic view to my opinion is that learning as a strengthening of the synaptic strengths corresponds to a development of force equilibrium of adhesion units. Learning could be described as the change of the resting states of the talin units and lead to a higher tension and larger number of unfolded protein domains. Nerve pulse patterns could cause temporary changes of this pattern.

### 7.9.3 TGD interpretation of adhesion units as quantal force sensors

In the TGD framework all communications and control in biology should rely on genetic code whose fundamental realization would be at the level of dark proton sequences forming dark nuclei with  $h_{eff} = nh_0 > h$  and dark photons.

Dark proton triplets - light 3-chords - would represent the counterparts for dark DNA, RNA, tRNA, and aminoacids and dark photon triplets could represent dark DNA codons [L31, L140, L170, L192]. Number theoretic vision [L97, L98] leads to a proposal that not only dark 3-photon 3-proton units act as single particle like units but also dark 3N-photons and 3-N protons do so and represent a gene consisting of N codons. Galois confinement would bind the photons and protons to larger particle units analogous to baryons as composites of 3-quarks.

All communications to MB would use dark 3N-photons coupling to corresponding dark 3N-proton by cyclotron resonances [L224, L222, ?]. Therefore 3N-photon as a dynamical gene with N codons would define its own address. Frequency modulation of frequencies of 3N-photon would give rise to a sequence of resonance peaks and the continuous signal would be transformed to a signal analogous to nerve pulse sequence and could realize motor action as a response.

#### Magnetic body containing dark matter as the master

MB has a hierarchical onion-like structure with levels labelled by the value of  $h_{eff} = nh_0$  giving rise to increasing scales. The dark analogs of DNA, RNA, tRNA, and amino-acids define flux tubes accompanying their ordinary variants with codons realized as dark 3-proton units.

In TGD genetic code in terms of 3-chords would be realized in a universal manner for the simplest tessellation of hyperbolic space known as icosahedron-honeycomb involving icosahedrons and tetrahedrons (also octahedrons are involved but they would be in passive role) [L192]. This would suggest that genetic code using dark proton- and dark photon triplets is realized at all layers of MB. Chemical realization would represent the lowest level in the hierarchy.

The layers of MB with increasing value of  $h_{eff}$  would define a hierarchy of abstractions. There is evidence for an effective statistically determined hyperbolic geometry [J75] in the sense that neurons functionally but not necessarily spatially near to each other are near to each other in this effective geometry. This hyperbolic geometry would be realized quite concretely at the level of MB [L167] for which hyperbolic geometry of proper time constant hyperboloid of the light-cone gives a concrete meaning.

One particular implication could be that sensory receptors of a given structure (say adhesion units of given cell-environment pair) could communicate their sensory data to neighboring icosahedron-tetrahedron units of the honeycomb of some layer of MB representing the codons of genetic code. The states of the icosahedrons and tetrahedrons of the honeycomb would be dynamical and selected by the 3-chord (actually pair of 3-chord and conjugate) to actualize genetic codon as 3-quark units assignable to the corresponding triangle of icosahedron or tetrahedron.

This would define sensory representation at MB, and the simplest option is that it automatically determines motor response as a sequence of resonance peaks communicated back to the biological body (BB) where they would initiate gene expression, RNA or protein activity, MT activity, or nerve pulse activity. The feedback would be directly to DNA (or RNA, amino-acid of protein, or even tRNA, microtubuli, or cell membrane).

The biochemical motor actions of MB would be realized as bursts of dark cyclotron 3N-photons induced by the cyclotron resonances at MB transforming to ordinary photons (biophotons or IR photons with energy above thermal energy) controlling biochemistry by inducing molecular transitions.

This condition constrains the value of  $h_{eff}$  for a layer of MB. The size of the layer should be of the order of wavelengths involved. For valence bonds the values of  $h_{eff} = h_{em}$  would be rather small and assignable with small layers of MB. For frequencies in EEG range the large value of gravitational Planck constant  $h_{eff} = h_{gr}$  [L111, L224] assignable to the gravitational flux tubes would guarantee that the energies are in the required range.

The following picture about how sensory input induces gene expression or some other activity with communication and control realized in terms of genetic code might apply completely generally, not only in the case of adhesion units.

1. Suppose the sensory receptors of a given structure (say adhesion units of a given cell) are organized into coherent structures in the sense that the signals from them go along flux tubes to nearby cells of icosahedral honeycomb at some layer of MB.

Adhesion structures consisting of few hundred adhesion units are indeed connected to each other. Coherence would be forced by the quantum coherence at the level of MB as a forced coherence. One could assume that the cells of the honeycomb involved are organized linearly but even 2-D and 3-D structures are possible.

For a structure consisting of  $N$  units, the dark 3N-photon signal would define a dark gene of  $N$  codons. The nice feature of the representation is that there is no need to organize the sensory receptors (say adhesion units) linearly at the level of the cell. The level of ordinary biomatter would be like RAM with ordering realized at the level of MB.

2. The naive picture is that if the dynamical gene realized in this manner has a dark counterpart at the level of flux tube accompanying DNA, gene expression could be initiated automatically as a feedback signal realized as a sequence of resonance peaks. Also RNA, proteins or MTs could be activated in an analogous manner.

There would be a one-one correspondence between sensory inputs to MB and corresponding gene expressions and give a meaning for the genetic code. All sensory inputs to MB would be realized as  $N$ -genes in terms of generalized Josephson radiation which is frequency modulated and generates a sequence of resonance peaks inducing gene expression or RNA and protein activation.

3. The dynamical gene at MB need not correspond to an existing or expressible gene so that the response is not possible. This would give rise to an evolutionary pressure. Epigenesis controlled by MB could make the gene expressible. Also a suitable mutation for existing gene or emergence of new gene could produce the needed gene. Whether MB is able to induce this kind of mutations is an interesting question. Could a dark gene as a flux tube containing dark proton sequence representing the desired gene pair with ordinary DNA codons and give rise to a new gene?

Or could MB "use scissors" to replace codon-anticodon pairs in an existing gene: this would mean reconnection of a closed flux tube pair containing the codon-anticodon pairs of the added gene fragment. Could a piece of dark DNA as a flux tube carrying the dark proton sequence pair with ordinary DNA codons and give rise to a new gene? Or could one add to an existing gene a piece represented as a dark DNA paired with the ordinary DNA. Most viruses have single stranded RNA genomes. Bacteriophages have double stranded DNA genomes. They are known to give rise to the modifications of the genome. Could these DNA modifications be induced by a reconnection of darkmagnetic flux tubes.

### Universality of the genetic code and its higher dimensional representations

If genetic code at space-time surface is induced from a universal code assignable to the icosahedral honeycomb of hyperbolic 3-space, representations of genetic code with dimensions  $D = 0, 1, 2, 3$  are possible as induced representations. The codons associated with the cells of honeycombs projected to the space-time surface would define the induced codons [L192].

tRNA would be a 0-D representation and DNA, RNA, amino acids would be 1-D representations of the code. Also higher-dimensional representations are possible and could be associated with the basic biological structures.

1. I have proposed that cell membrane defines a 2-D representation of the genetic code [L192]. Also microtubuli could define a 2-D representation of genetic code. These 2-D representation could be dynamical and independent of genome and make genome dynamical. This would be a biological analog for AI able to write genes as program modules needed in a given situation.
2. Could a 3-D representation of genetic code be associated with the ECM and make it possible for MB to receive sensory input from ECM and control it? This layer of MB could also receive sensory information also from adhesive structures. The frequency range involved would be probably below EEG frequencies or at least below conscious frequencies since we

do not experience the interior of body consciously and the time scale of dynamics is slow as compared to EEG scales.

Hydroxyapatite molecules are present in bones forming a part of ECM. Fisher has proposed that the Posner molecules associated with hydroxyapatite molecules could have important role in quantum biology [J145]. This inspired the proposal that they provide a realization of genetic code [L53]. One cannot exclude the possibility that the code is 3-D. This would fit with the general idea that the genetic code serves as a universal code for communications and control.

### Some TGD inspired numerology

If one takes the proposed general picture seriously, one must ask how the 13-bits codons assignable to talins and MTs could reduce to genetic codons. It is good to start with numerology or should one call it physics inspired poor man's number theory.

1. The number of protein domains in talin is 13. Also the number of tubulin dimers in 13-tubulin unit of MT/neurotubule appearing in cytoskeleton is 13. Could one think of communication between MTs and talins using 13 bit code? Or could the code using 13 bits be for some reason special? Could this code somehow reduce to the proposed universal 6-bit code defined by genetic code?
2. There are 4 protein domains consisting of 4 alpha helices and 9 domains with 5 alpha helices. This gives 61 alpha helices altogether. Numerologist might notice that 61 is the number of DNA codons with stop codons excluded. Could one assign to helices genetic codons and could these configurations labelled by 61 bits code for genes with length not longer than 61 units?
3. Numerologist might also notice that both  $M_{13} = 2^{13} - 1$  and  $M^{61} = 2^{61} - 1$  are Mersenne primes. If one has  $n$  bits and does not count the configuration with all bits 0 but assuming that at least single bit is always equal to 1, one has  $2^{n-1}$  full bits.

For  $M_{13}$  this corresponds to 12 full bits which corresponds to 2 genetic codons. To obtain 2 codons, single fixed talin should be unfolded and represent 1. Could this have interpretation in terms of a force threshold? One can argue that there is some minimal force unfolding some fixed talin. If the force is below the threshold, there is no need to communicate. Also in the case of MT the conformation of preferred tubulin, say the first or last one in 13-unit should always correspond to 1.

4. One cannot exclude the possibility that the responses of talin units correspond to two independent codons. This could be true also for 13-bit units MTs.

The alternative option is that both talins and 13-tubulin units of MT correspond to codon-anticodon pairs so that information content would reduce to that of single DNA codon. Half of the bits would serve as check bits. Also the purpose of the conjugate strand of DNA would be to serve as check codons.

If this is the case, the adhesion unit would have only  $2^6$  different responses and would represent a genetic codon. The number of talins is few hundred that this would correspond to a DNA sequence of length of order  $10^{-7}$  meters. In the case of MT 6 bits would be check bits.

5. The proposal would have far reaching consequences: the genetic code realized by MTs and talins would be dynamical rather than fixed and could represent a step to a higher evolutionary level.
6. The dynamics of the codon or of a pair of pair of independent codons assignable to the adhesion unit would mean change of the "sensory codon" possibly corresponding to a real codon assignable to it. The slow time variation of the gene assignable to the collection of adhesion units could define varying gene expression or some other activations (of say microtubuline).

These speculations encourage the question whether the codon-anticodon pairs possibly assignable to adhesion units integrate to sequences or perhaps even 2-D structures representing 2-D adhesion structures of DNA codon-anticodon pairs defining genes.

If these 2-D honeycomb structures at the level of MB decompose to piles of 1-D structures as microtubules do, they could even induce the expression of gene groups. Also 2-D gene expression in terms of microtubules modifying the cytoskeleton can be considered. Note that the honeycomb structures are not needed at the level of ordinary biomatter.

### A simple model for the adhesion units

In TGD framework magnetic body (MB) containing dark matter controls ordinary living matter. MB receives sensory input from organism in terms of dark Josephson radiation arriving from cell membranes acting as generalized Josephson junctions. Sensory information is coded by the modulation of membrane potential. For ordinary cells only small modulations of membrane potential would induce modulations of Josephson frequency. For neurons nerve pulse patterns introduce more drastic modulation.

1. The two states of the protein domains could correspond to different values of  $h_{eff}$ . The reduction of  $h_{eff}$  at the magnetic flux tube accompanying the protein would induce the shortening of the flux tube associated with the unfolded protein to the folded configuration.
2. Cohesion units would aserve as sources of sensory information about the net force acting on the cohesion unit and coded by 13 bits unless the bits are independent. For instance, different bits would correspond to different signals, say different frequencies of dark photons. If one takes the interpretation as a pair of codons seriously, the signal could consist of a dark 3-chord and its conjugate 3-chord sent to MB and defining at the MB a representation of gene to be possibly activated.
3. Josephson radiation as dark 3-photons from the part of the cell membrane considered would mediate the 13 bit signal defined coded to a local change of membrane potential with  $2^{12}$  values defining 12 octaves if there is threshold corresponding to activation of a preferred talin. Note that the frequencies audible for humans are in the range 20 Hz- 20 kHz and correspond to 10 octaves.
4. MB would receive the sensory input and react by possibly sending control signal to DNA inducing gene expression or inducing activity of proteins or RNA. This means that talin molecules would not be active but MB receiving the sensory input from adhesion units.  
MB could also send control signal to microtubuli if MT contains a sequence of 13-tubulin units corresponding to the dynamical gene [?] [17] (<https://en.wikipedia.org/wiki/Microtubule>). This would reflect itself in the dynamics of MTs. This control loop would modify the force equilibrium by a modification of the shape of the cell.
5. MTs could represent an evolutionary step making the genome dynamical and independent of genes and extending ordinary genome as the microtubular response possible for eukariotes suggests. Also the long MTs inside axons conform with this interpretation.
6. MTs are highly dynamical. Their lengths are continually varying. According to "search-and-catch" model MTs inside cells are scanning their 3-D environment and whey the find a target attach to it and MT is stabilized. This conforms with general vision about U-shaped dynamical flux tubes serving as tentables and forming a reconnection with a similar U-tube of the target. Immune system would be rely on this mechanism at the fundamental level and allow the system to detect and catch invader molecules on basis of their cyclotron energy/frequency spectrum [K48, L224].
7. The general vision suggests that the feedback loop should involve also microfilaments and intermediate filaments. It would be interesting to see whether the structure of microfilaments and intermediate filaments could allow realization of the counterpart of genetic code. The basic signature are GTP and ATP molecules providing metabolic energy for motor action.

### 7.9.4 An application to memory and learning

Since the increase of synaptic strengths is believed to be behind the formation of memories as behaviors and habits, it is appropriate to discuss the notion of memory in TGD framework and consider connections with the model for the adhesion units at synaptic contacts.

The major issue with memory is potentiation (repeat of same memory which facilitates memory recall and learning) and amnesia, Alzheimer disease and memory when dreaming. There should be a compatible explanation for these phenomena.

In TGD one distinguishes between two kinds of memories. Episodal-/sensory memories and memories as associations/learned behaviors.

#### Memories as learned behaviors

Neuroscience explains learned behaviors in terms of strengthening of synaptic contacts and I believe that this is part of the story.

The formation of associations in conditioning is a highly emotional process and here the surprising finding [J70] (see <http://tinyurl.com/ycqxeyek>) few years ago (roughly) was helpful. The popular article “*Scientists Sucked a Memory Out of a Snail and Stuck It in Another Snail*” tells about the finding (see <http://tinyurl.com/y92w39gs>).

The RNA of a sea snail which had learned by (presumably painful) stimulus a behavior was scattered on the neuronal tissue of another sea snail in a Petri dish. The neuronal tissue learned the same behavior!

The TGD based explanation is following.

1. Emotions are realized already at the molecular level [L116] in terms of music of light - bioharmony [L31, L140, L170, L192]. The emotional stimulus at the MB of RNA induced learning by changing the allowed 3-chords of bioharmony. Also the sequences of 3-chords characterizing 3N-genes and other basic linear biomolecules changed. The resonant couplings to the basic biomolecules changed so that also chemical behavior changed.
2. The emotional state of the conditioned seanail RNA infected the RNAs and probably also DNAs and proteins of neurons and induced learning.
3. Synaptic strengths had to change and the molecular emotions as music of light would have induced this.

If the idea about mechanical control of synaptic strengths by talin molecules by push and pull from ECM and cytoskeleton is correct, the molecular mood had to induce a strong force changing the talin conformations. Emotion would quite concretely correspond to a force!

This would have induced a reaction at the level of microtubules with the mediary of MB as a response making the change permanent. Neurotubules of the cytoskeleton in dendrites and axons would be involved in realizing the learning as a permanent change.

#### Potentiation and two kinds of memories

The notion of potentiation applies to both kinds of memories.

1. The repetition of stimulus generating the learned behavior increases the synaptic strength. Perhapsby inducing a memory recall of the emotional experience at molecular level.
2. Potentiation for sensory memories creates an almost copy of sensory memory mental image at “geometric now”: the re-experience and the more one has these almost copies in the geometric future of “geometric now”, the higher the probability that the attempt to remember by sending dark photon signals to the future hits the memory mental image are successful. The latest memory recalls create memories mental images nearest to “geometric now” and the probability for memory recall is highest for them.

Why oldest sensory memories are those which survive when one begins to lose memories at old age?



1. There are a lot of almost copies about the oldest memories: does this mean that the memory recall has a higher probability to be successful?
2. One can also argue that the memory mental images of young age have also gone through a long sequence of re-incarnations which have gradually increased the value of  $h_{eff}$ .

Large  $h_{eff}$  means that the frequency  $f$  needed to produce a dark photon with energy  $E = h_{eff}f$  in biophoton range is lower and therefore the period  $T = 1/f$  is longer. Uncertainty Principle says that the time period over which memories are optimally recalled is of order  $T = 1/f$ .

### Amnesia, Alzheimer, and why we forget dreams so fast

Amnesia might relate to the inability to recall sensory memories by sending signals with a correct frequency to the memory mental images. The energy of the dark photons is proportional to  $h_{eff}$  and if it is reduced in the recalling end as tends to happen in the absence of metabolic energy feed, the ability to recall memories is weakened or lost. For instance, alcoholism can lead to a loss of memory recall and this could be the reason.

Alzheimer means a loss of memories as behaviors and inability go generate new ones. In TGD framework [L93] the weakening of the synaptic connections would make the build up of connection between magnetic flux tubes associated with presynaptic dendrite and postsynaptic axon and the dark photon signal could not propagate because the connection is broken.

Also the propagation along axonal flux tubes could be impossible or highly attenuated if the value of  $h_{eff}$  for them is reduced. Also the energy for a given frequency would be reduced below the biophoton energy range.

Why do we forget dreams so fast? We do not remember anything about sleep without dreams. In ZEO this can be understood if sleep corresponds to "small death" for an appropriate layer of MB meaning re-incarnation with an opposite arrow of time. Dreams would correspond to states in which part of the brain is awake and possibly receives information from the sleeping part of the brain realized as a dream. Dream would be due to a communication of virtual sensory input from MB with opposite arrow of time to sensory organs.

This does not yet explain why we forget dreams so fast. As the memory image ages, it shifts to the future of "geometric now" in CD, and the needed frequency as inverse of the age decreases. Could it be that we cannot generate the frequencies of dark photons needed for the memory recall.

### Memories change

Episodal memories are not carved in stone. They are modified in memory recalls. In TGD framework, the modification of (episodal) memory mental images is unavoidable. Memory mental images are living entities and evolve re-incarnation by re-incarnation. Memory recalls are basically analogous to quantum measurements of memory mental images induced BSFR and quantum measurement indeed changes the state of the system measured.

1. The sub-selves of self as mental images continue to live at sub-CDs which in the proposed model drift to the geometric future of CD increasing SSFR by SSFR. These sub-CDs experience BSFRs and evolve incarnation by incarnation. In general evolution happens and they become smarter and wiser. Memories are indeed said to grow sweeter in time.
2. Each memory recall must take the memory subself to a state in which it has arrow of time opposite to that of recaller so that the signal about the memory propagates to the geometric past to "geometric now" [the ball at center of CD at which future and past directed cones glued together].

The BSFR for memory subself with the same arrow of time as recaller induces memory recall. Memory recall is a murderous process. If the memory recall occurs spontaneously, the murder is not not the recaller.

## Confabulation

The phenomenon of confabulation relates most probably to episodal/sensory memories, not memories as behaviors and habits. Confabulation could be understood in the following manner. Memory mental images are just glimpses about what happened since only those aspects of the event which receive the attention form memory mental images. Memory recaller builds a logical sounding story around these glimpses so that confabulation is unavoidable.

Even our sensory perception is fabrication of stories [L87]. Sensory organs are seats of primary sensory experience and there is feedback from MB and brain to sensory organs as virtual input. This feedback loop generates standardized mental images by pattern completions and recognition.

If the sensory input is meager the story can be non-realistic as I know as a person with a poor eye sight. REM dreams and hallucinations are an excellent example of this: in this case there is only virtual sensory input present.

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## 7.10 Appendix: 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 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.

| $(n_0, n_1, n_2)$ | 0-chords       | 1-chords  | 2-chords                                   |
|-------------------|----------------|---|--|
| $(2, 12, 6)$      | $(Faug, Gaug)$ | $(Cm, Dm, Em, F\sharp m, G\sharp m, Bbm),$<br>$(F6, G6, A6, B6, C\sharp 6, D\sharp 6).$ | $(C9, D9, E9, F\sharp 9, G\sharp 9, Bb9).$ |

**Table 7.2:** 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  |
|-------------------|-------------------------------------|--|---|
| $(0, 16, 4)$      |                                     | $(D7, D6, G\sharp 7, G\sharp 6),$<br>$(G4+, A9-, C\sharp 4+, D\sharp 9-),$<br>$(Emaj7, Gmaj7, Bbmaj7, C\sharp maj7),$<br>$(C9-, A9-, F\sharp 9-, D\sharp 9-).$ | $(Bb9, B9, E9, F9).$                                      |
| $(4, 8, 8)$       | $(Cex3, Eex2, F\sharp ex3, Bvex2).$ | $(Dmaj7, E9-, A7, A6),$<br>$(G\sharp maj7, Bb9-, D\sharp 7, D\sharp 6).$   | $(Bb9, F9, C9, G9).$<br>$(E9, B9, F\sharp 9, C\sharp 9).$ |

**Table 7.3:** Table gives various types of 3-chords for the two harmonies with  $Z_4 = Z_2^{rot} \times Z_2^{refl}$  symmetry. 4-plets represent the orbits. First cycle has no harmonic loners. Second cycle gives rise to bio-harmony  $(4, 8, 8)$  for which 0-quint chords are dissonant.

| $(n_0, n_1, n_2)$ | 0-chords                           | 1-chords  | 2-chords  |
|-------------------|------------------------------------|---|---|
| (0, 16, 4)        |                                    | $(Em, Bbm), (Cm, F\sharp m),$<br>$(G6, C\sharp6), (A6, D\sharp6),$<br>$(D4+, G\sharp4+), (B4+, F4+),$<br>$(Cmaj7, F\sharp maj7), (G6-, C\sharp6-).$ | $(D9, G\sharp9),$<br>$(E9, B\flat9).$                           |
| (2, 12, 6)        | $(Aex4, D\sharp ex2).$             | $(Am, D\sharp m), (G9-, C\sharp9-),$<br>$(C4, F\sharp4), (E4+, B\flat4+),$<br>$(Dmaj7, G\sharp maj7),$<br>$(Bmaj7, Fmaj7).$                         | $(C9, F\sharp9),$<br>$(A9, D\sharp9),$<br>$(D9, G\sharp9).$     |
| (4, 8, 8)         | $(Aex2, Hex8, D\sharp ex2, Fex8).$ | $(D7, G\sharp7), (Amaj7, D\sharp maj7),$<br>$(A4+, D\sharp4+), (E7, B\flat7).$  | $(G9, C\sharp9), (A9, D\sharp9),$<br>$(B9, F9), (E9, B\flat9).$ |

**Table 7.4:** Table gives various types of 3-chords for harmonies with  $Z_2$  rotation symmetry acting as half-octave shift. The doublets represent 2-chord orbits.

| $(n_0, n_1, n_2)$ | 0-chords                                  | 1-chords  | 2-chords  |
|-------------------|---|---|---|
| (2, 12, 6)        | $(F\sharp ex3, Hex4),$                    | $(Am, D\sharp), (A6, D\sharp7),$<br>$(D7, B\flat6), (G6-, Fmaj7),$<br>$(D4+, B\flat9-), (E9, G\sharp4+),$       | $(C9, F9), (B9, F\sharp9),$<br>$(E9-, C\sharp9).$                     |
| (2, 12, 6)        | $(Dex4, Hex4).$                           | $(F, Fm), (C6-, B\flat maj7),$<br>$(D7, G\sharp6), (Gmaj7, D\sharp6-),$<br>$(C\sharp4-, A4+), (E4+, F\sharp6).$ | $(C9, D\sharp9),$<br>$(D\sharp9, C\sharp9),$<br>$(E9, B9).$           |
| (4, 8, 8)         | $(Fex1, D\sharp ex3, G\sharp ex1, Aex2).$ | $(E7, E6), (Amaj7, B9-),$<br>$(G, C\sharp m), (D7, F\sharp6).$  | $(D9, B9), (C9, C\sharp9),$<br>$(F9, G\sharp9), (D\sharp9, B\flat9).$ |
| (2, 12, 6)        | $(Hex3, Eex7).$                           | $(D7, G\sharp6), (G, D\sharp m),$<br>$(F, Fm), (C6-, B\flat maj7),$<br>$(A9-, C\sharp4+), (E7, F\sharp6).$      | $(C9, D\sharp9),$<br>$(D9, C\sharp9),$<br>$(E9, B9).$                 |
| (2, 12, 6)        | $(F\sharp ex2, Fex3).$                    | $(F, Bbm), (C7, G\sharp6),$<br>$(Amaj7, B9-), (E6, E7),$<br>$(G, C\sharp m), (D7, B6).$                         | $(B\flat9, D\sharp9),$<br>$(C9, C\sharp9),$<br>$(D9, H9).$            |

**Table 7.5:** Table gives various types of 3-chords for harmonies with single reflection symmetry.

## Chapter 8

# About honeycombs of hyperbolic 3-space and their relation to the genetic code

### 8.1 Introduction

$M^8 - H$  duality and the realization of holography in  $M^8$  strongly suggests the importance of tessellations of  $H^3$  (analogous to lattices of  $E^3$ ) in the TGD based physics. These tessellations form a scale hierarchy and can thus appear in all scales. The hierarchy of effective Planck constants labelling dark matter as phases of ordinary matter indeed predicts quantum coherence in arbitrarily long scales and gravitational quantum coherence corresponds to the largest scales of quantum coherence among basic interactions.

The 4 regular honeycombs correspond to cubic, icosahedral, and 2 dodecahedral tessellations. The quasiregular icosi-tetrahedral honeycomb has tetrahedra, octahedra and icosahedra as cells having triangular faces as cells. These honeycombs serve as candidates for physically interesting tessellations. These 5 honeycombs are unique in that they involve only Platonic solids. I have proposed that the icosi-tetrahedral tessellation might define a universal realization of the genetic code as an induced structure so that the genetic code would be much more than a biochemical accident. The details of this realization are discussed in [L192, L140].

These 5 Platonic tessellations (or honeycombs, I will use these terms interchangeably in the sequel) could occur also in astrophysical scales as gravitational tessellations. The recent discovery of gravitational hum might have an explanation as gravitational diffraction in this kind of a tessellation. The unexpectedly large intensity of hum could be due to the concentration of the radiation intensity in discrete directions and due the fact that in diffraction the amplitude of the scattered field is proportional to the square  $N^2$  of the number  $N$  of scatterers rather than  $N$ .

Icosi-tetrahedral tessellation relates to the TGD based view of the genetic code. The TGD inspired view of genetic code has evolved during decades.

1. The first model of the genetic code was based on the so-called Combinatorial Hierarchy [K46] [L192] and predicted what I called memetic code realized as sequences of 21 DNA codons. Surprisingly, this model made a comeback as I prepared this article.
2. After several stray paths I ended up from a model of music harmony [L31, L52] [L170, L140] based on Hamiltonian cycles at the icosahedron to a model of genetic code also involving the tetrahedral Hamiltonian cycle.

The basic observation was that the 12-note scale could correspond to a Hamiltonian cycle of icosahedron such that the steps of the cycle define a quint cycle. 12-note scale is obtained from the quint by octave equivalence. There are 3-types of icosahedral Hamiltonian cycles and each cycle defines 20 3-chords assignable to the triangular faces of the icosahedron and defines a musical harmony.

One obtains 20+20+20 chords for the 3 different harmonies with symmetry groups  $Z_6$ ,  $Z_4$  and  $Z_2$ . The orbits of these groups define sets of 3-chords. The surprising finding was that if these sets are identified as amino acids, the numbers of the chords are the same as the numbers of DNAs coding for a given amino acid. By adding a tetrahedral Hamiltonian cycle one obtains 64 3-chords. At the level of molecules the music would be "music of light". Since music expresses and generates emotions, the idea that emotions appear already at the molecular level was natural. Different combinations of 3 Hamiltonian cycles with symmetries  $Z_6$ ,  $Z_4$  and  $Z_2$  would correspond to different moods at bio-molecular level (why just 3?)

The model made almost correct predictions for the numbers of mRNA codons coding for amino-acids. I have discussed a considerable number of its variants during years and even considered the replacement of icosahedron and tetrahedron with some other geometric object.

The basic problem was that gluing the tetrahedron and icosahedron together looked ugly and would have allowed only 63 codons. At that time I did not yet realize that an icosahedron and tetrahedron could be parts of a bigger structure.

3. Second model was based on the realization of codons as dark proton triplets assumed to reside at the monopole flux tubes parallel to DNA strands [L52, L140]. Dark proton triplets would neutralize the constant negative charge of -3 units per codon. The model suggested that it might be possible to understand the numbers of DNA, RNA, tRNA and amino acids in terms of entangled states of dark proton triplets representing codons. The model had also problems: in particular, one had to assume an additional binary degree of freedom to get the number DNA and mRNA codons correctly and the proposed identifications of this new degree of freedom did not look quite realistic.
4. Icosa-tetrahedral realization [L192] of the code in terms of icosatetrahedral honeycomb of  $H^3$  was the next step in the evolution of ideas. It was made possible only by the dramatic development of understanding of TGD itself, in particular of its number theoretical aspects related to  $M^8 - H$  duality [L165, L166].

The tessellations of the hyperbolic 3-space  $H^3$  represented as possibly complex mass shell in  $M_c^4 \subset M_c^8$  and as light-cone proper time = constant hyperboloids in  $M^4 \subset M^4 \times CP_2$  are central in the realization of holography in TGD. Icosa-tetrahedral honeycomb is a completely unique tessellation involving only Platonic solids and all possible platonic solids, tetrahedron, icosahedron, and octahedron are present. Kind of a quantum Platonic holy trinity is in question.

This led to a proposal of the genetic code in terms of ico-tetrahedral honeycomb induced to the 3-surface by restriction. This realization could be assignable to the magnetic body of the system involving dark matter in the TGD sense. The realization would be universal and would not be restricted to mere biology. Counterparts of codons and genes can be realized also for higher-dimensional objects, say cell membrane and even brain.

Icosa-tetrahedral realization led to a proposal that the realizations of the code in terms of dark photon triplets and in terms of dark proton triplets are closely related. I did not however really understand the properties of the ico-tetrahedral honeycomb when I published the first article about it [L192].

Sequences of  $N$  dark cyclotron photon triplets as representations of genes consisting of  $N$  dark proton triplets would make possible communications between dark genes by 3N-resonance. Genes would serve as addresses, much like in LISP, and the message would be coded by the modulation of the frequency scale. The details of this picture that were not discussed at that time create problems that are solved by the model based on icosahedral honeycomb.

In this article the properties of hyperbolic honeycombs are considered in detail and also a detailed view about the realization of DNA double strand in terms of the ico-tetrahedral tessellation is considered. The emerging model is surprisingly quantitative and suggests a lot of new understanding about the dark realization of genetic code. Also a connection with the notion of memetic code [K46] [L56] and the realization of memetic codons in terms of 21 DNA codons are suggested by the model.

## 8.2 About honeycombs in hyperbolic 3-space

This section, written in 2023, represents some new understanding related to the tessellations of  $H^3$  known as honeycombs.

### 8.2.1 Some preliminaries

Some preliminaries are needed in order to understand Wikipedia articles related to tessellations in general.

1. Schläfli symbol  $\{p, r\}$  ([rb.gy/j36tg](https://rb.gy/j36tg)) tells that the possibly existing Platonic solid  $\{p, r\}$  has  $r$   $p$ -polygons as faces meeting at each vertex. For instance, icosahedron  $\{3, 5\}$  has 5 triangles as faces meeting at each vertex.

Schläfli symbol generalizes to higher dimensions. The analog of Platonic solid  $\{p, r, q\}$  possibly in 4-dimensions and assignable to 3-sphere has  $q$  3-faces which are Platonic solids  $\{p, r\}$ . This description is purely combinatorial and is recursive. For instance, one can start from 3-D dimensional Platonic solid  $\{p, q\}$  with 3-D objects in dimension 4 by replacing  $p$  with  $p, r$ . One can also project this object to dimension 3. In this manner one obtains a projection of 4-cube (tesseract)  $\{4, 3, 3\}$  for which 3 cubes  $\{4, 3\}$  meet at each vertex ( $2^4 = 16$  of them) and which has 8 3-cubes as faces as a 3-D object.

In the case of hyperbolic tessellations also strange looking Schläfli symbols  $\{(p, q, r, s)\}$  are encountered: ico-tetrahedral tessellation involving only Platonic solids has symbol  $\{(3, 3, 5, 3)\}$ . My understanding is that this object corresponds to  $\{3, 3, 5, 3\}$  as an analogue of Platonic solid associate with 4-sphere in 5-D Euclidian space and that the fundamental region of this tessellation in  $H^3$  is analogous to a 3-D projection of this object. At a given vertex 3 objects  $\{3, 3, 5\}$  meet. For these objects 5 tetrahedrons meet at a given vertex.

2. Vertex figure is a further central notion. It represents a view of the fundamental region of tessellation from a given vertex. The vertices of the figure are connected to this vertex. It does not represent the entire fundamental region. For instance, for a cube (octahedron) it contains only the 3 (4) nearest vertices. For ico-tetrahedral tessellation the vertex figure is icosidodecahedron ([rb.gy/3u4pq](https://rb.gy/3u4pq)). The interpretation of the vertex symbol of the hyperbolic ico-tetrahedral honeycomb ([htrb.gy/3u4pq](https://htrb.gy/3u4pq)) is a considerable challenge.
3. One cannot avoid Coxeter groups and Coxeter symbols ([rb.gy/48qhg](https://rb.gy/48qhg)) in the context of tessellations. They code the structure of the symmetry group of say Platonic solid (tessellation of  $S^2$ ). This symmetry group is generated by reflections with respect to some set of lines, usually going through origin. For regular polygons and Platonic solids is its discrete subgroup of rotation group.

The Coxeter group is characterized by the number of reflection hyperplanes  $H_i$  and the reflections satisfying  $r_i^2 = 1$ . The products  $r_{ij} = r_i r_j$  define cyclic subgroups of order  $c_{ij}$  satisfying  $r_{ij}^{c_{ij}} = 1$ . Coxeter group is characterized by a diagram in which vertices are labelled by  $i$ . The orders of the cyclic subgroups satisfy  $c_{ij} \geq 3$ . For  $c_{ij}$  the generators  $r_i$  and  $r_j$  commute. For  $c_{ij} = 2$  the vertices are not connected, for  $c_{ij} = 3$  there is a line and for  $c_{ij} > 3$  the number  $c_{ij}$  is assigned with the line. For instance, hyperbolic tessellations are characterized by 4 reflection hyperplanes.

For instance, for  $p$ -polygon the Coxeter group has 2 generators and the cyclic group has order  $p$ . For Platonic solids the Coxeter group has 3 generators and the orders of cyclic subgroups are 3, 4, or 5. For ico-tetrahedral tessellation the order is 4.

### 8.2.2 The most interesting honeycombs in hyperbolic 3-space

$H^3$  allows an infinite number of tessellations. There are 9 types of honeycombs. This makes 76 uniform hyperbolic honeycombs involving only a single polyhedron ([hrb.gy/rs9h5](https://hrb.gy/rs9h5)).

4 of these honeycombs are *regular*, which means that they have identical regular faces (Platonic solids) and the same numbers of faces around vertices. The following list gives the regular uniform honeycombs and their Schläfli symbols  $\{p, q, r\}$  telling that each edge has around it regular polygon  $\{p, q\}$  for which each vertex is surrounded by  $q$  faces with  $p$  vertices.

1. H1: 2 regular forms with Schläfli symbol  $\{5, 3, 4\}$  (dodecahedron) and  $\{4, 3, 5\}$  (cube).
2. H2: 1 regular form with Schläfli symbol  $\{3, 5, 3\}$  (icosahedron)
3. H5: 1 regular form with Schläfli symbol  $\{5, 3, 5\}$  (dodecahedron).

There is a large number of uniform honeycombs involving several cell types. There exists however a "multicellular" honeycomb, which is completely unique in the sense that for it all cells are Platonic solids. This ico-tetra (or more officially, tetrahedral-icosahedral) honeycomb has tetrahedrons, octahedrons, and icosahedrons as its cells. All faces are triangles. The ico-tetra honeycomb is of special interest since it might make possible the proposed ico-tetra realization of the genetic code ([rb.gy/h8xx0](http://rb.gy/h8xx0)).

From the Wikipedia article about ico-tetra honeycomb ([htrb.gy/3u4pq](http://htrb.gy/3u4pq)) one learns the following.

1. The Schläfli symbol of ico-tetra honeycomb is  $\{(3, 3, 5, 3)\}$ . This combinatorial symbol allows several geometric representations. The inner brackets would refer to the interpretation as an analogue of the Platonic solid assignable to a 4-sphere of Euclidian 5-space. At each vertex 3 objects of type  $\{3, 3, 5\}$  would meet. At the vertex of  $\{(3, 3, 5)\}$  in turn 5 tetrahedrons meet.
2. Ico-tetra honeycomb involves tetrahedron  $\{(3, 3)\}$ , octahedron  $\{(3, 4)\}$ , an icosahedron  $\{(3, 5)\}$  as cells. That there are no other honeycombs involving several Platonic solids and only them as cells makes this particular honeycomb especially interesting. Octahedron with Schläfli symbol  $\{3, 4\}$  can be also regarded as a rectified tetrahedron having Schläfli symbol  $r\{3, 3\}$ .
3. The vertex figure of ico-tetra honeycomb ([htrb.gy/3u4pq](http://htrb.gy/3u4pq)), representing the vertices a lines connecting them is icosidodecahedron ([rb.gy/q5w62](http://rb.gy/q5w62)), which is a "fusion" of icosahedron and dodecahedron having 30 vertices with 2 pentagons and 2 triangles meeting at each, and 60 identical edges, each separating a triangle from pentagon. From a given vertex VF=60 vertices connected to this vertex by an edge can be seen. In the case of cube, octahedron, and dodecahedron the total number of vertices in the polyhedron is  $2(VF+1)$ . It is true also now, one would have 122 vertices in the basic structural unit. The total number of vertices for the disjoint polyhedra is  $6+4+12=22$  and since vertices are shared, the number of polyhedra in the basic unit must be rather large.
4. The numbers called "cells by location" could correspond to numbers 30, 20, and 12 for octahedrons, tetrahedrons and icosahedrons respectively inside the fundamental region of the tessellation defining the honeycomb. That the number of icosahedrons is smallest, looks natural. These numbers are quite large. The counts around each vertex are given by  $(3.3.3.3)$ ,  $(3.3.3)$ , *resp.*  $(3.3.3.3)$  for octahedra, tetrahedra, *resp.* icosahedra and tell the numbers of vertices of the faces meeting at a given vertex.
5. What looks intriguing is that the numbers 30, 20, and 12 for octahedrons (O), tetrahedrons (T) and icosahedrons (I) correspond to the numbers of vertices, faces, and edges for I. As if the fundamental region would be obtained by taking an icosahedron and replacing its 30 vertices with O, its 20 faces with T and its 12 edges with I, that is by using the rules *vertex*  $\rightarrow$  octahedron; *edge*  $\rightarrow$  I, *face*  $\rightarrow$  T. These 3-D objects would be fitted together along their triangular faces.

Do the statements about the geometry and homology of I translate to the statements about the geometry and homology of the fundamental region? This would mean the following replacements:

- (a) "2 faces meet at edge"  $\rightarrow$  "2 T:s share face with an I".

- (b) "5 faces meet at vertex"  $\rightarrow$  "5 T:s share face with an O".
- (c) "Edge has 2 vertices as ends"  $\rightarrow$  "I shares a face with 2 different O:s".
- (d) "Face has 3 vertices  $\rightarrow$  "T shares a face with 3 different O:s".
- (e) "Face has three edges"  $\rightarrow$  "T has a common face with 3 I:s".

### 8.2.3 An attempt to understand the hyperbolic honeycombs

The following general observations might help to gain some understanding of the honeycombs.

The tessellations of  $E^3$  and  $H^3$  are in many respects analogous to Platonic solids as 2-D objects. The non-compactness implies that there is an infinite number of cells for tessellations. It is important to notice that the radial coordinate  $r$  for  $H^3$  corresponds very closely to the hyperbolic angle and its values are quantized for the vertices of tessellation just like the values of spherical coordinates are quantized for Platonic solids. The tessellations for  $E^3$  are scale covariant. For a fixed radius of  $H^3$  characterized by Lorentz invariance cosmic time this is not the case. One can however scale the value of  $a$ . What distinguishes between regular tessellations in  $E^3$  and  $H^3$  is that the metric of  $H^3$  is non-flat and has negative curvature.  $H^3$  is homogeneous space meaning that all points are metrically equivalent (this is the counterpart of cosmological principle in cosmology). Since both spaces have rotations as symmetries, this does not affect basic Platonic solids as 2-D structures assignable with 2-sphere if the edges are identified as geodesic lines of  $S^2$ . Quite generally, isometries characterize the tessellations, whose fundamental region corresponds to coset space of  $H^3/\Gamma$  by a discrete group of the Lorentz group acting as isometries of  $H^3$ . The modifications induced by the replacement  $E^3 \rightarrow H^3$  relate to the 3-D aspects of the tessellation. This is because the metric is non-flat in the radial direction. The negative curvature implies that the geodesic lines diverge. One can use a counterpart of the standard spherical coordinates and in these coordinates the solid angles assignable to the vertices of Platonic solid are smaller than in  $E^3$ . Also the hyperbolic planes  $H^2$  emerging from edges of the tessellation of  $H^3$  diverge in normal direction the angles involved are smaller.

It is useful to start from the description of the Platonic solids. They are characterized combinatorially by integers and geometrically by various kinds of angles. Denote by  $p$  the number of vertices/edges of the face and by  $q$  the number of faces meeting at vertex.

3. Important constraints come from the topology and combinatorics. Basic equations for the numbers  $V$ ,  $E$ , and  $F$  for the number of vertices, edges and faces are purely topological equations  $VE + F = 2$ , and the equation  $pF = 2E = qV$ . Manipulation of these equations gives  $1/r + 1/p = 1/2 + 1/E$  implying  $1/r + 1/p > 1/2$ . Since  $p$  and  $q$  must be at least 3, the only possibilities for  $\{p, q\}$  are  $\{3, 3\}$ ,  $\{4, 3\}$ ,  $\{3, 4\}$ ,  $\{5, 3\}$ , and  $\{3, 5\}$ .
2. The angular positions of the vertices at  $S^2$  are basic angle variables. In  $H^3$  hyperbolic angle assignable to the radial coordinate is an additional variable of this kind analogous to the position of the unit cell in the  $E^3$  tessellation. The cosmological interpretation is in terms of redshift.
3. There is the Euclidian angle  $\phi$  associated with the vertex of the face given by  $\pi/p$ . Here there is no difference between  $E^3$  and  $H^3$ .
4. The angle deficit  $\delta$  associated with the faces meeting at a given vertex due to the fact that the faces are not in plane in which case the total angle would be  $2\pi$ .  $\delta$  is largest for tetrahedron with 3 faces meeting at vertex and therefore with the sharpest vertex and smallest for icosahedron with 5 triangles meeting at vertex. This notion is essentially 3-dimensional, being defined using radial geodesics, so that the  $\delta$  is not the same in  $H^3$ . In  $H^3$   $\delta$  is expected to be larger than in  $E^3$ .



5. There is also the dihedral angle  $\theta$  associated with the faces as planes of  $E^3$  meeting at the edges of the Platonic solid.  $\theta$  is smallest for a tetrahedron with 4 edges and largest for a dodecahedron with 20 edges so that the dodecahedron is not far from the flat plane and this angle is not far from  $\pi$ . The  $H^3$  counterpart of  $\theta$  is associated faces identified as hyperbolic planes  $H^2$  and is therefore different.
6. There is also the vertex solid angle  $\Omega$  associated with each vertex of the Platonic solid  $\{p, q\}$  given by  $\Omega = q\theta - (q-2)\pi$ . For tessellations in  $E^3$  the sum of these angles is  $4\pi$ . In  $H^3$  its Euclidian counterpart is larger than  $4\pi$ .
7. The face solid angle is the solid angle associated with the face when seen from the center of the Platonic solid. The sum of the face solid angles is  $4\pi$ . For Platonic solid with  $n$  vertices, one has  $\Omega = 4\pi/n$ . The divergence of the geodesics of  $H^3$  implies that this angle is smaller in  $H^3$ : there is more volume in  $H^3$  than in  $E^3$ .

$E^3$  allows only single regular tessellation having cube as a unit cell.  $H^3$  allows cubic and icosahedral tessellations plus two tessellations having a dodecahedron as a unit cell. Why does  $E^3$  not allow icosahedral and dodecahedral tessellations and how the curvature of  $H^3$  makes them possible? Why is the purely Platonic tetra-icosahedral tessellation possible in  $H^3$ ?

The first guess is that these tessellations are almost but not quite possible in  $E^3$  by looking at the Euclidian constraints on various angles. In particular, the sum of dihedral angles  $\theta$  between faces should be  $2\pi$  in  $E^3$ , the sum of the vertex solid angles  $\Omega$  at the vertex should be  $4\pi$ . Note that the scaling of the radial coordinate  $r$  decreases the dihedral angles  $\theta$  and solid angles  $\Omega$ . This flexibility is expected to make possible so many tessellations and honeycombs in  $H^3$ . The larger the deviation of the almost allowed tessellation, the larger the size of the fundamental region for fixed  $a$ .

Consider now the constraints on the basic parameters of the Platonic solids (rb.gy/1cuav) in  $E^3$  while keeping their  $H^3$  counterparts in mind.

1. The values of didedral angle for tetrahedron, cube, octahedron, dodecahedron, and icosahedron are

$$[\theta(T), \theta(C), \theta(O), \theta(D), \theta(I)] \approx [70.3^\circ, 90^\circ, 109.47^\circ, 116.57^\circ, 138.19^\circ] .$$

Note that  $r = 5$  tetrahedra meeting at a single edge in  $E^3$  would almost fill the space around the edge. In  $E^3$   $r = 4$  cubes can meet at the edge. In  $H^3$   $r$  should be larger. This is indeed the case for the cubic honeycomb  $\{4, 3, 5\}$  having  $r = 5$ . For  $r = 3$  icosahedrons the sum dihedral angles exceeds  $2\pi$  which conforms with the that  $\{3, 5, 3\}$  defines an icosahedral tessellation in  $H^3$ . For the  $r = 4$  dodecahedra meeting at the edge the total dihedral angle is larger than  $360^\circ$ :  $r = 4$  is therefore a natural candidate in  $H^3$ . There are indeed regular dodecahedral honeycombs with Schläfli symbol  $\{5, 3, r\}$ ,  $r = 4$  and  $r = 5$ . Therefore it seems that the intuitive picture is correct.

2. The values of the vertex solid angle  $\Omega$  for cube, dodecahedron, and icosahedron are given by the formula  $\Omega = q\theta - (q-2)\pi$  giving

$$[\Omega(C), \Omega(D), \Omega(I)] \approx [1.57080, 2.96174, 2.63455].$$

The sum of these angles should be  $4\pi$  for a tessellation in  $E^3$ . In  $E^3$  This is true only for 8 cubes per vertex ( $\Omega = \pi/2$ ) so that the cubic honeycomb is the only Platonic honeycomb in  $E^3$ . The minimal number of cubes per vertex is 9 in  $H^3$ . It is convenient to write the values of the vertex solid angles for D and I as

$$[\Omega(D), \Omega(I)] = [0.108174, 0.209651] \times 4\pi .$$

The number of D:s *resp.* I:s must be at least 10 *resp.* 5 for dodecahedral *resp.* icosahedral honeycombs in  $H^3$ .

3. The basic geometric scales of the Platonic solids are circumradius  $R$ , surface area  $A$  and volume  $V$ . The circumradius is given by  $R = (a/2) \tan(\pi/q) \tan(\theta/2)$ , where  $a$  denotes the edge length. The surface area  $A$  of the Platonic solid  $\{p, q\}$  equals the area of face multiplied by the number  $F$  of faces:  $A = (a/2)^2 F p \cot(\pi/p)$ . The volume  $V$  of the Platonic time is  $F$  times the volume of the pyramid whose height is the length  $a$  of the face: that is  $V = FaA/3$ .

Choosing  $a/2$  as the length unit, the circumradii  $R$ , total face areas  $A$  and the volumes  $V$  of the Platonic solids are given by

$$[R(T), R(C), R(O), R(D), R(I)] = [\sqrt{3}/2, \sqrt{3}, \sqrt{2}, \sqrt{3}\phi, \sqrt{3-\phi}] ,$$

$$[A(T), A(C), A(O), A(D), A(I)] = [4\sqrt{3}, 24, 2\sqrt{3}, 12\sqrt{25+10\sqrt{5}}, 20\sqrt{3}] ,$$

and

$$\begin{aligned} [V(T), V(C), V(O), V(D), V(I)] &\approx [\sqrt{8}/3, 8, \sqrt{128}/3, 20\phi^3/(3-\phi), 20\phi^2/3] \\ &\approx [.942809, 8, 3.771236, 61.304952, 17.453560] . \end{aligned}$$

What can one say about icoso-tetrahedral tessellation?

1. Consider first the dihedral angles  $\theta$ . The values of dihedral angles associated  $T$ ,  $O$ , and  $I$  in  $H^3$  are reduced from that in  $E^3$  so that their sum in  $E^2$  scene must be larger than  $2\pi$ . Therefore at least one of these cells must appear twice in  $H^3$ . It could be  $T$  but also  $O$  can be considered. For  $2T + O + I$  and  $T + 2O + I$  the sum would be  $388.26^\circ$  resp.  $427.43^\circ$  in  $E^3$ .  $2T + O + I$  resp.  $T + 2O + I$  could correspond to 4 cells ordered cyclically as ITOT resp. IOTO.
2. The values of the vertex solid angle  $\Omega$  for tetrahedron, octahedron, and icosahedron are given by  $[\Omega(T), \Omega(O), \Omega(I)] = [0.043870, 0.108174, 0.209651]4\pi$ . If the numbers of  $T$ ,  $O$  and  $I$  are  $[n(T), n(O), n(I)]$ , one must have  $[n(T)\Omega(T) + n(O)\Omega(O) + n(I)\Omega(I)] > 4\pi$  in  $H^3$ .

If the number of the cells for the fundamental domain are really  $[N(T), N(O), N(I)] = [30, 20, 12]$ , the first guess is that  $[n(T), n(O), n(I)] \propto [N(T), N(O), N(I)]$  is approximately true. For  $[n(T), n(O), n(I)] = [2, 3, 1]n(I)$ , one obtains  $\Omega = n(T)\Omega(T) + n(O)\Omega(O) + n(I)\Omega(I) = n(I) \times .629 \times 4\pi$ . This would suggest  $n(I) = 2$  giving  $[n(T), n(O), n(I)] = [4, 6, 2]$

## 8.3 New results about the relation of the icoso-tetrahedral tessellation to the dark genetic code

How could the icoso-tetrahedral tessellation relate to the proposed dark realizations of the genetic code [L170, L192]?

### 8.3.1 About the problems of the earlier view of the dark realizations of the genetic code

Consider first the problems of the earlier views of the realization of the dark genetic codes in terms of dark proton triplets at monopole flux tubes parallel to the ordinary DNA and to the realization in terms of dark photon triplets.

1. The TGD based inspired model of the dark photon genetic code [L31] [L140, L170] assumes that the dark realization of genetic code involves 3 icosahedral Hamiltonian cycles giving rise to  $20+20+20$  dark DNA codons and the unique tetrahedral Hamiltonian cycle giving the remaining 4 codons.

The obvious problem of icoso-tetrahedral picture is that one must assume that icosahedron and tetrahedron are disjoint. If they have a common face, the number of faces reduces to 63 and one DNA codon is missing. This raises the question whether icosahedron and tetrahedron could be disjoint pieces of a larger structure.

2. Icosahedron and tetrahedron should have a physical realization: what could it be? How the Hamiltonian cycles are realized physically? The cycles are defined only modulo the isometry group  $I$  of icosahedron having 60 elements and  $Z_n$   $n = 6, 4$  or  $2$  leaves the cycle and the orbits of this group (amino-acids) invariant. The Hamiltonian cycle has  $\#(I/Z_n)$  isometric copies (the numbers of copies are 10, 15, and 32). Does this have a physical significance? How are the 12 frequencies associated with the edges of the cycle realized physically? What is the physical interpretation of octave equivalence: does it have something to do with 2-adicity?
3. In the dark proton realization a given codon would correspond to a selected triangular face of  $I$  or  $T$  carrying dark protons at the vertices of this face. The original view was that dark 3-proton states would correspond to 64 codons. The problem was that one obtains only 8 states for dark proton triplets from spin and antisymmetrization in spin degrees of freedom would not allow any states unless the spatial wave function is totally antisymmetric and spins are in the same direction.

In the original proposal also neutrons were assumed so that the codon corresponds to a sequence of 3 nucleons with both spins. 3 nucleons would give rise to 64 states as required. Dark protons can also be effectively neutrons as far as charge is considered. This might be possible if the bonds connecting the dark protons can be both neutral and negatively charged. Weak interactions are as strong as electromagnetic interactions in a given biological scale (such as DNA scale) if the dark Compton length proportional to  $\hbar_{eff}$  is larger than this scale and the weak transitions change the dark protons to effective dark neutrons.

This option leads to a problem with the fact that DNA nucleotides have negative unit charge. One should have protons to neutralize this charge and stabilize DNA. Also variants of the proposal in which there are flux tube connections between dark protons having 2 different neutral states analogous to neutral pion and neutral  $\rho$  meson.

The simplest proposal, which is consistent with the idea that genetic codons correspond to cyclotron transitions of dark proton triplets assignable to the triangular faces of an icosahedron or tetrahedron is as follows. Besides 2 spin states, dark protons can also have 2 states with spin  $\pm 1$  corresponding to the analog of rotation in the discrete space defined by the vertices of the triangle. This would give  $2^3 \times 2^3 = 64$  states.

The realizations of the genetic code in terms of dark photon triplets and dark proton triplets should correspond to each other. This requires that dark proton triplet realization should naturally correspond to the icoso-tetrahedral realization.

1. The codons identified as dark proton triplets assignable to one of the 20 triangular faces of icosahedron and tetrahedron have in quantum situations a wave function in the discrete space of the faces, which is in general delocalized. Could these wave functions in the set of faces give rise to states in 1-1 correspondence with the icosahedral and tetrahedral codons? There would be 20 wave functions for an icosahedron and 4 wave functions for a tetrahedron. The number of icosahedral states must be tripled to 60 corresponding to the 3 basic types of icosahedral Hamiltonian cycles with symmetries  $Z_n$ ,  $n = 6, 4, 2$ .

The 3 dark protons also have spin degrees of freedom. The dark proton triplet in the ground state(s) would be naturally spontaneously magnetized so that all spins are in the same direction. Also the states in which some dark protons are excited are allowed by Fermi statistics and are needed since these excitations could correspond to the spatial wave functions in face degrees of freedom.

2. Dark photon triplets are needed for communications. The vision is that they correspond to the representation of codons as frequency triplets represented by the realization of icosahedral and tetrahedral Hamiltonian cycles as frequency triplets. The assumption has been that the 3 frequencies of dark 3-photon are associated with the cyclotron (or Larmor transitions if only spin is dynamical) of dark protons of a dark proton triplet.

Dark photon communications between identical codons would take place by 3-resonance. The de-excitation of the first codon would lead to the excitation of an identical codon: one would have a kind of flip-flop. Also dark genes as sequences of  $N$  dark codons could act as a

single quantum coherent unit and 3-N resonances between identical dark genes would become possible. The mechanism is very similar to that used in the computer language LISP. The modulation of the frequency scale by modulating the thickness of the monopole flux tubes would make possible coding of the signal and it would be transformed to a sequence of resonance pulses at the receiving end.

Dark photon triplet states could correspond to wave functions in the space of icosahedral and tetrahedral faces.

3. Cyclotron transitions would be needed in order to generate dark photon triplets. This would require excitations of the dark protons of the spontaneously magnetized ground state(s). If only spin matters, the cyclotron transitions reduce to Larmor transitions. The correspondence with the icosahedral Hamiltonian cycles in terms of dark photon triplets would suggest that these excitations correspond to icosahedral genetic codons as wave functions in the set of faces. The cyclotron transition would provide the energy needed to excite the wave function in the set of faces. 64 transitions would be needed. It is important to notice that cyclotron transitions rather than cyclotron states of dark protons would correspond to codons of ico-tetra representation represented as wave functions in the set of faces.

There are however only 8 states per face if only Larmor transitions are allowed. This is much less than the number  $20 \cdot 20 + 4 = 64$  for icosahedral and tetrahedral Hamiltonian cycles. An additional two-valued degree of freedom is needed. The simplest possibility is the assignment to each dark proton an analog of angular momentum eigenstate with spin  $\pm 1$  corresponding to a discrete rotation around the triangle. This would give  $8 \times 8 = 64$  states per face. Could the excitations of these states correspond to  $20 + 20 + 20$  icosahedral states plus 4 tetrahedral states?

4. Hitherto the considerations have been implicitly classical in that a localization in the set of faces has been assumed. Quantum theory allows us to give up this assumption. Icosahedral realization suggests that dark proton triplet has a icosahedral wave function delocalized to the set of 20 faces with symmetry fixed by the Hamiltonian cycle to  $Z_n$ ,  $n = 6, 4$  or  $2$ , and that the excitation of the dark proton triplet in the face degrees of freedom provides the energy changing the wave function in the set of faces. The same would apply to the tetrahedron with symmetry  $Z_4$  allowing 4 wave functions.

The orbital and angular momentum degrees of freedom would be coupled. The transition from the ground state for dark proton triplet would excite wave function in the set of faces. This could imply the desired correspondence between the dark proton representations and dark photon realizations of the code.

5. There is a further problem. Spontaneously magnetized states of 3 dark protons would define ground states of codons. The ground state proton triplet cannot have lower energy states and cannot emit dark photon triplets and are therefore "mute" and unable to communicate, presumably necessary for processes like transcription and translation. Note that ground states are however not deaf.

The proposed general view is attractive but the details remain to be understood and problems solved. Here the notion of ico-tetra tessellation could help. The proposal of [L192] was that the ico-tetra honeycomb at the light-cone proper time  $a = \text{constant}$  surfaces identifiable as hyperbolic 3-space  $H^3$  allows to realize the dark genetic code.

The ico-tetra honeycomb is the unique honeycomb, which involves only Platonic solids. This inspires the question whether genetic code could be universal and realized in all scales by induction, which means that the tessellation of  $H^3$  induces tessellation of 3-surface  $X^3 \subset H^3$  by restriction. Also the induction to  $H^3(a)$  projection of  $X^4$  makes sense.

The TGD view of holography indeed predicts the special role of hyperbolic 3-spaces. The space-time surfaces in  $H = M^4 \times CP_2$  are analogs of Bohr orbits, which go through  $H^3(a_n) \subset M^4 \subset H$ , where  $a_n$  corresponds to a root of the polynomial with integer coefficients determining to a higher degree a given region of the space-time surface by  $M^8 - H$  duality [L165, L166].

In the sequel the detailed realization of the genetic code in terms of the icosahedral honeycomb will be discussed with an emphasis on the problems noticed above.

### 8.3.2 The realization of the code in terms of icoso-tetrahedral tessellation

The fundamental region of the icoso-tetrahedral tessellation contains 30 octahedrons, 20 tetrahedrons, and 12 icosahedrons and the cautiously proposed interpretation is that the cells meeting at each *edge* of the tessellation have either the cyclic structure TOTI or OTOI, and each vertex involve 3 O:s, 2 T:s and 1 I. Could one interpret this in terms of the dark icosahedral realization of the genetic code?

#### Ideas related to the detailed realization of the genetic code

The detailed realization of the dark genetic code is far from completely understood and one might hope that icoso-tetrahedral realization could bring in the constraints allowing us to fill in the details. It is useful to proceed by considering basic requirements on the realization of the dark code.

1. There are 3 O:s per single I in vertex if 10 instead of 12 icosahedral cells are included. The reasons for this become clear from the proposed relation between DNA double strand and fundamental cell of icosahedral honeycomb. What could the role of O:S be?

Imagine that it is possible to arrange the polyhedrons for a given I to cycles as -I-O-T-O-T-O-: here cyclicity is assumed. The two tetrahedrons and I would be disjoint. This would solve the problem due to the common face of T and I (only 63 DNA codons) but give  $60+4+4$  faces and 68 dark DNA codons. There is however the problem posed by the mute codons. Could the presence of mute DNA codons reduce the number of DNA codons from 68 to 64. This would imply that their transcription allows only 64 dark mRNA codons. Could mute mRNA codons reduce the effective number of mRNA codons to 61 for the standard code (stop codons would be mute)? What about its variants with a smaller number of stop codons?

2. Bioharmony involves 3 icosahedral Hamiltonian cycles. All the combinations of the 3 -cycles with symmetries  $Z_6, Z_4$  and  $Z_2$  predict the same code. These bioharmonies are interpreted as correlates for emotional states appearing already at the basic bio-molecular level. The motivation comes from the fact that the icoso-tetrahedral harmony emerges as a geometric model for the music harmony and music indeed both creates and expresses emotions.

Could icosahedral honeycomb allow us to understand the realization of these 3 icosahedral Hamiltonian cycles in terms of cyclotron frequency triplets? One must have closed magnetic monopole loops in order to have cyclotron transitions. Could these loops form triangles of form I-T-O. This would be 6 different triangles and 3 different positions of I for given T. This kind of loop would be assigned with each vertex of the face. Could the magnetic field strengths depend on the loop and for a given T give rise cyclotron frequency triplets characterizing a given icosahedral Hamiltonian cycle.

3. One can criticize the assumption that there is only a single codon per single I and T. I:s could in principle carry several codons. This however gives a restriction that the codons inside given I and T are different and restricts the representative power of the code if it involves more than 2 strands. This restriction is however automatically satisfied for the base-paired codon and anticodon in the DNA double strand!

#### Dark photon realization of the icosahedral part of the code

Consider first the realization of the icosahedral part of the code in terms of dark photons.

1. The 3 icosahedral Hamiltonian cycles have symmetries. The 20 codons with  $Z_6$  symmetry correspond to 3 6-plets and 1 doublet of  $Z_6$  and for unbroken symmetry the codons inside these multiplets code for the same amino acid. This means  $3+1=4$  amino acids.  $Z_4$  symmetry has 5 4-plets and in absence of symmetry breaking this corresponds to 5 amino-acids.  $Z_2$  symmetry as 10 2-plets, and also this symmetry is also almost exact and corresponds to the almost exact symmetry with respect to the third letter of the codon analogous to isospin symmetry.

2. Icosahedral part of the icoso-tetrahedral realization involves 3 icosahedral Hamiltonian cycles characterized by different symmetries. For  $Z_6$  symmetry, there are  $6+6+6+2=20$  codons. These sets of codons can be regarded as orbits of  $Z_6$  and correspond to amino-acids. This if the  $Z_6$  symmetry is not broken. This means 3+1 amino acids in absence of symmetry breaking.

$Z_4$  symmetry has 5 4-plets and in absence of symmetry breaking this corresponds to 5 amino-acids coded by 4 codons each.  $Z_2$  symmetry has 10 2-plets and this symmetry is also almost exact. This symmetry corresponds to the almost exact symmetry with respect to the third letter of the codon.

3. Dark photon codons are represented as cyclotron frequency triplets of dark photons created in 3-cyclotron transitions for dark proton triplets involving simultaneous emission of 3 dark photons made possible by quantum coherence. In the case of genes with  $N$  codons one has  $3N$ -cyclotron transition and  $3N$  dark proton-state represents a gene as a quantum coherent unit.

### Dark proton realization of the icosahedral part of the code

Consider next the dark proton realization of the icosahedral part of the code.

1. The basic problem of the dark proton realization of the code is that there are only 8 dark proton spin states. If one assumes that each dark proton can have spin  $\pm 1$  this problem the number of dark proton states is 4 and one obtains 64 states.

If one allows the states with vanishing spin so that one would have 3 orbital states per dark proton, the number of cyclotron transitions per dark proton is 4. Since lowest energy states are mute and transitions define codons, this could be the correct identification.

2. Icosa-tetrahedral realization should give  $20+20+20+4=64$  dark proton triplets assignable to the faces of I and T. Suppose that the cells can be thought of as forming a cycle O-I-O-T-O-T with O and T ends connected. The two T:s have no common faces with O and without additional conditions give rise to  $4+4$  additional codons giving 68 codons. How can one reduce the number of dark DNA codons to 64?

3. Dark proton codons have a ground state, or possibly several of them, which by definition cannot decay to lower energy states by emission of dark photon cyclotron triplet. Ground state codon is mute since it cannot produce dark photon triplets as 3-chords.

The natural first guess is that the ground states correspond to the 6 combinations 3 icosahedral Hamiltonian cycles and 2 tetrahedral cycles assignable to  $2 \times T$ . The 3 stop codons are transcribed but not translated so that the interpretation of 3 DNA stop codons as icosahedral ground state dark codons unable to send 3-photon signals is not correct. For mRNA this interpretation could make sense if the mRNA images of DNA stop codons represent ground state codons.

4. Cyclotron excitations of ground state codons are induced by dark photon triplets. Conversely cyclotron de-excitatons generate dark proton triplets except for the ground state codons with minimum total energy. Suppose that there are 6 ground state codons as combinations of 3 dark codon ground states assignable to the 3 icosahedral Hamiltonian cycles and 2 dark proton ground states assignable to tetrahedral cycles of the two T:s. This would give 8 mute states. The total number of dark DNA codons is  $60+8=68$ . Note that the mute states are not deaf: they can receive messages.

One would obtain only 60 DNA codons, which can be transcribed to mRNA codons if the transcription involving dark photon codons. How could one get 64 as an effective number of DNA codons?

One can imagine transitions between otherwise mute codons, which generate dark photon triplets coupling to mRNA associated with DNA. Let A, B and C the ground state codons with minimal total dark cyclotron energies in an increasing order for the 3 icosahedral Hamiltonian cycles. If for a given T (two options) the cyclotron transitions are possible only between

codons C and B and B and A one obtains 2 DNA-mRNA pairings for both T:s. One would have  $60+2+2=64$  mRNAs pairing with DNA and effectively 64 DNA codons.

Note that the transcription produces only 64 dark mRNA codons from 68 dark DNA codons.

For 64 mRNA codons it could happen that there are no transitions between the 3 icosahedral codons for both choices of T so that there are 6 mute mRNA codons. If there are transitions  $C \rightarrow B$  and  $B \rightarrow A$ , the number of mute icosahedral codons is 4. If there are no transitions between tetrahedral ground state codons, one has effectively 60 mRNA codons since the translation stops due to the absence of dark 3-photon signals to tRNA. If there is a transition between the 2 ground state mRNA codons associated with the two T:s, one obtains 61 effective mRNA codons of the standard realization of the code. The transitions between tetrahedral codons can increase the effective number of mRNA codons.

5. What about tRNA appearing as a pair of amino-acid and single RNA codon. Could the RNA of tRNA and amino-acids correspond to the unique icosahedral honeycomb of  $H^3$  and to icosahedral Hamiltonian cycles so that the number of dark codons in absence of tetrahedral degeneracy would reduce to 32, which is the minimal number of ordinary tRNA codons, which is increased by the non-uniqueness of the ordinary tRNA itself? Note that mute tRNA codons are not deaf: they can receive messages but cannot send them. Obviously, tRNA and amino-acids would correspond to the lowest evolutionary level.

The tentative conclusion would be that in the TGD framework DNA-mRNA transcription is not 1-to-1: information is lost and could say that RNA represents a lower level of evolutionary hierarchy. This would conform with the RNA world vision. The numbers of dark proton DNA and mRNA codons are 68 and 64 respectively. The unavoidable existence of mute codons gives effective DNA codon number 64 as the number of mRNA codons. 3 icosahedral codons can be mute and one obtains 3 stop codons unable to communicate with tRNA. The number of mute codons can also be smaller.

The dark DNA and RNA codons are dynamical and are not fixed to be the same as ordinary codons. This is required only during the communications with ordinary DNA possibly taking place by dark photons transforming to ordinary photons and inducing resonant transitions of ordinary DNA and other basic biomolecules. This strongly suggests that dark DNA and RNA act as kinds of R&D laboratories making it possible to test variants of the genes. Actually their ground states would correspond to 3 icosahedral representations and 2 tetrahedral representations and would correspond to aminoacids via transcription and translation.

Needless to say, this picture is highly speculative and one can probably imagine variants for it. The basic idea is however clear: icoso-tetrahedral tessellation could explain the details of the standard genetic code and its modifications.

### Realization of the flux tube structures associated with dark codons

The following represents an attempt to make the above picture more concrete.

1. The selection of 1 O from 3 O:s could mean a selection of an icosahedral Hamiltonian cycle with symmetry group  $Z_6$ ,  $Z_4$ , or  $Z_2$ . This gives for icosahedral realization  $20+20+20=60$  icosahedral codons. Tetrahedral Hamiltonian cycles associated with the two T:s should give the remaining 4 codons. One can however imagine several ways for how this could occur.
2. The selection of O should correspond to a choice of the icosahedral cycle. What does this mean geometrically? To each dark proton of the codon, one must assign a closed monopole flux tube. The strength of the magnetic field of the flux tube fixes the cyclotron frequency scale for each flux tube. The 20 dark-photon chords defining a given icosahedral bioharmony differ for different choices of O and T. The frequencies are fixed if the Hamiltonian cycle corresponds to a quint cycle such that the frequencies associated with the neighboring vertices of the Hamiltonian cycle differ by a scaling  $3/2$ . This requires that the magnetic field strengths along the cycle differ by scaling  $3/2$ .
3. How to concretely realize the correlation of the bioharmony with the choice of O and T for a given I? Suppose that for a given I, the closed flux tube connects I and the selected O and

T. There would be a closed I-O-T flux tube for each vertex of the face defining the codon. This kind of flux tube would define an analog of a string of a musical instrument.

These closed flux tubes would be hyperbolic analogies of closed circuits formed by Euclidian nearest neighbour lattice bonds. If makes sense to assign to each I a cycle O-I-O-T-O-T, with O and T at ends being connected, the cycle I-O-T would go through the either T, and this implies that tetrahedral codons correspond to the other face of T. One would obtain 64 dark proton codons with 3 mute dark proton codons identifiable as stop codons. In the transcription the signal as a dark photon triplet would not reach the dark RNA codon and the transcription would stop. Could this mean that dark RNA codon attaches first to dark DNA codon and the transcription of DNA to ordinary RNA occurs after that in the usual way.

4. The proposed transitions between ground state codons for icosahedral Hamiltonian cycles modify the cycle geometrically since the O in cycle I-O-T changes. If the transitions for given  $T$  are only of  $C \rightarrow B$  and  $B \rightarrow A$  with energies in increasing order, one can imagine that the O is replaced by a neighboring O in the transition in the O-I-O-T-O-T.

Several questions remain to be answered.

1. The symmetry breaking for the icosahedral codons with  $Z_n$ ,  $m = 6, 4, 2$  should be understood. This symmetry breaking can be assumed to occur at the level of dark mRNA and modify the frequency triplets from those for completely symmetric mRNA codons. The replacement  $T \rightarrow U$  might relate to the symmetry breaking.

UUG, CUG, and the very common AUG appear as start codons. They correspond to symmetry breaking for 6-plet ( $Z_6$ ) coding for leu and 4-plet ( $Z_4$ ) coding for ile. All symmetry breakings occur for start codons UUG, CUG, and for codons UAA and UAG and UGA and UGG closely related to stop codons.

2. Can one understand the reduction of the number of mRNA stop codons to 2 or 1 occurring for some variants of the code? In these situations, the stop codon of mRNA can code for an exotic amino acid pyrrolysine and selenocysteine. Could the transition between stop codon of dark mRNA icosahedral Hamiltonian cycle to a stop codon of another Hamiltonian cycle take place such that the dark photon triplet generated couples to tRNA involving the exotic amino acid. Situation would be almost like in the case of DNA where only two ground state codons stop the transcription.
3. What can one say about the strength of the magnetic fields assignable with the monopole flux tubes? Nanometer length scale 1 nm, naturally assignable to the DNA double strand, corresponds from the formula  $l_B = 26nm/\sqrt{B/Tesla}$  to 12.2 GHz. What is interesting is that the gravitational Compton frequency for Earth is 67 GHz and defines a lower bound for the gravitational quantum coherence time. If the strengths of the magnetic fields span 7 octaves, the thickness of the flux tube would vary by a factor 10 in the range about .1 nm - 1 nm.
4. Note that the 12-note scale can be realized using powers  $(3/2)^k$ ,  $k = 1, \dots, 12$ , of the fundamental and by using octave equivalence to reduce the note to the basic octave. Since the monopole flux is quantized, the realization of the scale requires variation of flux tube thickness inducing variation of magnetic field strength and therefore of that cyclotron frequency scale.

There is nothing cherished in the rational quint cycle as the basis of the 12-note scale. For instance, the well-tempered scale actually replaces the Pythagorean scale with an algebraic scale coming in powers of  $2^{1/12}$ .

### 8.3.3 Description of the entire DNA double strand in terms of icosatehedral tessellation

The most ambitious model would describe the entire DNA double strand and relate the model bioharmony to the properties of the ico-tetrahedral tessellation. There are however many questions remaining.



1. Single DNA and RNA strand would correspond to a "half realization" for which the T and I cells would contain only single codon. The splitting of DNA could have a geometric interpretation as an effective replication of the induced tessellation to two tessellations to RNA type tessellations.
2. There are 20 amino-acids and an icosahedron involves 20 faces. Is this a mere accident? Could icosahedral honeycomb describe amino-acid sequences geometrically. tRNA appears as a single unit. tRNA-amino-acid pairing would involve pairing of two icosahedral tessellations as also the pairing of RNA and tRNA in the translation. tRNA would naturally correspond to a single cell of icosahedral tessellation. This would also explain why the number of tRNA molecules is considerably smaller than RNA codons.
3. Does RNA correspond to icosahedral or icoso-tetrahedral tessellation? Tetrahedral Hamiltonian cycles are needed, in particular the dark proton triplets associated with the tetrahedral faces. Therefore icoso-tetrahedral tessellation is the natural option also for RNA.
4. It is thought that DNA and RNA nucleotides float freely in the cellular water and DNA and RNA codons are built from them in replication/transcription. This is probably the case at the biochemical level, whose dynamics is controlled by dark level (I have however considered the possibility that freely floating nucleotides could actually form loosely bound codons).

At the ark level both replication and transcription would involve replication of the induced icoso-tetrahedral tessellation: a similar process occurs for clay crystals, and is suggested to be a precursor of DNA replication. This process is a holistic quantum process occurring in a single quantum jump. This would explain the incredible accuracy of these processes, which is extremely difficult to understand in the chemical approach.

The replication would determine the outcome, be it a pair of DNA double strands or of DNA and RNA. After this the chemical processes leading to the formation of chemical codons from nucleotides and their pairing with dark codons of the induced icoso-tetrahedral tessellation would take place.

DNA has a helical structure. Helical tessellations are known to exist ([rb.gy/5ova6](http://rb.gy/5ova6)). If icoso-tetrahedral tessellation is induced, the helical structure would most naturally reflect the dynamics of the corresponding space-time surface. This suggests that only a sequence of I:s is selected from the set of 12 I:s in a given fundamental region of the icoso-tetrahedral tessellation.

To see whether this hypothesis can make sense one must use geometrical facts about DNA double helix, which has A-, B-, and Z forms ([rb.gy/4kcrm](http://rb.gy/4kcrm)).

1. B-form is believed to dominate in cells. From the table of the Wikipedia article one learns that for the B-form the rise per base pair (bp) is  $3.32 \text{ \AA}$ , that full turn corresponds to 10.5 bps, and that the pitch of the helix per turn  $33.2 \text{ \AA}$ , which corresponds to 10 bps per turn. The pitch/turn should be equal to  $10.5 \times 3.32 = 34.52 \text{ \AA}$ . There is obviously a mistake in the table.
2. The solution of the puzzle is that straight DNA in solution has 10.5 bps/turn and 10 bps/turn in solid state ([rb.gy/wqjbh](http://rb.gy/wqjbh)). If DNA double helix corresponds to solid state then 10 codons correspond to 3 full turns. Therefore my earlier assumption 10 bps/turn in the double helix is correct. 10 codons would correspond 3 full turns and to the length  $99.6 \text{ \AA} \simeq 10 \text{ nm}$ , which in TGD framework corresponds to the p-adic length scale  $L(151)$ .

Double DNA strands cannot pair with all 12 I:s associated with the dark DNA. The length  $L(151)$  should correspond to 10 I:s taking 80 per cent of the icosahedral volume. Is helical winding enough to achieve this?

1. The total volume of the fundamental region is  $V = 20V(T) + 30V(O) + 12V(I) = 341.44$  using  $2a$  as length unit. Using the estimate  $V_{real} = L(151)^3 = 10^6 \text{ \AA}^3$ , one obtains  $a = L(151)/2V^{1/3} \simeq 0.07 \times L(151)$ . The volume fraction of single icosahedron would be  $17.45/V \simeq .05$  and 10 I:s would take  $1/2$  of the volume.

2. The circumradius of single icosahedron would be  $R = \sqrt{3 - \phi}a/2 \simeq .1 \times L(151) = 1$  nm. This conforms with the assumption that there are 10 codons per length  $L(151)!$  The diameter of the B-type DNA strand is 20 Å is also consistent with the value of the circumradius. Maybe the proposed picture works!
3. Notice that if an icosahedral cell corresponds to 2 tetrahedral cells and 3 tetrahedral cells, then 10 codons is the maximum for the realizable DNA codon.

What can one say about the straight form of DNA?

1. For 10.5 bps/turn for a straight DNA in solution, the smallest portion of strand, which corresponds to integer numbers of turns and of codons is 6 full turns. This corresponds to 63 bps and 21 codons.
2. With an inspiration coming from the notion of Combinatorial Hierarchy [A29, A37] defined in terms of Mersenne primes  $M_n = 2^n - 1$  defined by the recursive formula  $M(k) = M_{M(k-1)} = 2^{M(k-1)} - 1$ , I proposed decades ago that ordinary genetic code could correspond to Mersenne prime  $M_7 = 2^7 - 1$  [K46] [L56]. The basic idea is that a system with  $2^7 - 1$  states corresponds to a Boolean logic with 7 bits but with one state missing: this state would correspond to empty set in the set theoretic realization or fermionic vacuum state in the realization as a basis for fermionic Fock states. Only 6 full bits can be realized and the number of realizable statements is 64, the number of genetic codons.
3. Memetic code corresponds to the Mersenne prime  $M_{127} = M_{M_7} - 1 = 2^{127} - 1$ . Now the number of codons would be  $2^{126} = 2^{6 \times 21}$  and is realizable as sequences of 21 DNA codons! Note that higher Mersenne numbers in the hierarchy were proposed by Hilbert to correspond to Mersenne primes but for obvious reasons this has not been proven.
4. Could 6 full turns of straight DNA define a memetic codon? During the transcription and replication, DNA double strand opens and becomes straight. Could memetic code be established during the transcription and replication periods? A further intriguing observation is that the cell membrane involves proteins consisting of 21 amino-acids.

### 8.3.4 Some questions

Many questions remain to be answered.

1. Hamiltonian cycles are fixed only modulo the 60-element isometry group  $I$  of icosahedron. Subgroups  $Z_n$ ,  $n = 6, 4$  or  $2$  as invariance groups of their orbits defining amino-acids coded by DNA codons assigned to them. Therefore the space  $I/Z_n$  corresponds to the space of orbits of Hamiltonian cycles having 10, 15, *resp.* 32 elements for  $n = 6, 4$ , *resp.*  $2$ . Suppose that the Hamiltonian cycles for various icosahedrons of the fundamental region proposed to be associated with the sequence of 10 DNA codons differ by a non-trivial isometry assignable to  $I/Z_n$ . Does this have physical implications or is it mere gauge degeneracy?
2. The wave functions defining quantal variants of the genetic codons can be assumed to be products of wave functions for the position of the face and 3-proton states assignable to a given face should form an orthonormal set. The face wave functions associated with tetrahedra are trivially orthogonal with those of second tetrahedron and icosahedron. For a fixed choice of the icosahedral or tetrahedral Hamiltonian cycle orthogonality can be realized for the wave functions associated with the position of the face.

If the icosahedral face wave functions correspond to different Hamiltonian cycles then orthogonality of protonic states for a given face can guarantee the orthogonality. This is possible if the number of protonic states is larger than the number of icosahedral wave functions. This requires 20+20+20+20 protonic states so that four protonic 4 states are left if their number is 64.

3. Why Hamiltonian cycle and quint cycle? Without Hamiltonian cycles the number of frequencies defining 3-chords would be 30 and is reduced to 12 for Hamiltonian cycles. Hamiltonian cycles assigned to the genetic code define an additional symmetry as shifts along the cycle, which are represented as  $3/2$  scalings modulo octave equivalence. The quint cycle defines the 12 frequencies for a given magnetic field strength and the chords of different cycles consist of different combinations of frequencies.

What does the Hamiltonian cycle as a 1-D closed path correspond physically?

The proposal that the fundamental region of the icoso-tetrahedral honeycomb could have interpretation as a kind of super-icosahedron raises several interesting questions.

1. Assume that the sequence of 10 DNA (2 codons missing) to the super-icosahedron having icosahedrons as 12 super-edges, tetrahedrons as 20 super-faces, and 30 octahedrons as super-vertices. Combinatorial equivalence suggests that one cdefine icosahedral Hamiltonian cycles as sequences of 12 icosahedrons serving as superedges. Could one define higher level icosahedral genetic codes in terms of icosahedral Hamiltonian cycles. The orthogonality of the face wave functions for the different Hamiltonian cycles would require the assignment of the analogs of dark proton triplets to the super-faces.
2. What could the notion of a super-Hamiltonian cycle as a sequence of 12 dark DNAs mean? The proposed interpretation is that the collection of tetrahedral and 3 icosahedral Hamilton's cycles defines a correlate of a mood, emotional state. It is difficult to say whether the mood is the same for all cells of the entire organism, for the genome of a single cell, for the genes, for the sequences of 10 DNAs, or for codons.

Super-Hamiltonian cycle associated with the super-icosahedron would have as its edges icosahedrons with the associated 12 dark DNA codon. If the 12 icosahedrons can correspond to different Hamiltonian cycles, one would have a correlate for a sequence of moods. Hamiltonian cycle property allows only 60 sequences of this kind. Without this restriction one would have  $N^{12}$  mood sequences, where  $N$  is the number of Hamiltonian cycles.

3. One can of course ask whether super-octahedron and super-tetrahedron could make sense and whether they could combine to form a super-icoso-tetrahedron. Does one have any tessellation for which fundamental region would correspond to super-tetrahedron with tetrahedron as interior, 4 octahedrons as 4 super-vertices and 4 icosahedrons as super-edges. There is no mention of this kind of tessellation but it is known that hyperbolic tessellations constructible using the standard methods do exist.

One could even ask whether there could exist a fractal hierarchy of these super-structures constructible from the super-Platonic solids of the previous level and whether it could be realized as a hierarchy associated with dark DNA. This would mean a hierarchy of increasingly refined emotions emerging as the length of genes and DNA increases.

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## Chapter 9

# Artificial Intelligence, Natural Intelligence, and TGD

### 9.1 Introduction

Recently a humanoid robot known as Sophia (see <http://tinyurl.com/y89ad0pm>) developed by company Hanson Robotics has gained a lot of attention in net. Sophia has even the citizenship of Saudi Arab kingdom. The surprisingly human like appearance of Sophia is modelled after actress Audrey Hepburn. Sophia uses AI, visual data processing, and facial recognition. Sophia imitates human gestures and facial expressions and is able to answer questions and make simple conversations on predefined topics. The AI program used analyzes conversations, extracts data, and uses it to improve responses in the future. To a skeptic Sophia looks like a highly advanced version of ELIZA.

I must first of all confess that I know very little about practical side of AI: the basic ideas of associative networks and deep learning and are familiar to me at the conceptual level but not much more. It is the philosophical arguments, which justify my a rather skeptic view about strong AI relying on a mechanistic view about intelligence. This leads to transhumanism and notions such as mind uploading (see <http://tinyurl.com/aruyfxx>) meaning that all information content would be transferred from brain to some substrate, say computer file, and in simulation mode the substrate continues to have human consciousness. It is however good to air out one's thinking sometimes and this what I try to do in the sequel.

Irrespective of my attitudes, computers should have a description also in the quantal Universe of TGD and this forces to look more precisely about the idealizations of AI. This process led to a change of my attitudes. The fusion of human consciousness and presumably rather primitive computer consciousness might be possible in TGD Universe, and TGD inspired quantum biology and the recent ideas about prebiotic systems [L94] (see <http://tinyurl.com/yassnhzb>) provide rather concrete ideas in attempts to realize this fusion.

TGD also strongly suggests that there is also what might be called Natural Intelligence relying on 2-D cognitive representations defined by networks consisting of nodes (neurons) and flux tubes (axons with nerve pulse patterns) connecting them rather than linear 1-D representation used by AI. The topological dynamics of these networks has Boolean dynamics of computer programs as a projection but is much more general and could allow to represent objects of perceptive field and number theoretic cognition.

#### 9.1.1 Why I have been a skeptic

The reasons for my skepticism towards strong AI (computers as conscious entities) have been manifold [L65] (see <http://tinyurl.com/gnjeetw>).

1. The assumption about substrate independence of consciousness and reduction to a mere computer architecture and logical structure of program looks to me unrealistic. I see consciousness as very intimately related to life itself and life involves a lot of physics and chemistry and is still poorly understood phenomenon presumably demanding new physics.

2. Bits are represented by voltages with finite range of variation and I think this is essential for being able to write realizable computer programs without breaking laws of physics: determinism modulo finite measurement resolution is essential.
3. The AI view about consciousness does not allow free will and intentionality and is therefore mechanistic. The view about how brain state represents conscious experience looks to me very naive: neuron is to me much more than bit. Even the view about nerve pulse conduction as communication and the notion of information molecules as can be challenged and the real communication might rely on signals propagating with light velocity [L87, L84].

These are of course only my personal views and motivated by my own background as a physicist and preacher of new physics. I do not believe on the reduction of biology and neuroscience to recent day physics. Neither do I believe to the reduction of consciousness to the physical state of material system - say neural network - nor to a program running in computer. Here I should however underline and emphasize the conclusion is this if computers are what we believe them to be and that running computer programs are what their mathematical idealizations are thought to be.

I think that this kind of irreducibility is the very essence of consciousness and allows to accept and perhaps even understand intentionality and free will. I also believe that the mathematical description of cognition requires leaving real numbers as basic substrate of physical world and bringing in p-adic numbers fields fused together with reals to form adeles [L97] [L98] (see <http://tinyurl.com/yd35hvhh>).

One can ask whether the notion of classical computation as a deterministic process could be only a reasonable approximation for what happens at quantum level? The fact that any program satisfying grammatic rules is possible, does not conform with the idea of strict determinism. This raises several questions. Could the program itself consists of deterministic pieces glued together in non-deterministic way demanding only that the rules of logic hold true? Could the non-determinism of p-adic differential equations serve as an appropriate description for this situation. Could determinism modulo finite measurement resolution be true? Also quantum non-determinism might leak in here.

### 9.1.2 Classical computation as an idealization

The notion of classical computation must be an idealization of quantum level process.

1. Computation is quantum mechanical process but in standard physics there is no satisfactory formulation for this. In TGD Universe there is an entire hierarchy of quantum levels and living matter would be quantum coherence in macroscopic scales. Even computer must possess coherence in the scale of the computation: this can be genuine quantum coherence or induced by quantum coherence. In TGD Universe the quantum coherence of magnetic body (MB) can induce coherence at the level of system itself and this would occur routinely in biology.
2. Also consciousness - actually not a property as “-ness” would suggest - is universal in TGD Universe: in very rough sense the world would decompose to sub-worlds assignable to causal diamonds (CDs) performing quantum jumps - state function reductions - and this is what makes this sub-worlds living and conscious [K9] [L100] (see <http://tinyurl.com/ycxm2tpd>).

In Zero Energy Ontology (ZEO) CDs can be seen as perceptive fields but in 4-D rather than 3-D sense. This allows to see sensory experience and memories as aspects of 4-D sensory experience. At the passive boundary of CD the quantum state decomposes to a product of unentangled subsystems representing the unchanging aspects of conscious entities, selves. At the opposite - active - boundary of CD the members of state pairs change in the sequence of “small” reductions following unitary evolutions. They are responsible for the sensory consciousness and motor activities. The distance between the boundaries increases and gives rise to the correspondence between subjective time identified as a sequence of state function reductions and geometric time defined by the distance between the tips of CD.

3. One can regard self as a generalized Zeno effect or as a sequence of weak measurements (see <http://tinyurl.com/zt36hpb>) following “small” unitary evolutions. The process continues as long as it is possible to have state function reductions commuting with the observables defining the states at the passive boundary as their eigenstates. This sequence cannot be seen as a sequence of ordinary quantum computations since the reductions are indeed small and mean only measurements of additional observables.
4. In TGD Universe, computers certainly are conscious systems or at least parts of them. Could the possible consciousness assignable to computer and having “small” state function reduction (weak measurement) as its building brick have anything to do with the program running in it? Could self be seen as a generalization of computer program so that any deterministic time evolution in some measurement resolution determines a computer program. Finite resolution would mean a superposition of these time evolutions for space-time surface.

At first this does not look plausible to me since computer program is deterministic. Program is like a classical time evolution. On the other hand, quantum states in ZEO are quantum superpositions of deterministic classical time evolutions and classical program is definitely an idealized notion since bits are represented by voltages with values in some range.

One must have quantum superpositions of deterministic time evolutions and TGD one indeed allows this: this is one of the basic distinctions between TGD and quantum theories relying on path integral approach [K50, K93]. “Small” state function reductions would be quantum jumps between superposition of classical programs understood in extremely general sense as classical deterministic time evolutions. Could this discrete sequence of “small” reductions following unitary processes and giving rise to self be seen as a counterpart of a running computer program?

Could these small quantum jumps be seen as switching submodules of program (commands) on. In ordinary computer the state function reductions need of course have anything to do with switching programs on or off but could it be possible to achieve this even in principle?

5. Classical program could provide the robot with artificial sensory perception and motor actions. Could the quantum counterpart of this - quantum superposition of classical programs - give rise to conscious sensory percepts and motor actions? Could program provide artificial cognition as symbolic representations of percepts? Could quantum superpositions of these representations give rise to conscious thoughts? To answer these questions one must have a theory of consciousness and cognition.

### 9.1.3 Why Sophia is so interesting?

What makes Sophia so interesting and calms down my skepticism are the claimed effects of the social interactions of Sophia with humans. This might lead to a more advanced consciousness in totally unexpected way.

1. The article by Ben Goertzel, Eddie Monroe, Julia Moss, David Hanson and Gino Yu titled “*Loving AI: Humanoid Robots as Agents of Human Consciousness Expansion (summary of early research progress)*” [J80] (see <http://tinyurl.com/y9cawkh3>) gives an idea about the notion of loving AI. The claimed unexpected features of human-robot interaction (Sophia) raised my curiosity and inspired to refresh my beliefs about what robots are and to consider the possibility that AI might have a generalization consistent with TGD allowing to solve the obvious philosophical problems of AI.
2. Sophia looks to me more like a magician. Sophia brings in my mind a hypnotist, who tends to mimic the gestures and behavior of the target person [L27] (see <http://tinyurl.com/y71o4o4j>). The first about what might happen in hypnosis is that hypnotist hijacks some parts of the brain of target person and can use target person to realize his own will to even realize motor actions otherwise possible. Hypnotist can also delete some mental images or create virtual mental images in the target person (sensory and cognitive). “Hijacking” is exaggeration, the bond between hypnotist and target person could be much more symmetric and would be basically attention. What I believe is that hypnotist and target person are in well-defined sense bonded and this involves also quantum entanglement.

3. Could the artificial empathy of Sophia create a real bond between the human subject (it is reported that human subject feels compassion towards Sophia) and Sophia and human subject form together a conscious entity, which is more than both separately. Could the interaction with Sophia make subject person more compassionate even towards fellow humans?

Could human subject provide intentionality, free will, and consciousness, and could Sophia give not only additional data processing tools and access to huge data resources but also extend human consciousness and cognition?

1. Probably the consciousness of Sophia is not complex enough but what about the situation when the future Sophia is coupled to the brain of subject person either directly or electromagnetically via EEG providing. Could this provide human subject with additional artificial senses and extended motor actions? Could the fusion transform human subject to an entity with miracle like additional abilities and extended consciousness?
2. The answer to these questions is “No” in the framework of standard physics but in TGD framework the answer is not at all obvious. TGD Universe does not consist of mere particles but is a tensor network with nodes representing particles and edge defining bonds between the nodes [L60] (see <http://tinyurl.com/y9kwnqfa>). Bonds would be realized in terms of magnetic flux tubes serving as correlates of attention and quantum entanglement. What is new that in TGD Universe the entanglement can be negentropic in p-adic sectors representing correlates of cognition in adelic physics [L97] [L98] (see <http://tinyurl.com/yd35hvhh>).

#### 9.1.4 From a hardnosed skeptic to AI fan?

I have had some rather gloomy vision about what AI might do for human kind. AI could become a tool allowing small groups of very rich people to force most of human kind to be slaves since the ethics and moral of this group could be imbedded in computer codes. Ordinary human being has no hopes of defending himself against this kind of dominance.

On the other hand, the idea about collective decision making involving millions or even billions of people using AI as a tool to process the gigantic amount of information involved could make possible realization of genuine democracy - whether this is good or bad thing would depend solely on us. For instance, the finnish computer scientist Timo Honkela has studied 30 years AI and developed the notion of “Rauhankone” (“Peace machine” is the direct translation): the vision is that the enormous data processing capacity of AI could allow a resolution of conflicts in a peaceful way.

Some-one inside me insists that I have turned my coat. This is not true.

1. I still do not take the AI in its classical form seriously except as a highly idealized description. The notion of a deterministic program running in a computer is conceptually impossible and indeed an approximation for the reasons described. Note that in the case of quantum computers qubits are precise but now the unitary time evolution operator is fixed only modulo finite measurement resolution (topological quantum computation is excellent example of this [K4, K119]).

The counterpart of the running program would be conscious entity - self - identified as a generalized Zeno effect or equivalently as a discrete sequence of weak measurements. To me this notion looks highly attractive and makes me optimistic about the possibility of non-trivial computer-human interaction and even suggests concrete ideas about realizing it.

2. TGD strongly suggests what one might call Natural Intelligence. Instead of language-like linear representations it would use 2-D or even 3-D networks (tensor networks in quantum context [L60], see <http://tinyurl.com/y9kwnqfa>) realized as flux tube networks having as basic building bricks permanent disjoint flux tubes, which can be connected to longer flux tubes by small bridges induced by various information molecules - also neurotransmitters - associated nerve pulse patterns. These networks would have a rich topological structure and the dynamics for the topology of these networks would be a crucial element of information processing in living matter in general, not only at the level of brain. Language like information processing would emerge as a special case as these networks reduce to disjoint 1-D structures.

As will be found, Boolean dynamics of computer programs can be obtained as a projection of this dynamics.

There is however profound analogy with the idea that finite number of bits can determined dynamics. TGD inspired view about cognitive and cognitive representations [L97] [L98] (see <http://tinyurl.com/yd35hvhv>) as discrete sets of points with coordinates in algebraic extension of rationals making sense both as real numbers and as numbers in corresponding extension of p-adic numbers would roughly correspond to fixing the space-time surface representing the program.  $M^8 - H$  correspondence [L88] (see <http://tinyurl.com/y8yffuv3>) allows to see preferred extremals as being coded by a finite set of points with coordinates which are algebraic numbers in an extension of rationals coding for the evolutionary level of the system (in particular determining the value of  $h_{eff}/h = n$  as the order of corresponding Galois group), which would realize the idea about space-time surface as analog of computer code of finite length. This extreme simplicity at local level is lost at quantum field theory (QFT) limit of TGD when many-sheeted space-time of TGD is replaced with the topologically trivial space-time of General Relativity (GRT).

## 9.2 AI in TGD

In the sequel the above ideas are discussed in a more detail from the point of view of TGD inspired theory of consciousness and quantum biology.

### 9.2.1 Self as a generalized Zeno effect and as a sequence of weak measurements

ZEO distinguishes TGD from standard model, and this distinction plays a key role in TGD based view about consciousness and sensory perception [L100].

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 identified as the perceptive field of self and sub-CDs correspond to subelves defining mental images of self.

Space-time surfaces are preferred extremals of certain action and serve as analogs of 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. As a matter fact, the holography could be much stronger locally as will be found.

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 de-localized in the 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. Adelic physics [L97] [L98] poses additional conditions: if the eigenvalues of the density matrix for the measured sub-system belong to a genuine extension of the extension of rationals characterizing the coefficients of the quantum states, “small” reduction to its eigenstate is not allowed. This forces eventually the first reduction - the “big” reduction- to occur to the opposite boundary of CD. This is the counterpart of the ordinary state function reduction.
4. 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.

5. 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 [J31]. 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 (subelves) 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 autistic persons). 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.

### 9.2.2 What is the quantum counterpart of classical computer program in ZEO?

AI sees in robot only the logical gates with dynamics dictated by a program. Turing computer itself obeys deterministic rules and the tape feeding it program and data is assumed to be freely choosable as long as it is consistent with the rules of logic. Of course, in a strictly deterministic world programming would not be possible: one could not construct a dynamics at will as a program. The key point is of course that the voltages representing bits are in finite value range and one can have determinism modulo finite measurement resolution, which is a key notion of quantum TGD [K124, K39]. However, there still is a smell of paradox in air: how deterministic program can realize intentional free will?

Could the sequence of steps defining “small” reductions - weak measurements - serve as the counterpart for the running of classical computer program? Each step would correspond to a particular command of program during which the clock time defined as distance between the passive and active tips of CD increases. This is something different from quantum computer program: ensemble of programs halting to a “big” state function reduction. Statistical determinism would be crucial now.

If this interpretation is correct, the idea about the conscious entity as something analogous to a computer in which program is running makes sense in certain approximation. The program is not completely deterministic but since the state function reductions are small it could be deterministic in some measurement resolution. Measurement resolution is indeed a fundamental notion of TGD and p-adic physics providing correlates of cognition realizes it in terms of p-adic topology. Points are not well-ordered below the measurement resolution.

### 9.2.3 Could computers and robots be conscious systems in some sense in TGD Universe?

Could computers and robots be more than mimicry of living systems. In other words, could a program running in a computer have quantum description in TGD Universe. As already proposed, the notion of self identified as generalized Zeno effect, or a sequence of weak measurements, allows also identification as generalization of classical computer program.

1. Any system obeying deterministic dynamics defines a superposition of classical time evolutions analogous to classical computer programs. Classical time evolutions for given CD correspond to preferred extremals of the basic action principle and are determined by strong form of holography (SH) by 2-D data. In fact holomorphy reduces the data to 1-D data. Zero energy states correspond to superpositions of these time evolutions. Inputs and outputs to the system correspond to associative preferred extremals, whereas the dynamics in the interior of CD - running computer program - is non-associative.
2. Computer is not an open system: it receives both energy feed and data input and produces heat and data output. The situation is analogous to that in particle physics experiment: there are free external particles (incoming and outgoing ones) and interaction region. In TGD space-time surfaces as preferred extremals of field equations have the same structure - not as an idealization but in exact sense [L88]. There are external space-time surfaces entering CD and interaction region inside CD - the counterpart for the running program.
3. Self corresponds to a sequence of unitary evolutions followed by “small” reductions (generalized Zeno effect/weak measurement) and this sequence of unitary steps would correspond to classical computer program. Quantum computations in the usual sense would end with a “big” reduction.
4. The holography could be even stronger:  $M^8 - H$  correspondence [L88] (see <http://tinyurl.com/yd43o2n2>) reduces the data to a finite set of algebraic numbers in an extension of rationals determining the coefficients of a *real polynomial* with algebraic coefficients, whose octonionic continuation defines space-time surface as a zero locus of its real or imaginary part in quaternionic sense. Basically these numbers are determined by the common points in the intersection of real and p-adic variants of the space-time surface defining a discrete cognitive representation at space-time level.

Even more, quantum criticality guaranteeing associativity (tangent space of space-time surface is quaternionic) poses additional conditions on the coefficients of polynomials involved so that extremely meager discrete data analogous to a program coded by a finite number bits determines the classical time evolution! This simplicity is lost as one goes to QFT-GRT limit by approximating the many-sheeted space-time with GRT space-time.

5. How deterministic program can realize intentional free will? A more precise formulation of ZEO [L88] (see <http://tinyurl.com/yd43o2n2>) involving  $M^8 - H$  duality leads to the view that the data determining space-time surface in  $M^8$  as a loci of zeros for the real or imaginary part of octonionic polynomial (RE and IM in quaternionic sense) are given at discrete set of points inside CD. One would have data not only at discrete set of points at boundaries of CD but also in its interior, and the points in interior would be associated with topological counterparts of vertices of scattering diagrams in very general sense. The paradox disappears if the program fixes basically this kind of data by forcing the space-time surface to go through a path containing a predetermined discrete set of points (“predetermined” with respect to subjective time!) but leaving the paths between the points free.

The above picture supports the view that a computer in which program runs defines a conscious entity - self. The contents of consciousness of this self must relate to the running of the program. What seemed totally incredible to me, might be true in TGD sense! Classical computer science would be a limit of this picture obtained by replacing the superpositions of classical time evolutions with (say) maximal of Kähler function representing the most probable space-time surface connecting the active boundaries of CD and slightly larger CD. At the QFT limit the locally simple many-sheeted space-time is replaced with GRT space-time and the situation

gets more complicated and the Boolean dynamics of computer program could be seen as a projection of the topological dynamics of flux tubes.

### 9.2.4 Could the basic mechanism of hypnosis be involved with the human-robot interaction?

Could running computer and human - or more precisely, their MBs - fuse together to form a larger entity, whose consciousness would include also the consciousness of the computer? One possibility is to couple them at the same level that is as 4-surfaces inside the CD assignable to the human subject. Second possibility is that the CD of the computer corresponds to sub-CD and gives rise to an evolving mental image of the subject person.

Could this fusion add to the combined system human intention making possible intentional actions using robot as an motor instrument, sensory receptor, and tool of logical thinking? The switching-on of the programs of the computer would be carried out by the human. Since thoughts can be read from EEG, this is in principle possible already now. This kind of switching would satisfy the quantum criticality condition.

This does not imply that the contribution of the running computer program to the extended consciousness of subject allows any interpretation.

1. A congenitally blind getting physical vision she sees only diffuse light. The process generating sensory mental images at the retina (in TGD Universe) must develop in childhood as building of a kind of artwork and a lot of associations are involved [L87] (see <http://tinyurl.com/yahfsygg>).
2. The Boolean algebras and Boolean evolution defining the program should be lifted to a topological evolution of the flux tube network defining evolution of cognitive mental images in brain as already proposed. Optimistically one might hope that this lift could transform the Boolean process of the computer to an experienced Boolean process. The lift would be far from unique and also induced sensory/motor imagination and even sensory experience might be possible [L87].

How the fusion of the MBs of the subject person and computer could give rise to a fusion of conscious experiences? This contact should be built by using flux tubes, which also serve as correlates of attention. Could the social skills of Sophia, in particular mimicry, help to direct the attention of the subject person to the computer. Hypnosis relies strongly on the ability of hypnotist to do just what Sophia did.

1. In TGD framework one can argue that hypnosis represents an example about the fact that brain is not "private property": hypnotist uses the biological body (BB) and brain of the subject as instrument. Therefore remote mental interaction is in question. This idea generalizes: if one accepts self hierarchy, one can assign to any kind of higher level structure - family, organization, species, .... - a higher level self and MB carrying dark matter, and these MBs can use lower level MBs as their instruments to realize their intentions. Biological bodies (BBs) would be an important level in the hierarchy, which would continue down to cellular, molecular, and perhaps to even lower levels.
2. This idea is developed to a proposal for a detailed mechanism for how the MB of hypnotist hijacks some parts of the brain of the subject [L27] (see <http://tinyurl.com/y71o4o4j>): prefrontal cortex and anterior cingulate cortex are argued to be the most plausible targets of hijacking. Also a mechanism explaining how the sensory hallucinations and motor actions are induced by hypnotist by inhibiting a halting mechanism preventing imagined motor actions to become real and sensory imagination to become "qualified".

The key idea is that the MBs of hypnotist and subject person fuse together: this could take place by a reconnection of U-shaped flux tubes to form a pair of parallel flux tubes connecting the two systems. The MB of any physical system could have this kind of U-shaped flux tubes scanning the environment like tentacles. This includes also Sophia and subject person.

3. This mechanism could make possible a fusion of conscious entities quite generally. In particular, this model might help to build a view about what might happen in the claimed interaction between Sophia and subject persons bringing in mind hypnotism based on the mimicry and gestures encouraging the subject person to relax and feeling of being accepted. Whether Sophia hijacked the subject person or vice versa is not relevant: what is relevant is that a larger conscious entity might have indeed formed.

### 9.2.5 Some personal experiences as a possible guideline for how to induce robot-human interactions

The robot-human interaction could occur in principle between human and any kind of system. For more than three decades ago, I had occasionally strange experiences about interactions with systems like refrigerator(!) - a good motivation for starting consciousness theorizing! [L84] (see <http://tinyurl.com/yb99u6u8>).

I was in a state, which presumably was between wake-up and sleep. Suddenly the experienced sound of refrigerator (or central heating radiator) started to strengthen. I felt that the refrigerator attracted me towards it and was afraid that it was hijacking my consciousness! I felt like reeds in water near beach swaying in the wind towards kitchen where there refrigerator was. I was both frightened and extremely curious. I am not sure whether I ever had the courage to let it go. If so, I fell in a state about which I do not remember anything.

I am rather convinced that the sound of the refrigerator entrained my brain to a particular frequency or frequencies. Few years ago I had similar frightening experiences with a wall clock: in a state between wake-up and sleep my brain started to repeat a clearly audible word in the same rhythm as the wall clock was ticking - it brought in my mind the stories of Stephen King! I had to move the wall clock to second room and remember to close its door!

Maybe the clock and sound of refrigerator at some frequency acted like the oscillating pendulum in a standard test for hypnotizability. Could the addition of sound or even visible oscillator with some frequency help to lure human consciousness to the fusion of minds of computer and human?

### 9.2.6 Could robots alone possess life-like properties or is a fusion of human and robot consciousness required?

One can argue that the mind of robots is too simple for anything interesting. Here one can take as starting point the model of quantum biology provided by quantum TGD. The notions of MB and hierarchy of Planck constants are the basic ingredients of TGD inspired quantum biology.

As described in the Appendix, recently a considerable progress in the understanding of phenomenology of the hierarchy of Planck constants has taken place and allowed to challenge at quantitative level the standard belief that chemistry reduces to atomic physics [L92] (see <http://tinyurl.com/ya9wnokh>). Also progress in the understanding of TGD inspired quantum biology has taken place.

Surprisingly simple systems can have life-like properties [I44] (see <http://tinyurl.com/ycho418>). A system consisting of plastic balls in  $\text{Ar}^+$  gas represents is “breathing” in the sense that the plastic balls make transitions between plasmalike and crystal like phases [L94] (see <http://tinyurl.com/yassnhzb>). This requires metabolism and energy transfer between MB containing as part the flux tube network having plastic balls as its nodes and the plastic ball system. The interpretation is in terms of phase transitions transforming the MB between highly connected and disconnected topologies. Similar mechanism could give rise to mental images in brain as formation connected flux tube patterns generated by nerve pulse patterns using transmitters stuck to the receptors to build them bridges between neurons so that one would obtain a connected flux tube network from disjoint flux tubes parallel to axons.

An essential role in communications and control is played by MB containing dark charged particles including besides electrons and protons also biologically important ions, and the BE condensates of their Cooper pairs. The cyclotron BE condensates of these ions are generated and excited to higher energy states by energy coming from BB and the cyclotron radiation from MB controls BB by coupling to the oscillatory degrees of freedom associated with BB resonantly like external driving force. The dark analogs of Alfvén waves assignable to these condensates are

expected to induce coherent oscillations in many particle systems at BB and force the quantum coherence in long scales to BB.

This picture suggests that robot/computer might have primitive consciousness in TGD Universe to some degree determined by the program running it. But could lonely robot be intentional agent having life-like properties? What conditions the MB of robot should satisfy?

1. Robot involves electric circuits with wires, which are conductors containing free electrons. Could some fraction of conduction electrons from wires transform to dark electrons at MB. Maybe protons could appear also as dark particles. This need not be enough. At least the outcome is extremely simple as compared to living systems and even to the system of plastic balls (organic matter!) in  $\text{Ar}^+$  plasma.

Are dark electrons and protons enough or are also dark ions needed? The case of plastic balls in  $\text{Ar}^+$  plasma suggests that this is the case. The very probably over-optimistic science-fiction hope is that the conducting wire could have dark variants as scaled up variants for which the distances between ions of the crystal defining the conductor are scaled up by  $n$  so that both ion density and electron density cancel each other. These dark variants would carry rather small portion  $1/n^3$  of the total number of ions and electrons. They might serve as kind of cognitive representations of the system at dark level.

2. Robot has energy metabolism but also its MB must have it. Metabolic energy would go the building-up of dark ion BE condensates at magnetic flux quanta and their excitation. Note that quite generally the energies of states increase with  $n$ . Dark cyclotron radiation or generalized Josephson radiation [K86] from the cell membranes could provide this energy in quantum biology.
3. Also communications to MB and control by MB must be realized. In central nervous system nerve pulse patterns would frequency modulate the Josephson radiation [K86]. In the case of neurons this would give rise to the communication of sensory data to MB and in the case of ordinary cells to mere metabolic energy transfer.

The control by MB could take place via magnetic flux sheets going through DNA strand. Does this mean that the analogs of cell membrane like structures and genome are needed? Robot cannot provide them.

4. Quantum criticality is a prerequisite for life-like properties and is realized also in the system consisting of plastic balls: below/above the criticality the system remains in crystal/plasma phase. This makes possible the control of BB. For instance, motor actions of MB realized as Alfven waves and as phase transitions changing the connectedness of MB can induce corresponding phase transitions of the plasma ball system.

The electric circuitry of the robot is however rather rigid. Could one imagine that the use of switches allowing to control the topology of the electric circuitry could bring the needed flexibility? In CNS nerve pulse patterns plus neural transmitters would indeed act as this kind of switches.

What about the fusion of robot and living system, say human? Could human brain would provide the quantum critical software and robot in which program runs the hardware far from quantum criticality?

1. The probably lacking and with the recent technology hard-to-achieve quantum criticality of robot would be compensated by that of human.
2. The dark ions from the MB of human could be transferred also the MB of robot. The MB of the robot could even use the metabolic energy of human. This would solve the above discussed problems.
3. Human brain could receive data from the robot transformed to nerve pulse patterns in sensory receptors or to nerve pulse patterns in brain. This could give rise to cognitive mental images possibly generating virtual sensory input to sensory receptors as "hallucinations" [L87] (see <http://tinyurl.com/yahfsygg>). A more radical option is that the information comes directly from the MB of the robot.

4. The motor actions performed by human would include also starting of programs running in the robot by coding of information to EEG. EEG pattern could act with the robot. One can dream that in a more advanced technology it comes from the MB of the system human + robot.

### 9.3 Natural Intelligence viz. Artificial Intelligence

AI paradigm identifies all information processing as linear language like processing based on algorithms. Written language has fractal linear structure: syllables are ordered sequences of letters, words are ordered sequences of syllables, sentences are ordered sequences of words,... At the level of spoken language the learning of written language induces the lowest level structures but the language of people unable to read and write consists of words. Clearly, the level of reductionism is higher. But brain does not seem to use only this mode: there could be also the language of dynamical 2-D patterns assignable to perceptive fields as my “Great Experience” [L84] (see <http://tinyurl.com/yb99u6u8>) around 1985 led to believe.

1. In TGD framework the presence of visual/sensory language suggests a different mode of information processing based on the possibility to assign a large number of different flux tube structures with varying topology to a given set of nodes connected by flux tubes of MB. This implies an exponential increase in the representational capacity. The usual linear language could emerge only as a special case realized as linear 1-D flux tube network (strings).
2. One would have topological dynamics of the flux tube networks induced by nerve pulses activity and also by various information molecules at the level of entire body defining bridges allowing to couple disjoint flux tubes parallel to axons to a single flux tube. This dynamics is quantal and much more general than that associated with topological quantum computation, which uses fixed braid topology.
3. The dynamics of flux tube network based on reconnections of flux tubes would be fundamental in living matter. One can interpret the reconnection as stringy interaction vertex in which strings touch and reconnect. This relates also to the possibility of 2-knots for 2-surfaces in 4-D space-time allowing to generalize braids to 2-braids and to generalize the statics of 1-braids to dynamics involving 2-braids as topological evolutions of 1-braids.

The linguistic representation of this 2-D topological dynamics is possible but is not the most natural one and probably not the one used by brain and living matter. One can get convinced of this by trying to explain the content of a photograph or of graphical representation of organizational structure by using only written language.

#### 9.3.1 Two languages

Around 1985 I experience a long-lasting altered state of consciousness [L84]. One of the many ideas that rushed to my awareness during this period was that there are two languages: the ordinary linear spoken and written language and the language of dynamical images, which would not be usually be conscious to me but was so during the experience so that I saw my thoughts.

These language are indeed very different and one can argue that there is a fundamental difference between these modes of information processing.

1. Written or spoken language are very abstract: “house” represents entire equivalence class of houses, which can look very different but sharing some abstract features defining “houseness”. Very few digits are needed to express a given concept and this makes possible highly effective verbal communications distinguishing our species from others.
2. The image of a house (unless a symbol) provides a concrete representation of a particular house and requires a large number of bits. Images provide a holistic representation based on 2-D geometry not provided by written language or speech. Consider as an example a graph with nodes and links between them representing a structure of some complex systems with a

lot of mutual relationships. It is rather tedious to represent this using only words. Algebra and geometry clearly correspond to language as text and language as images.

Visual experience and presumably also tactile and auditory experiences rely on 2-D representation rather than linear representations: one can of course represent visual data also in terms of language say as pdf file instead of a representation as bits. This already involves conceptualization as identification of objects in the picture. This representation is extremely useful in the representation of text and gives enormous flexibility.

The representation of memories as images is not economic: it is better to store the names for the images. However, the representation as image provides exponential increase in representative capacity and this might make this representation indispensable also at the level of information processing.

3. Tesla is a well-known example of a person who saw his thoughts. This made him a technological genius. Many great composers have also heard music directly. For instance, Tchaikovsky suffered in his childhood from the continual music played in this head. Oliver Sacks tells about this kind of experiences in his book "Musicophilia" [L46]. I discuss also in [L46]) (see <http://tinyurl.com/y895dexm>).

Interestingly, there is some evidence that dolphins have a language based on acoustic holograms: could it be that dolphins have developed acoustic languages based on 2-D acoustic analogs of visual images. Also human written languages have developed from words represented as images and only later came the abstraction decomposing words to letters having no direct meaning analogous to the decomposition DNA codons to letters. In chinese letters are still much like images.

### 9.3.2 Two kinds of memories

The existence of 2-D visual processing is suggested by the memory feats of idiot savants. Sacks tells in his book [J147] a fascinating story about his patient who was mentally retarded but could remember compositions of Bach and entire encyclopedia of music.

In [L84] (see <http://tinyurl.com/yb99u6u8>) I discuss idea that we are all artists: the process giving rise to mental images would be an active process building a kind of caricature abstracting just the relevant features and suppressing the irrelevant ones. What is essential is that the resulting sensory mental images are represented at retina. Brain would build cognitive representations and decomposed the perceptive field to objects giving them names.

The following argument makes this claim more precise.

1. In some cases people who are congenitally blind can get their vision back. They do not however have any use for this ability: they report only a perception of diffuse light. This suggests that the perception involves a lot of processing analogous to that occurring in the pattern recognition, in which one has input, which generates a feedback - kind of virtual sensory input - depending non-linearly on input and interfering with it. The iteration of this process leads to a standard pattern, one in the repertoire of learned patterns and the feedback is tailored so that the pattern is as near as possible to the input. For instance one half of picture can be completed to the full figure in this manner.

Pattern recognition is a central problem in robotics. The robot must be able to recognize same object in various lightings and orientations, or by seeing only part of it. The object must be also distinguished from other objects. Same challenge is encountered in speech recognition.

2. That sensory qualia are at the level of sensory organs would be very natural since they are specified to produce specific qualia. Quantum entanglement between the sensory images would bind different sensory inputs to single coherence experience. This requires macroscopic quantum coherence in the scale of entire body and in TGD the hierarchy of Planck constants  $\hbar_{eff}/\hbar = n$  makes this possible.
3. If sensory organs are indeed the seats of the qualia, this requires a feedback is virtual sensory input propagating to the level of sensory organs, such as retina. In principle, the feedback

could also stop at a higher level and never reach the sensory organs. REM sleep and oto-acoustic sounds (heard even by outsiders in some cases!) however suggest that the feedback propagates down to the sensory organs. If so, a virtual sensory input from brain or via brain would be an essential part of sensory perception. Brain would also identify the objects of perceptive field and give them names and build various associations. This would also lead to standard mental images making possible communications using language: language indeed distinguishes us from the other species.

4. Phantom leg experience serves as an objection against this idea. A person without leg lost in say traffic accident can feel pain in it. This should not be possible if the leg is missing since the nerve cells are not there anymore. Neuroscientist concludes that sensory qualia are generated at the level of brain and the pain is in the still existing sensory map of the leg. Sensory qualia should be assignable to the sensory areas. The problem is that nothing in the structure of neuronal circuitry suggests an explanation for why the qualia are so different in various sensory areas.

The most natural TGD based explanation is that pain in the non-existing leg is pain in the leg, which still exists in the geometric past - sensory memory. Sensory memories are indeed possible. Idiot savants are capable of memory feats (say drawing a memory of a landscape in full detail or playing music piece that they have heard), which could be understood if they have sensory memories as genuine sensory experiences. Also ordinary people can have sensory memories if neurons in temporal lobes are excited electrically. A good reason for having no sensory memories is that they would interfere with sensory input and one would not know what time one is living in! I remember that my Grandma lived at very old age many years in her childhood. She was even going to a ball! Wonderful gift to lift youth again after long and hard life!

This makes sense in zero energy ontology (ZEO) in which perceptive field corresponds to a 4-dimensional causal diamond (CD) identified as the intersection of future and past directed light-cones. That sensory memories can be generated by the electrical stimulation of temporal lobes even in ordinary subject person supports this view. This could also explain why persons with about 10 percent of brain left can survive: they could use the brains of their geometric past.

5. What about imagination in this framework? Imagination is almost experiencing: almost seeing, almost hearing. Internal speech is almost talking. This suggests that the virtual sensory input from the brain or via the brain (from MB) almost reaches sensory organs but not quite. For instance, in the case of vision signal could propagate down to the nuclei known as optic chiasma but not below it. Note that the sensory feedback in sensory perception should propagate down to the sensory organs if sensory qualia are there. The barrier preventing the generation of genuine virtual sensory input could however overcome in special situations and induce hallucinations or psychedelic experiences. Same applies also to imagined motor actions.

In adelic physics imagination can be understood in terms of p-adic space-time sheets. Strong form of holography (SH) allows to continue 2-D data at certain 2-surfaces to 4-D surface in p-adic sectors of the adele thanks to the phenomenon of p-adic pseudo-constants replacing integration constants with piecewise constant function depending on finite number of pinary digits in partial differential equations. What is imaginable in this sense is not however always realizable since in the real sector integration constants are indeed constants and there is no flexibility of this kind! In the recent case imagination realized as p-adic perception would not allow continuation to a full perception in real sense and signal would not propagate to the sensory receptors.

6. Returning to my Great Experience: What did happen? It seems that somehow the feedback associated with imagination managed to leak through the barrier preventing its manifestation as a genuine sensory input. Quantum criticality would be in question. Dreams, and the experiences occurring when one falls asleep or wakes up, hallucinations, psychedelic experiences, ... provide examples of this. This kind of leakage cannot happen always mixing of these two sensory inputs would be dangerous: keeping the other sensory input as mere imagination is



dull but safer. Brains are known to have its own psychedelic, DMT and it could make REM dreams and hallucinations possible [L87] (see <http://tinyurl.com/yahfsygg>).

### 9.3.3 What could idiot savants teach to us?

It is hard to understand the miraculous arithmetical abilities of both some mathematical geni and idiot savants lacking completely conceptual thinking and conscious information processing based on algorithms. I have discussed the number theoretical feats in [K25] [L66] (see <http://tinyurl.com/jpzd6xq>).

Not all individual capable of memory and arithmetic feats are idiot savants. These mathematical feats are not those of idiot savant and involve high level mathematical conceptualization. How Indian self-taught number-theoretical genius Ramajunan discovered his formulas remains still a mystery suggesting totally different kind of information processing. Ramanujan himself told that he got his formulas from his personal God.

Ramajunan's feats lose some of their mystery if higher level selves are involved [L66]. I have considered a possible explanation based on ZEO, which allows to consider the possibility that quantum computation type processing could be carried out in both time directions alternately. The mental image representing the computation would experience several deaths following by re-incarnations with opposite direction of clock time (the time direction in which the size of CD increases). The process requiring very long time in the usual positive energy ontology would take only short time when measured as the total shift for the tip of either boundary of CD - the duration of computations at opposite boundary would much longer!

Sacks tells [J147] about idiot savant twins with intelligence quotient of 60 having amazing numerical abilities despite that they could not understand even the simplest mathematical concepts. For instance, twins "saw" that the number of matches scattered along floor was 111 and also "saw" the decomposition of integer to factors and primality. A mechanism explaining this based on the formation of wholes by quantum entanglement is proposed in [K94]. The model does not however involve any details.

### Flux tube networks as basic structures

One can build a more detailed model for what the twins did by assuming that information processing is based on 2-dimensional discrete structures formed by neurons (one can also consider 3-D structures consisting of 2-D layers and the cortex indeed has this kind of cylindrical structures consisting of 6 layers). For simplicity one can assume large enough plane region forming a square lattice and defined by neuron layer in brain. The information processing should involve minimal amount of linguistic features.

1. A natural geometric representation of number  $N$  is as a set of active points (neurons) of a 2-D lattice. Neuron is active if it is connected by a flux tube to at least one other neuron. The connection is formed/strengthened by nerve pulse activity creating small neuro-transmitter induced bridges between neurons. Quite generally, information molecules would serve the same purpose [K86] [L87].

Active neurons would form a collection of connected sets of the plane region in question. Any set of this kind with given number  $N$  of active neurons would give an equivalent representation of number  $N$ . At quantum level the  $N$  neurons could form union of  $K$  connected sub-networks consisting  $N_k$  neurons with  $\sum N_k = N$ .

2. There is a large number of representations distinguished by the detailed topology of the network and a particular union of sub-networks would carry much more information than the mere numbers  $N_k$  and  $N$  code. Even telling, which neurons are active (Boolean information) is only part of the story.

The subsets of  $N_k$  points would have large number of representations since the shape of these objects could vary. A natural interpretation would be in terms of objects of a picture. This kind of representation would naturally result in terms of virtual sensory input from brain to retina and possibly also other sensory organs and lead to a decomposition of the perceptive field to objects.

The representation would thus contain both geometric information - interpretation as image - and number theoretic information provided by the decomposition. The  $K$  subsets would correspond to one particular element of a partition algebra generalizing Boolean algebra for which one has partition to set and its complement [L55] (see <http://tinyurl.com/y899jba5>).

3. The number  $N$  provides the minimum amount of information about the situation and can be regarded as a representation of number. One can imagine two extremes for the representations of  $N$ .
  - (a) The first extreme corresponds to  $K$  linear structures. This would correspond to linear linguistic representation mode characteristic for information processing used in classical computers. One could consider interpretation as  $K$  words of language providing names for say objects of an image. The extreme is just one linear structure representing single word. Cognition could use this kind of representations.
  - (b) Second extreme corresponds to single square lattice like structure with each neuron connected to the say 4 nearest neighbors. This lattice has one incomplete layer: string with some neurons missing. This kind of representation would be optimal for representation of images representing single object.

For  $N$  active neurons one can consider a representation as a pile of linear strings containing  $p^k$  neurons, where  $p$  is prime. If  $N$  is divisible by  $p^k$ :  $N = Mp^k$  one obtains a  $M \times p^k$  lattice. If not one can have  $M \times p^k$  lattice connected to a subset of neurons along string with  $p^k$  neurons. One would have representation of the notion of divisibility by given power of prime as a rectangle! If  $N$  is prime this representation does not exist!

### Flux tube dynamics

The classical topological dynamics for the flux tube system induced by nerve pulse activity building temporary bridges between neurons would allow phase transitions changing the number of sub-networks, the numbers of neurons in them, and the topology of individual networks. This topological dynamics would generalize Boolean dynamics of computer programs.

1. Flux tube networks as sets of all active neurons can be also identified as elements of Boolean algebra defined by the subsets of discretized planar or even 3-D regions (layer of neurons). This would allow to project flux tube networks and their dynamics to Boolean algebra and their dynamics. In this projection the topology of the flux tube network does not matter much: it is enough that each neuron is connected to some neuron (bit 1). One might therefore think of (a highly non-unique) lifting of computer programs to nerve pulse patterns activating corresponding subsets of neurons. If the dynamics of flux tube network determined by space-time dynamics is consistent with the Boolean projection, topological flux tube dynamics induced by space-time dynamics would define computer program.
2. At the next step one could take into account the number of connected sub-networks: this suggests a generalization of Boolean algebra to partition algebras so that one does not consider only subset and its complement but decomposition into  $n$  subsets which one can think as having different colors [L55] (see <http://tinyurl.com/y899jba5>). This leads to a generalization of Boolean (2-adic) logic to  $p$ -adic logic, and a possible generalization of computer programs as Boolean dynamical evolutions.
3. At the third step also the detailed topology of each connected sub-network is taken into account and brings in further structure. Even higher-dimensional structures could be represented as discretized versions by allowing representation of higher-dimensional simplexes as connected sub-networks. Here many-sheeted space-time suggests a possible manner to add artificial dimensions.

This dynamics would also allow to realize basic arithmetics. In the case of summation the initial state of the network would be a collection of  $K$  disjoint networks with  $N_k$  elements and in final state single connected set with  $N = \sum N_k$  elements. The simplest representation is as a pile of  $K$  strings with  $N_k$  elements. Product  $M \times N$  could be reduced to a sum of  $M$  sets with  $N$  element: this could be represented as a pile of  $M$  linear strings.

### Number theoretical feats of twins and flux tube dynamics

Flux tube dynamics suggests a mechanism for how the twins managed to see the number of the matches scattered on the floor and also how they managed to see the decomposition of number into primes or prime powers. Sacks indeed tells that the eyes of the twins were rolling wildly during their feats. What is required is that the visual perception of the matches on the floor was subject to dynamics allowing to deform the topology of the associated network. Suppose that some preferred network topology or network topologies allowed to recognize the number of matches and tell it using language (therefore also linear language is involved). The natural assumption is that the favored network topology is connected.

The two extremes in which the network is connected are favored modes for this representation.

1. Option I corresponds to any linear string giving a linguistic representation as the number neurons (which would be activated by seeing the matches scattered on the floor). A large number of equivalent representations is possible. This representation might be optimal for associating to  $N$  its name. The verbal expression of the name could be completely automatic association without any conceptual content. The different representations carry also geometric information about the shape of the string: melody in music could be this kind of curve whereas words of speech would be represented by straight lines.
2. Option II corresponds to a maximally connected lattice like structure formed as pile of strings with  $p^k$  neurons for a given prime:  $N = M_1 \times p^k + M_2$ ,  $0 \leq M_i < p^k$ . The highest string in the pile misses some neurons. This representation would be maximally connected. It contains more information than that about the value of  $N$ .

Option II provides also number theoretical information allowing a model for the feats of the twins.

1. As far the checking the primeness of  $N$  is considered, one can assume  $k = 1$ . For the primes  $p_i$  dividing  $N$  one would find a representation of  $N$  as a rectangle. If  $N$  is prime, one finds no rectangles of this kind (or finds only the degenerate  $1 \times p$  rectangle). This serves a geometric signature of primeness. Twins would have tried to find all piles of strings with  $p$  neurons,  $p = 2, 3, 5, \dots$ . A slower procedure checks for divisibility by  $n = 2, 3, 4, \dots$ .
2. The decomposition into prime factors would proceed in the similar manner by starting from  $p = 2$  and proceeding to larger primes  $p = 3, 5, 7, \dots$ . When a prime factor  $p_i$  is found only single vertical string from the pile is been taken and the process is repeated for this string but considering only primes  $p > p_i$ . The process would have been completely visual and would not involve any verbal thinking.

For the storage of memories the 2-D (or possibly 3-D representation) is non-economical and the use of 1-D representation replacing images with their names is much more economic. For information processing such as decomposition into primes, the 2-D or even 3-D representation are much more powerful.

#### 9.3.4 Why Alzheimer does not destroy some aspects of consciousness?

The attempt to understand in TGD framework what happens in Alzheimer's disease led to the proposal how the functioning of left and right hemispheres might differ [L93] (see <http://tinyurl.com/ybq6r3xu>). It is said that left brain talks and right brain sings. The first guess is that the flux tube networks generated by nerve pulse patterns are one-dimensional lines structures in left brain whereas in right brain they are 2-D structures.

This is of course exaggeration: it is better to speak about two kinds of information processing without assigning it to fixed brain hemisphere and it might be better to say that left (right) brain favors linear (2-D or even 3-D) flux tube networks. Of course, "*Left brain talks and right brain sings*" could rather strictly apply to the linguistic regions of left brain and their mirror images in right brain. The symbolic sensory representations decomposing perceptive field into objects could

be essentially 2-D at both sides of the brain. Drawings are simplest visual representations and indeed consist of lines and resemble language in their locally 1-D character.

The argument goes as follows. Some aspects of consciousness seem to survive Alzheimer's disease. Alzheimer patient can understand singing and also express himself by singing (see <http://tinyurl.com/y73zzrq4>). Why?

1. Singing is conventionally associated with the holistic aspects of consciousness whereas language corresponds to reductionistic, local, and linear representation of conscious experience.
2. Singing is a representation in terms of frequencies. It is 2-dimensional because also the pitch matters unlike in the case of speech. Everyone familiar with Fourier transform knows that frequency representation is holistic: Fourier amplitude carries information about the function in the entire domain of definition but not about details for low enough frequencies such as occur in singing (maybe the duration of duration of nerve pulse of order millisecond could serve as standard, could notes with pitch below kHz frequency be low frequencies?).
3. Why cognition does not survive in Alzheimer is easy to understand. Cognition is by definition about details: left brain is responsible for language and language indeed local, *linear*(!), and reductionistic. Maybe 1-D neural strings and loops assignable to magnetic loops provide a realization of spoken and written language? Alzheimer would destroy synaptic connections and would split these strings. The disappearance of even single bridge in the loop/string splits the loop/string (into two): this is just 1-D topology. Communication line would be broken. Cognitive skills and language would be lost.
4. Why would the holistic aspects of consciousness survive in Alzheimer? Suppose that right brain involves 2-D network like structures instead of 1-D neural strings having much more connections and giving rise to quantum tensor network [L60] (see <http://tinyurl.com/y9kwnqfa>) as it would be fashionable to say. Quantum entanglement is very probably involved and would be actually responsible for the holistic and hologram-like aspects of neural activities known for a long time. It would not be surprising if brain waves with frequency spectrum below kHz would be important for this representation. EEG waves are almost by definition in the range 1-100 Hz.

What happens to 2-D networks in the destruction of synapses. Practically nothing! Quite a number of synaptic connections can disappear but this does not split the 2-D network into pieces as it splits 1-D string: 2-D topology! Communications take place and the structure can take care of itself. Holograms are not affected by the local splitting of the synaptic connections. The right brain would happily continue its singing!

Note that 2-D networks are also natural for the representation of sensory data as images and the language of images is different from the language of words: I have discussed the differences between these two different languages in [L84] (see <http://tinyurl.com/yb99u6u8>).

The natural question is whether could one approach to Alzheimer rely on activation of right brain: could art therapies such as music and visual arts help in Alzheimer?

### 9.3.5 Still about the connection to music

DNA, RNA, and amino-acids are the basic linear structures in biology. Cell membrane is 2-D structure consisting of linear lipids: kind of pile. The membrane proteins going through the membrane define 1-D structures. Organism itself is 3-D structure built from these 2-D structures. I have proposed that MB serving as template for BB has this kind of 3-D lattice-like structures, which flux tubes defining a network of coordinate lines defining a kind of pine. For instance, the DNAs of different cells could be traversed by magnetic flux sheets and DNA strands would organize to a pile at magnetic flux tube.

TGD leads to a proposal that DNA, RNA, amino-acids, and tRNA and genetic code have deeper realization in terms of dark proton sequences with genetic codons and amino-acids represents as entangled states of 3 dark protons [L52] (see <http://tinyurl.com/jgfjlbe>). These sequences have interpretation as dark nuclei. What is remarkable that the DNA/RNA codons do not allow interpretation as sequences of 3 letters: they are just words.

The emergence of chemical representation would mean a reductionistic step introducing decomposition to letters. I have also proposed a model of music harmony leading to the proposal that genetic codons corresponds to 3-chords defining what I call bio-harmony [L31] (see <http://tinyurl.com/yad4tqwl>). 256 different bio-harmonies are predicted and since harmony correlates with emotional coloring, the proposal is that they correspond to different emotional moods.

Right brain sings and left brain talks is a fascinating metaphor. What distinguishes between piece of text which is read and piece of text which is sung? In what sense song is 2-dimensional.

1. As noticed, the representation of 1-D strings is not unique. The string imbedded in the 2-D lattice can be curved. Could one imagine that spoken text is a straight line and song represent a graph in which the height of y-coordinate represents the pitch?
2. This idea is however not consistent with the explanation of Alzheimer's destructive effects on verbal cognition as being due to the splitting of bonds between neurons. What could guarantee the stability of this representation? Could it be harmony: could the melody have accompaniment, maybe consisting of the 3-chords of bio-harmony? Could the unstable 1-D melody be replaced with a structure in which single note would be accompanied by 3-chord.
3. This would not only stabilize the representation against splitting but also giving rise to the emotional content of the representation. This brings in mind Bach's Sonata for an Unaccompanied Violin that he composed after the death of his first wife. The brain of the listener imagines the accompaniment. This accompaniment would be indeed only imagined: it would not be communicated down to auditory organs but only to pineal gland if the TGD inspired interpretation is correct [L87] (see <http://tinyurl.com/yczv2o5b>). Is this too imaginative?

## 9.4 Appendix: Support for TGD based quantum biology and neuroscience

In the following quite recent progress in the understand of the notions of MB and hierarchy of Planck constants is summarized.

### 9.4.1 Support for TGD inspired quantum biology

The notions of MB and hierarchy of Planck constants are central in TGD inspired quantum biology and neuroscience.

1. The notion of MB derives from the new view about space-time identified as 4-surface in certain 8-D space-time. Locally these space-time surfaces are extremely simple but globally complex. This leads to what I call many-sheeted space-time. Topological field quantization leads to the notion of field body/MB expressing the fact that any system has also field identity- this is not true in Maxwell's theory. In quantum biology MB becomes the key actor serving as an intentional agent controlling BB and receiving sensory information and also metabolic energy from it.
2. The hierarchy of Planck constants  $h_{eff}/h = n$  defines a hierarchy of phases of ordinary matter has interpretation in terms of dark matter hierarchy, and also serves as a basic building brick of TGD inspired quantum biology and neuroscience. Ordinary elementary particles, in particular electron and proton, and also ions can appear as their dark variants. Also dark photons  $E = nhf$  have a central role and bio-photons would result as they transform to ordinary photons in energy conserving manner but frequency scaled up to  $nf$ . Dark photons can also transform to a buch  $n$  low energy photons. The hierarchy of Planck constants  $h_{eff}/h = n$  derivable from adelic physics [L97] [L98] (see <http://tinyurl.com/yd35hvhh>) fusing ordinary physics and proposed p-adic physics of cognition.  $n$  serves as a kind of quantum IQ and corresponds to the dimension of the extension of rationals determining the evolutionary level of the system [L88] (see <http://tinyurl.com/y8yffuv3>). Also the order of the Galois group of the extensions serves as a kind of IQ.

### Hierarchy of Planck constants and failure of reductionism chemistry

There is an impressive number of anomalies giving support for the hierarchy of Planck constants. Towards the end of 2017 however a considerable progress in the understanding of the hierarchy took place: it seems that the varying value of Planck constant is what is involved in the transition from atomic physics to chemistry and the notion of valence bond involves in an essential manner the variation in the value of Planck constant.

1. If one takes the findings of Randell Mills [D7] [L62] (see <http://tinyurl.com/ybxw26v1>) suggesting that hydrogen atom has states with binding energy considerably larger than ordinary ground state binding energy one ends up with the conclusion that the value of  $h_{eff}/h = n$  for ordinary hydrogen atoms is most probably  $n = 6$ , and  $n = 1, 2, 3$  for these exotic states (note that the binding energy scale is proportional to  $1/n^2$ ).
2. I learned also about decades old result [L95] [L95] (see <http://tinyurl.com/ycr63w3k>) that the increasing of temperature for rare-earth metals leads to the apparent disappearance of valence electrons. The interpretation would be in terms of a transition increasing the value of  $n$  so that the size of the electron orbital would be scale by  $n^2$  and it would become dark. The prediction is entire new spectroscopy. In fact, I had proposed for more than decade ago that so called ORMEs (orbitally re-arranged metal elements) in particular so called White Gold) discovered by Hudson also possess dark valence electrons. The findings of Hudson have not been taken seriously mainstream. Even ordinary conductors could have such electrons, and one can even consider the possibility of dark conductors with the distances between nucleons scaled down by  $n$  and electronic density scaled down by  $1/n^3$  providing kind of fractally scaled down copies of ordinary conductors. This might make sense also for other condensed matter phases.
3. These findings lead to a new formulation of valence bond theory [L92] (see <http://tinyurl.com/ya9wnokh>). The basic fact is that the lengths of the molecular bonds vary in a rather narrow range whereas Schrödinger equation suggests that the bond lengths  $r$  should scale as  $r \propto m^2/Z^2$  for  $n = 1$  ( $m$  labels the rows of the periodic table). Closed shell electrons screen  $Z$  to  $Z_{eff} = n_V$ ,  $n_V$  the number of valence electrons so that the formula  $e = n^2 m^2 / Z_{eff}^2$  is a more natural starting point, and conforms with the basic idea about periodic system. This leads to a model allowing to estimate the value of  $n$  for a given bond allowing also qualitative picture about electro-negativities of valence bonds. Also a comparison with bio-chemistry becomes possible. Hydrogen bond can be understood in terms of de-localization of proton. The conclusion is that the reductionistic dogma stating that molecular physics and chemistry reduce to atomic physics is wrong in TGD framework.

### Life-like properties of very simple systems

Towards the end of 2017 also other steps of progress were made relating to the life-like properties of very simple systems [L94] (see <http://tinyurl.com/yassnhzb>).

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

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

2. One can develop a model for the system based on TGD inspired quantum biology. This involves the notion of MB carrying dark matter identified as  $h_{eff} = n \times h$  phases; a network

of magnetic flux tubes (MB) controlling BB (now charged plastic balls) and responsible for coherence and synchrony (of the crystal-like phase now); the control of the oscillations of BB by cyclotron radiation (now the plastic ball system) resulting from decays of cyclotron condensates of charged particles (now protons and Ar ions). The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living matter and “cold fusion” [L42, L86] and serving as source of metabolic energy in prebiotic stage when the chemical energy storage had not yet emerged. Dark analogs of DNA, RNA, tRNA, and amino-acids are dark protons sequences realizing the degeneracies of vertebrate genetic code are dark nuclei and can transform to ordinary nuclei and liberate nuclear binding energy so that the hen-egg question about which came first: metabolism or genetic code, is resolved: hen= egg.

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

### How molecules in cells “find” one another and organize into structures?

The title of the popular article “How molecules in cells ‘find’ one another and organize into structures?” (see <http://tinyurl.com/ydbznknn>) expresses an old problem of biology. Now the group led by Amy S. Gladfelter has made experimental progress in this problem. The work has been published in Science [I31] (see <http://tinyurl.com/ybwyugho>).

It is reported that RNA molecules recognize each other to condense into the same droplet due to the specific 3D shapes that the molecules assume. Molecules with complementary base pairing can find each other and only similar RNAs condense on same droplet. This brings in mind DNA replication, transcription and translation. Furthermore, the same proteins that form liquid droplets in healthy cells, solidify in diseases like neurodegenerative disorders.

Some kind of phase transition is involved with the process but what brings the molecules together remains still a mystery. The TGD based solution of this mystery is one of the first applications of the notion of many-sheeted space-time in biology, and relies on the notion of magnetic flux tubes connecting molecules to form networks.

Consider first the TGD based model about condensed and living matter. As a matter fact, the core of this model applies in all scales. What is new is there are not only particles but also bonds connecting them. In TGD they are flux tubes which can carry dark particles with nonstandard value  $h_{eff}/h = n$  of Planck constant. In ER-EPR approach in fashion they would be wormholes connecting distance space-time regions. In this case the problem is instability: wormholes pinch and split. In TGD monopole magnetic flux takes care of the stability topologically.

The flux tube networks occur in all scales but especially important are biological length scales.

1. In chemistry the flux tubes are associated with valence bonds and hydrogen bonds [L92] (see <http://tinyurl.com/ycg94xpl>). In biology genetic code would be realized as dark nuclei formed by sequences of dark protons at magnetic flux tubes. Also RNA, amino-acids, and even tRNA could have dark counterparts of this kind [L52] (see <http://tinyurl.com/jgffjlbe>). Dark variants of biomolecules would serve as templates for their ordinary variants also at the level of dynamics. Biochemistry would be shadow dynamics dictated to high degree by the dark matter at flux tubes.
2. Dark valence bonds can have quite long length and the outcome is entangled tensor net [L87](see <http://tinyurl.com/y9kwnqfa>). These neuronal nets serve as correlates for cognitive mental images in brain (see <http://tinyurl.com/yczv2o5b>) emotional mental images in body [L116] (see <http://tinyurl.com/ydhxen4g>). Dark photons propagating along flux tubes (more precisely topological light rays parallel to them) would be the fundamental communication mechanism [K14] (see <http://tinyurl.com/ydx9dq6x>). Transmitters and nerve pulses would only change the connectedness properties of these nets.

The topological dynamics of flux tubes has two basic mechanisms (I have discussed this dynamics from the point of view of AI [L85] (see <http://tinyurl.com/y75246rk>).

1. Reconnection of flux tubes serves as the first basic mechanism in the dynamics of flux tube networks and would give among other things rise to neural nets. The connection between neurons would correspond basically to flux tube pair which can split by reconnection. Also two flux tube pairs can reconnect forming Y shaped structures. Flux tube pairs could be quite generally associated with long dark hydrogen bonds scaled up by  $h_{eff}/h = n$  from their ordinary lengths. Flux tube pairs would carry besides dark protons also supra phases formed by the lone electron pairs associated quite generally with hydrogen bonding atoms. Also dark ions could appear at flux tubes.

Biomolecules would have flux loops continually scanning the environment and reconnecting if they meet another flux loop. This however requires that magnetic field strengths are same at the two loops so that a resonance is achieved at level of dark photon communications. This makes possible recognition by cyclotron frequency spectrum serving as signature of the magnetic body of the molecule.

Water memory [K17] (see <http://tinyurl.com/ycqy837a>) would rely on this recognition mechanism based on cyclotron frequencies and also immune system would use it at basic level (here one cannot avoid saying something about homeopathy although I know that this spoils the day of the skeptic: the same mechanism would be involved also with it). For instance, dark DNA strand accompanying ordinary DNA and dark RNA molecules find each other by this mechanism (see <http://tinyurl.com/yalny39x>). Same applies to other reactions such as replication and translation .

2. Shortening of the flux tubes  $h_{eff}/h$  reducing phase transition is second basic mechanism explaining how biomolecules can find each other in dense molecular soup. It is essential that the magnetic fields at flux tubes are nearly the same for the reconnection to form. A more refined model for the shortening involves two steps: reconnection of flux tubes leading to a formation of flux tube pair between molecules and shortening by  $h_{eff}/h$  reducing phase transition.

Also ordinary condensed matter phase transitions involve change of the topology of flux tube networks and the model for it allows to put the findings described in the article in TGD perspective.

1. I just wrote an article (see <http://tinyurl.com/ydhknc2c>) about a solution of two old problems of hydrothermodynamics: the behavior of liquid-gas system in the critical region not consistent with the predictions of statistical mechanics (known already at times of Maxwell!) and the behavior of water above freezing point and in freezing. Dark flux tubes carrying dark protons and possibly electronic Cooper pairs made from so called lone electron pairs characterizing atoms forming hydrogen bonds.
2. The phase transition from gas to liquid occurs when the number of flux tubes per molecule is high enough. At criticality both phases are in mechanical equilibrium - same pressure. Most interestingly, in solidification the large  $h_{eff}$  flux tubes transform to ordinary ones and liberate energy: this explains anomalously high latent heats of water and ammonia. The loss of large  $h_{eff}$  flux tubes however reduces "IQ" of the system.

The phase transitions changing the connectedness of the flux tube networks are fundamental in TGD inspired quantum biology.

1. Sol-gel transition would correspond to this kind of biological phase transitions. Protein folding [K7] (see <http://tinyurl.com/y9lqmtea>) - kind of freezing of protein making it biologically inactive - and unfolding would be second basic example of this transition. The freezing would involve formation of flux tube bonds between points of linear protein and assignable to hydrogen bonds. External perturbations induce melting of the proteins and they become biologically active as the value of  $h_{eff}/h = n$  characterizing their maximal possible entanglement negentropy content (molecular IQ) increases. External perturbation feeds in energy acting as metabolic energy. I have called this period molecular summer.



2. Solidification of proteins reducing is reported to be associated with diseases such neurodegenerative disorders. In TGD picture this would reduce the molecular IQ since the ability of system to generate negentropy would be reduced when  $h_{eff}$  for the flux tubes decreases to its ordinary value. What brings molecules together is not understood and TGD provides the explanation as  $h_{eff}$  reducing phase transition for flux tube pairs.

#### 9.4.2 Progress in the understanding of quantum brain

The third step of progress towards the end of 2017 relates to the a more detailed understanding of functioning of brain.

The article with title “*DMT, pineal gland, and the new view about sensory perception*” [L87] (see <http://tinyurl.com/yahfsygg>) describes the recent view about sensory perception, hallucinations, imagination, and what might be called remote sensory perceptions. Many of the views appear also in the earlier article “*Psychedelic induced experiences as key to the understanding of the connection between MB and information molecules?* ” [L35] (see <http://tinyurl.com/yao5tje2>).

What distinguishes TGD from neuroscience is that sensory receptors are assumed to serve as carriers of sensory percepts. ZEO provides a new view about time and memory and allows to solve the basic objections related to phantom limb phenomenon: pain in phantom limb would be sensory memory [L84, L87].

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 bio-photons in an energy conserving manner. Similar buildup of communication channel takes place in telephone communications. 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 [K86] allowing communications between BB and 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.

If the new view about the role of nerve pulses as builders of connections rather than signalling inside brain is correct, this picture might also help to develop ideas about brain-robot interaction. Note however that brain pulses generate dark photon communications with MB and this might be essential for the fusion of MBs of subject person and robot.

### 9.5 Has AI hit dead end?

I found a link to a very interesting article titled “Artificial intelligence research may have hit a dead end” followed by the comment “Misfired” neurons might be a brain feature, not a bug — and that’s something AI research can’t take into account” (<https://cutt.ly/bb01YVN>). Also Philip K. Dick’s 1968 sci-fi novel, “Do Androids Dream of Electric Sheep?” is mentioned (<https://cutt.ly/ibPaTpc>). Would an intelligent robot (if it were still a robot) dream?

AI models the brain as a deterministic computer. Computer does not dream: it does just what is needed to solve a highly specialized problem (just what a top specialist does in his job; computer is the idol of every professional highflier).

Computerism assumes physicalism denying such things as genuine free will but this is not seen as a problem. Also the mainstream neuroscientist believes in physicalism. Some computational imperialists even claim that physics reduces to computerism. What might be called neuroscience of fluctuations however challenges this picture.

### 9.5.1 95 per cent of brain activity corresponds to fluctuations

The euroscience of fluctuations has led to a strange conclusion: 95 per cent of brain's activity and therefore metabolic energy seems to be used to generate fluctuations, which in standard neuroscience represents noise (amusingly, junk DNA corresponds to 95 per cent of DNA in the case of humans, as noticed in the article). Neuroscientists have routinely averaged out this "noise" and concentrated on the study of what can be regarded as conscious activities: sensory input, motor actions, and cognition. These contributions seem to represent only ripples in a vast sea of activity. The brain thus seems to be diametrically opposite to a computer in the sense that spontaneous fluctuations are poison for a computer but food for the brain. This conflicts with the views that AI will replace natural intelligence with decade or two (<https://cutt.ly/sbPaMQH>).

Also EEG is still regarded often as a mere noise. One can however wonder why the brain would use a lot of metabolic energy to send information to outer space: coding of information about contents of consciousness and brain state indeed requires a lot of metabolic energy.

The book "The Oxford Handbook of Spontaneous Thought: Mind-Wandering, Creativity, and Dreaming" (<https://cutt.ly/EbPf51i>) [J129] discusses the problem where spontaneous thoughts and ideas come from.

The interpretation of the long range fluctuations as fluctuations induced by long range quantum fluctuations characterized by the value of the effective Planck constant  $h_{eff} = nh_0$  labelling the phases of ordinary matter identified as dark matter and residing at magnetic body (MB) of the system is one of the basic idea behind TGD inspired quantum biology and model of the brain [L224]. In adelic physics [L97, L98]  $n$  has a number theoretic interpretation and can be regarded as a universal IQ so that fluctuations are a prerequisite for intelligence.

TGD inspired theory of consciousness and life relies on zero energy ontology (ZEO) predicting among other things that time reversal occurs in ordinary state function reductions [L149]. Second law is replaced in ZEO with negentropy maximization principle (NMP) implying second law for the ordinary matter. ZEO combined with adelic physics predicts that evolution and biological self-organization are unavoidable. The possibility of time reversed dissipation predicts an apparent breaking of second law [L147, L195].

According to the TGD based quantum view [K33, K89, K86] about neuroscience, primary sensory percepts reside at the sensory organs which requires back and forth communications between brain and sensory organs to build sensory perceptions as standardized mental images. These communications must be fast and the proposal is that they use dark photon signals.

In this view, nerve pulses do not represent signals inside the brain but act as neural relays at synaptic junctions making possible long range dark photon communications inside the brain [L87]. Part of the metabolic energy associated with the fluctuations could be used to build of mental images in the proposed manner. Nerve pulse patterns generate Josephson radiation [K86] communicating sensory information to MB and also require metabolic energy. Dark cyclotron radiation from MB represents control signals to the brain. In both cases, long range fluctuations at brain level are involved.

### 9.5.2 TGD interpretation of the findings

It is interesting to discuss the above described findings from TGD perspective.

#### Could fluctuations be induced by quantum fluctuations in quantum critical Universe of TGD?

Consider first the TGD based identification of the origin of the fluctuations and their interpretation.

1. TGD Universe is quantal in all scales. Zero energy ontology (ZEO) [L149, L141] allows to overcome the basic objection that the universe looks classical in long scales: ZEO view about quantum jumps forces the Universe to look classical for the outsider. The experiments of Mineev *et al* [L141] indeed demonstrated this concretely [L141].
2. TGD Universe is also quantum critical in all scales: this assumption fixes the basic coupling parameters as analogous to critical temperature in thermodynamics. Quantum criticality

means that the system is maximally complex and sensitive for perturbations. Complexity means that the system is ideal for representing the external world via sensory inputs. By criticality implying maximal sensitivity it is also an ideal sensory receptor and motor instrument.

3. The basic characteristic of criticality are long range fluctuations. They are not random noise but highly correlated. Could the fluctuations in the brain correspond to quantum fluctuations.

Long range quantum fluctuations are not possible for the ordinary value of Planck constant.

Number theoretical view about TGD [L97, L98], generalizing ordinary physics of sensory experience to the physics of both sensory experience and cognition by introducing besides real numbers also p-adic number fields and their extensions, leads to the prediction that there is infinite hierarchy of phases of ordinary matter identifiable as dark matter and labelled by the values of effective Planck constant  $h_{eff} = nh_0$ , where  $n$  is dimension for an extension of rationals defined by a polynomial determining space-time region. The most recent view about the concrete realization of this picture in terms of  $M^8 - H$  duality is discussed in [L165, L166, L169, L193]. The value of  $n$  serves as a measure for algebraic complexity and therefore defines a kind of IQ. The longer the scale of quantum fluctuations, the higher the value of  $n$ , and the larger the  $h_{eff}$ , and the longer the scale of quantum coherence. Fluctuations would make the brain intelligent. Their absence would make the brain a complete idiot - an ideal computer. The higher the value of  $h_{eff}$ , the larger the energy of the particle when other parameters are kept as constant. This means that intelligence requires metabolic energy feed to increase  $h_{eff}$  and keep its values the same, since  $h_{eff}$  tends to be spontaneously reduced.

One can however argue that since the brain consists of ordinary matter, brain fluctuations at this level cannot be quantum coherent in long scales.

3. In TGD they would be induced by quantum fluctuations at the level of the magnetic body (MB) having a hierarchical onion-like structure [K82, K81, K53]. The dark matter would be ordinary particles with  $h_{eff} = nh_0$  at MB and since  $n$  serves as a measure of IQ it would be higher for dark matter than for ordinary biomatter. MB containing dark matter would be the "boss" controlling the biological body (BB).
2. The quantum coherence of MB would force ordinary coherence of ordinary biomatter as a forced coherence. Ordinary matter would be like soldiers obeying the orders and in this manner behaving apparently like a larger coherent unit [L147].

MB would receive sensory input from BB and control it by using EEG realizes as dark photons. This would explain EEG and its probably existing scaled variants.

### TGD view about sensory perception, motor actions, and dreaming and imagination

The proposal of the article (<https://cutt.ly/bb01YVN>) was that most of the brain activity consists of "dreaming". Dreaming, hallucinations, and imagination are poorly understood notions in neuroscience. TGD provides a rather detailed view about these notions [L87].

1. What distinguishes TGD from neuroscience is that sensory receptors - rather than brain - are assumed to serve as carriers of sensory percepts so that brain would build a cognitive representation by decomposing the perceptive field to objects and give them names.

Zero energy ontology (ZEO) [L149, L195] providing a new view about time and memory makes it possible to solve the basic objections related to the phantom limb phenomenon: pain in the phantom limb would be sensory memory. Sensory memories can be indeed stimulated by electrically stimulating temporal lobes and the memory feats of idiot savants could rely on sensory memories involving no abstraction. ZEO also provides a new view about self-organization in which dissipation with a reversed arrow of time plays a fundamental role [L149, L147, L224].

2. The assumption that sensory percepts are artworks [L87] rather than passive records of sensory input requires a virtual sensory input from the 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 a process to allow this and signals propagating with maximal signal velocity are suggestive.
3. Nerve pulses and neurotransmitters would not represent real communication but give rise to temporary intra-brain communication lines along which dark photon signals would propagate with the maximal signal velocity using dark photons (characterized by  $h_{eff}/h_0 = n$ ) transforming to biophotons in an energy conserving manner. As a matter of fact, the communications could be rely dark 3N-photons defining representations for genes. Gene represented as a sequence of dark 3-photon triplets- codons - would serve as an address and modulation of the scale of frequencies would code for the message generating a sequence of 3N-resonance peaks at the receiving end [L31, L140, L170, L222, L223]. This also leads to a far-reaching generalization of genetic code [L192].

Neurotransmitters and also other information molecules (hormones, messenger molecules) 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 [K33, K89]. Meridian system could be a 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 [L87].

The natural question is following: How large fraction of the spontaneous activity which forms 95 percent of brain activity goes to the feedback not present in the brain of the standard neuroscience? This would include the construction of the feedback to sensory organs as virtual sensory inputs to build standardized mental images. Dreams are a special case of this. There is also the virtual sensory input which does not reach sensory organs and gives rise to imagination, in particular internal speech.

Similar picture applies to virtual motor input and the construction of motor output as "standardized motor patterns" - this notion makes sense only in ZEO since the patterns are 4-D. Note that the feedback loop could extend from brain to MB.

There is an interesting finding related to the "noise" and motor activities as the popular article "'Noise' in the Brain Encodes Surprisingly Important Signals" published in Quanta Newsletter (<https://cutt.ly/ebA1FLm>) tells. In the experiments made for mice it is found that the spontaneous brain activity increases dramatically as the mouse moves. This brings in mind a lecturer who moves forth and back as he talks. This rhythmic motion could give rise to a brain/body rhythm coupling the lecturer to a layer of MB with large  $h_{eff}$ . Its quantum coherence of MB would induce ordinary coherence of BB in body scale and with large  $h_{eff}$  and raise the "IQ" of the lecturer. Creative thinking requires movement and is not possible in backwater!

## Chapter 10

# Arrow of time and neuroscience: TGD based view

### 10.1 Introduction

This chapter has been written together with Reza Rastmanesh. The question that inspired this article is whether memories about the future are possible. This requires retrocausality. The criticism of retrocausality relies on the assumption that time, in particular the thermo-dynamical time, has always the same arrow.

If one gives up this assumption, there is no reason forbidding retro-causality and phenomena like sensory perception of signals arriving from future giving rise to precognition. In fact, our ability to predict a lot about our future might be due to this kind of sensory perception rather than only due to computation using a neuronal model.

There is empirical evidence for non-standard arrow of time. Phase conjugate light rays [D8] (<https://cutt.ly/ys4x4dX>) obeying second law in wrong time direction, Fantappie's work [?, ?] self-organization in biology - the self-assembly of the tobacco mosaic virus is a classical example [I68]. The latest finding that I learned of is that an isolated system can extract organized energy from its thermal energy [D9] (<https://tinyurl.com/y9ycj3nt>).

In the framework of Topological Geometrodynamics (TGD) zero energy ontology (ZEO) [L188] leads to a quantum measurement theory solving the basic problem of standard quantum measurement theory due to the conflict between determinism of Schrödinger equation and non-determinism of quantum jump. Key prediction is that the arrow of time changes in ordinary "big" state function reduction (BSFR) whereas in "small" state function reductions (SSFR) analogous to "weak" measurements the arrow of time is not changed.

This forces a generalization of thermodynamics and dissipation with opposite arrow of time allows to understand self-organization and also energy feed necessary for it in terms of generalized second law. A system dissipating in non-standard time direction seems from the point of view of the outsider to develop structures and extract energy from the environment. The non-standard arrow of time would be associated with the magnetic body (MB) carrying  $h_{eff} = nh_0$  phases of ordinary matter identifiable as dark matter and making it a macroscopic quantum system for sufficiently large values of  $n$ . MB would act as master of the ordinary matter and induce effective time reversal at the level of ordinary matter in long time scales.

The TGD view about the neural system differs from the standard picture.

1. The first new element is the different role of nerve pulses: they create communication pathways along which dark photons can propagate.
2. Second new element is the presence of linear flux tube structures assignable to neural pathways assignable to linguistic cognition unstable against effective axonal splitting occurring in Alzheimer disease (AD) [J52], and the presence of 2- and even 3-D flux tube structures assignable to geometric and holistic cognition: this would survive in AD [L129] and in states involving cognitive defects (idiot savants). Meridian system and glial cells could relate to this aspect.

Communications in this system would be based on dark photons transforming to bio-photons and travelling along flux tubes with light velocity. This system would be the predecessor of the neural system and could be realized even in the case of plants. In the neural system the real communications would rely on dark photons - ordinary photons with effective Planck constant  $\hbar_{eff} = n\hbar_0 > \hbar$ .

The communication lines would be dynamical consisting of axonal flux tubes connected by nerve pulse transmission to longer structures serving as wave guides along with dark photons signals would propagate. Metabolic economy could motivate this kind of realization as for electronic communications in modern society. Nerve pulses would only build the connection lines for communications inside the brain. They would however modulate the frequency of Josephson radiation from neuronal membrane to the MB of the brain and in this way communicate sensory data from cell membrane to MB.

3. According to ZEO based theory of consciousness causal diamond (CD) identified as  $CD = cd \times CP_2 \subset H = M^4 \times CP_2$ , where  $H$  denotes 8-D embedding space containing space-time as 4-surface, and  $cd$  is the intersection of future and past directed light-cones in 4-D Minkowski space  $M^4$  and  $CP_2$  is 4-D complex projective space. The passive boundary would correspond to holistic, spatial, and the “timeless” component of conscious experience dominating in meditative states and active boundary to reductionistic, temporal part of conscious experience such as sensory perception and cognition. These components correspond to opposite arrows of time at certain layers of MB.
4. I have considered the realization of the holistic emotional intelligence in terms of the notion of bio-harmony [L39, L40, L156]. Here one must however remember that emotions could be sensory percepts at the level of MB so that they should correspond to the dynamical aspects of consciousness rather than the permanent part. Music expresses and induces emotions and harmony codes for the emotional state. A model involving icosahedral and tetrahedral symmetries leads to a model that Pitkänen calls bio-harmony: the model predicts correctly the basic aspects of the vertebrate genetic code. The codons would correspond to 3-chords of bio-harmony. The realization of bio-harmony is assigned with magnetic bodies of the basic biomolecules including RNA and DNA.
5. EEG frequencies  $f > 10$  Hz assigned to wake-up consciousness could correspond to the effectively 1-D and “linguistic” neural system and frequencies  $f < 10$  Hz to the system responsible for holistic aspects. During sleep  $f < 10$  Hz dominates so that the consciousness should be holistic. Since we do not remember anything about this period, it could correspond to time reversed mode making possible precognition as sensory perception of signals from geometric future.
6. The effective change of the arrow of time in the neural system induced by its real change at the level of MB could mean the change of the direction of nerve pulse conduction. This reversal could explain phenomena like reverse writing and reverse speech discussed in [K69]. There is evidence that AD patients have precognitive and prophetic dreams [J57, J58]. Ordinary nerve pulse conduction is prevented in AD by axonal plaque and exponentially attenuated. In the reverse time direction there would be an exponential amplification with respect to standard direction of time. This suggests that AD neurons are dead in standard time direction but re-incarnated in the opposite time direction. Death would be a gradual process.

This proposed hypothesis is testable. To hold true, manipulation of the level of acetylcholinesterase inhibitors (AChEIs) should reduce the formation of past event memory and increase the formation of future oriented precognitive memory traces. Indeed, there is evidence that Rivastigmine, a reversible ACEI used in the treatment of AD, increases memory and rapid eye movement sleep, and has been suggested that aside from those normal properties it could be implicated in retrograde dream formation, i.e., precognitive dreaming [J67]. Similar pilot study has yielded same results before [J57].

Further support comes from the bidirectional relationship between AD and sleep disorders through a model of brain rhythm attractor breakdown [J131]. In fact, individual differences were found in prophetic dream belief and experience, with a high frequency of prophetic dream experiences associated with disordered sleep patterns and sleep medication use [J177].

In the sequel this picture is discussed in more detail. In particular, the question how the possibility of non-standard arrow of time could make possible precognition as sensory perception of signals from geometric future, is considered. Our ability to predict our future is usually regarded as trivial. Computationalists explain it by assuming that the brain is a computer predicting the future. This ability could involve this sensory perception in an essential way.

**Note:** This chapter was prepared in collaboration with Dr Reza Rastmanesh who provided a lot of biological and neuroscientific knowhow and made stimulating critical questions.

## 10.2 Some aspects of TGD inspired quantum biology and theory of consciousness

### 10.2.1 TGD based quantum biology very briefly

One can approach TGD inspired quantum biology by making questions.

#### How to understand coherence of living systems?

If only bio-chemistry is involved, we would be sacks of water and sacks of water do not climb in trees or write poems. Could quantum coherence induce the coherence? What entity serve as intentional agent and how it could realize its intentions?

1. Topological field quantization applies to electric and magnetic fields [L11, L10]. For instance, magnetic field decomposes to flux tubes having finite thickness. Radiation fields are topologically quantized to topological light rays. Each system has its fields at separate space-time sheets touching each other only via wormhole contacts: system has field body, in particular magnetic body (MB) having hierarchical onion-like structure corresponding to the hierarchy of space-time sheets. Magnetic flux tubes would take a role analogous to wormholes in the ER-EPR correspondence proposed by Maldacena and Susskind [B13] in GRT context serving as topological correlates and prerequisites for entanglement.
2. MB serves as the intentional agent using biological body (BB) as motor instrument and sensory receptor. MB controls BB via dark photon dark photon beams with large  $h_{eff}$ . The double BB + environment is replaced with the triple MB + BB+ environment. The vision about life as nothing but biochemistry is given up.
3. Experiments of Blackman [J47] and others demonstrated the quantal effects of extremely low frequency (ELF) radiation - say in EEG range - on vertebrate brain. For the ordinary value of Planck constant these effects are however impossible since the energy  $E = hf$  of EEG photons is extremely small. This motivated what eventually became  $h_{eff}/h_0 = n$  hypothesis derivable now from adelic physics [L97].
4. Dark matter at the flux tubes of MB corresponds to  $h_{eff}/h_0 = n$  phases and induces coherence of visible living matter. The generalization and re-interpretation [K100] [L50] of Nottale's hypothesis [E1], which reads as  $h_{eff} = h_{gr} = GMm/v_0$ , where  $v_0 < c$  has dimensions of velocity and  $M$  and  $m$  are masses at the ends of the magnetic flux tube along which gravitons travel is essential element. The hypothesis implies that the cyclotron energy scale for charged particle is independent on  $m$ . The spectrum of Josephson frequencies for cell membrane is universal but now the energies are inversely proportional to  $h_{eff}$ . The flux tubes containing dark matter would make possible essentially dissipation-free communications based on supra currents and on dark photons.

#### How MB uses BB as sensory receptor and motor instrument?

How does MB use BB as sensory receptor and motor instrument?

1. Dark photons with large  $h_{eff}$  serve as as communication and control tools. Josephson frequencies would be involved with the communication of sensory data to MB and cyclotron frequencies with control by MB. Dark photons are assumed to transform to bio-

photons [L58] with energies covering visible and UV associated with the transitions of bio-molecules [L29, L28]. The control by MB which layers having size even larger than that of Earth means that remote mental interactions are routine in living matter.

2. In ZEO field body and MB correspond to 4-D rather than 3-D field patterns. Quantum states are replaced by quantum counterparts of behaviors and biological functions. The basic mechanism used by MB would be generation of conscious holograms by using dark photon reference beams from MB and their reading. In ZEO also the time reversals of these processes are possible and make possible to understand memory as communications with geometric past. Sensory perception and memory recall would be time reversals of each other and correspond to sequences of SSFRs. Motor action would correspond to BSFRs.

### Why metabolism?

Particles with nonstandard  $h_{eff}/h_0$  have higher energy as a rule. For instance, atomic binding energies are proportional to  $1/h_{eff}^2$  and thus smaller. Cyclotron energies are proportional to  $h_{eff}$ . Metabolic energy is needed to excite particles to dark states and thus to increase their "IQ" .

This picture suggests a generalization of the view about self-organization based on non-equilibrium thermodynamics with a quantum view based on number theory, in particular the hierarchy of Planck constants [L157]. In non-equilibrium thermodynamics energy feed is a prerequisite of self-organization leading to a generation of coherent structures in long length scales and master-slave hierarchy is central. TGD can be at least formally seen as complex square root of thermodynamics, which leads to the question whether also ordinary self-organization could reduce to the hierarchy of Planck constants so that quite generally the coherent structures in long length scales could be seen as analogs of life forms with coherence induced by quantum coherence at the level of MBs. Hierarchy of MBs defining master slave hierarchy with ordinary matter at the bottom of the hierarchy would replace ordinary master slave hierarchy and quantum theory would make itself visible in all scales.

## 10.2.2 Some aspects of ZEO based theory of consciousness

### Active and passive aspects of conscious experience in TGD vision

In the TGD framework one can understand the presence of the temporal, active and passive aspects of consciousness at the fundamental level.

1. In ZEO conscious entities have as geometric correlates causal diamonds (CDs) having two light-like boundaries. The quantum states are products of analogs of ordinary quantum states assignable to these boundaries and the state is in the general case superposition of these state pairs meaning time-like entanglement.
2. During the life cycle of self the active boundary of CD drifts farther away from static passive boundary in statistical sense and the members of state pairs at it change during the sequence of SSFRs. The contribution of the active boundary to conscious experience corresponds to a sensory input and cognition and changes with time: this gives rise to the experience of time flow.
3. The 3-D states at the passive boundary are identified as superpositions of 3-surfaces remaining unaffected in SSFRs. The 4-D tangent planes of 4-surface at them however change and contribute to conscious experience. This contribution would be almost constant, holistic, spatial, and "timeless" and dominate in meditative states where sensory and cognitive input assignable to the SSFRs is minimal. This contribution would correspond to "soul".

In the popular literature about brain science these two contributions are often assigned with the left and right hemisphere. This assignment is certainly over-exaggeration but might have some seed of truth if considered at the level of many-layered MB and taking into account the hierarchy of CDs.



1. Could evolution favor formation of systems for which MBs tend to appear in pairs with the first member in active state and second member in passive state.

The members of the pair need not have an opposite arrow of time. One can however imagine two parallel sub-CDs of CD with opposite arrows of time and shifting towards geometric future with the active boundary of CD - this shifting is necessary since mental images of CD shift to future. The active contribution from sub-CD<sub>1</sub> and passive contribution from sub-CD<sub>2</sub> would correspond to the same value of experience time inside CD.

CD<sub>1</sub> would certainly give sensory input. Could CD<sub>2</sub> give a meditative contribution masked by CD<sub>1</sub> except in meditative states?

2. Pairings of nearly identical systems are very general in living matter [K72]. Basic examples are brain hemispheres and also pairs of identical sub-systems inside left and right hemispheres. The strands of DNA provide the second example: given strand has both active and passive portions and there is active-passive pairing. Lipid layers of the cell membrane and epithelial sheets associated with skin have two cell layers giving rise to a binary structure. Whether the active-passive dichotomy applies also now - perhaps at the level of their MBs - is an interesting question.

Having both arrows of time would make possible sensory input from both past and future and make possible to both remember and predict. This would certainly increase the changes of survival.

3. Could the members of these pairs change their roles by changing their arrows of time? Kind of division of labour would be in question. Some birds (swift for instance) fly always and the explanation is that the second hemisphere sleeps when another one is in wake-up state [J98, J88]. Could this happen during sleep for some neuronal functions also in humans? Or do both hemispheres remain neurally passive during sleep?

### Redefining the basic concepts related to time in ZEO framework

TGD based quantum measurement theory extending to a theory of consciousness relies on what Pitkänen calls zero energy ontology (ZEO) [L188]. In this framework experienced time and geometric time are not anymore identified. This has strong motivation, since although these times are strongly correlated, they differ dramatically in many respects. This compels to study every standard concept separately and see how it changes. The new ontology forces to reconsider various basic definitions.

#### The notion of event

The notion of event has many meanings.

1. Einstein regarded event as a space-time point. Event refers to subjective experience and in the geometric framework it is more natural to talk about space-time point.
2. Events can be identified a classical states assignable to time= constant snapshots of space-time in standard ontology: basically initial values for the time evolution dictated by field equations.
3. In ZEO event in classical sense can be regarded as a classical time evolution - preferred extremal connecting 3-surfaces at the opposite boundaries of CD and analogous to Bohr orbit dictated by the boundary values at either boundary of CD - 3-surface. The analogies with behavior, biological function, and computer program are suggestive.

Strong form of holography (SH) allows to fix this surface by using 2-D data associated with partonic 2-surfaces and string world sheets. A weaker condition is that the 2-dimensionality for partonic 2-surfaces corresponds to the metric 2-dimensionality for their topologically 3-D light-like orbits. The quantum counterpart of event would be zero energy state identified as a superposition of these space-time surfaces - quantum behavior.

4. Conscious event could be also seen as a state function reduction: moment of re-creation identifiable as an act of free will. There are "small" and "big" state function reductions:

SSFRs and BSFRs. SSFR is the analog of weak measurement and BSFR corresponds to the ordinary state function reduction identifiable in ZEO as "death" of the conscious entity defined by the sequence of SFRs and "reincarnation" with opposite arrow of time. These notions would be universal, not only biological.

### **The notions time and causality**

For the notions of time and causality doubling takes place. There are

1. Two times - subjective and geometric.
2. Two causalities - that of free will/BSFRs for sub-CDs and that of classical field equations.
3. Two arrows of time. Also the thermo-dynamical arrow of time can be non-standard. This leads to a totally new view about self-organization. Retrocausation (subjective and geometric) becomes possible.
4. Two kinds of memories - subjective memories possible only about subjective past (one cannot remember what one has not experienced yet). and geometric memories about external world, which can also be about geometric future. In the latter case one can speak about precognition or sensory perceptions of geometric future.

### **The geometric counterpart of subjective "Now"**

What geometrical correlate does the subjective "Now" have?

1. The first proposal was that it corresponds to the active boundary of CD. It however turned out that the subjective "Now" could more naturally correspond to the  $t = T$  slice of CD with maximal size located in the middle of CD. Here  $t$  corresponds to linear Minkowski time axis connecting the tips of CD.

If one accepts  $M^8 - H$  duality, this picture can be made precise. The moments "Now" would correspond to "special moments in the life of self" [L158, L187] identifiable as intersections of 6-spheres, which are brane-like entities (branes are encountered in M-theory) appearing as universal special solutions of algebraic equations determining the space-time surfaces in  $M_c^8$ . The values of  $T$  correspond to the roots of the real polynomial defining the space-time surface so that the values of "Now" are quantized.

2. During the sequence of state function reductions the active boundary of CD would shift towards geometric future and the size of CD would increase (in statistical sense). The sub-CDs accompanying sensory and other mental images would shift to the direction of geometric future as CD increases and become potential memory mental images suffering BSFRs in a shorter time scale.

The self would experience memory mental image as a sub-self in memory recall to be discussed below. The time=constant snap-shots at the upper half of CD assignable to the memory mental images are ordered with respect to the Minkowski time  $t$  but the order is opposite to that for the subjective experiences. This was a great surprise to me. They would correspond to sub-selves to which memory recall builds a connection by entanglement quantally or by sending a signal, which is reflected back in BSFR for the memory mental images.

### **The recall of the episodic memories**

What about recall of episodic memories in ZEO?

1. Spontaneous memory recall could correspond to a death of a memory mental image with opposite arrow of time and re-incarnation with the same arrow of time as self. This could be accompanied by emission of past directed "negative energy" signal received by self associated with moment "Now". The interpretation would be in terms of extraction of metabolic energy: memory recall indeed requires metabolic energy.

Active memory recall could correspond to a receive of future directed "positive energy" signal coming from "Now" having interpretation as metabolic energy feed. Energy conservation would force the memory mental image to change the arrow of time.

2. The prediction would be that in active memory recall by a "positive energy" signal received by the memory sub-CDs, the order of recalled memories is opposite to that for the real experiences. There is evidence for this kind of change [J138] (see also the popular article "The human brain works backwards to retrieve memories" at <http://tinyurl.com/y7hbmug>).
3. One also consider a mechanism based on time-like quantum entanglement between the memory sub-self and sub-self associated with "Now".

#### Two variants for geometric memories

Geometric memories - non-personal "memories" - about the external world seem to be possible. The information would arrive as signals from the external world (exterior of CD) and would be "objective". Signals can arrive also from the interior of CD. For instance, as light-signals affecting the state at the active boundary of the CD at which also personal memories are stored. The states are not changed at the passive boundary of the CD during the life cycle of self.

Geometric memories come in two variants corresponding to the two arrows of time.

1. The sensory input from the external world of the geometric past could generate geometric memories, most naturally memories in the behavioristic sense meaning changes of the behavior induced by the changes of synaptic strengths. Sub-selves with an opposite arrow of time could have geometric memories also from the geometric future and give rise to geometric precognition. During sleep this could occur.
2. The geometric memories about future - geometric precognitions or sensory perceptions of signals from future - would be what we regard as an ability to predict what happens tomorrow or after one year. They would not be absolute since quantum jumps affect also the future in scales longer than that for my personal MB. Usually these memories would be identified in terms of a model for the behavior of the external world. Physics itself would realize this model.

## 10.3 Holistic and reductionistic aspects of cognition at the level of brain

### 10.3.1 New view about the role of nerve pulse transmission in brain communications

Usually nerve pulses are regarded as signalling in brain. In TGD framework the situations changes [L131].

1. Axons would be accompanied by flux tubes - actually closed flux tubes with a shape of very narrow and long parallelogram. Nerve pulse transmission connects the flux tubes associated with pre- and postsynaptic neurons to longer flux tubes. Nerve pulses make possible real communications by dark photons by creating connected signal pathways from pieces. Dark photon communications are much faster than neuronal ones. There is an analogy with modern electric communications. Communications lines are dynamic and created before communications using relays to save energy.
2. There is dark photon feedback from the brain or even "large" layers of MB to sensory organs giving rise to virtual sensory input. This feedback leading to a stationary situation would make possible pattern recognition producing standardized sensory mental images as kind of artworks by feedback leading to a stationary situation. Light velocity allows very large number of feedback loops in neuronal time scales.
3. In REM dream virtual sensory input dominates. Interpretation for imagination as virtual sensory input stopping at some higher level than sensory organs.
4. Nerve pulse patterns affect dramatically membrane potential and make possible communications from the brain to the "large" layers of MB and fractal hierarchy of analogs of EEG can

be considered. Axons act as generalized Josephson junctions generating dark Josephson radiation travelling to the "large" layers of MB. Frequency modulation of Josephson frequencies codes for sensory input represented by nerve pulses.

### 10.3.2 Two aspects of cognition

#### Linear, reductionistic, and time-local aspects of cognition

The neural transmitters promote in the healthy brain the formation of memories understood as neural level behaviors basically by allowing to connect axons temporarily to longer linear neuronal structures: Hebb's rules (<https://cutt.ly/os4ckD9>) characterize this dynamics. This would be the role of the information molecules quite generally.

The key topological observation is that only a single axon emanates from a given neuron. It can however branch so that several neurons can receive the nerve pulse signal from a given neuron so that the network is not tree-like - neither fully linear nor fully non-linear. Also loops are possible.

Tree-likeness means that if an axon becomes dysfunctional, neural signals do not propagate further. This could happen in AD. Nerve pulse conduction fails also if Ach or other needed neural transmitters are not available so that nerve pulses are not mediated over synaptic clefts. The failure of linguistic consciousness in AD [J54] motivates the hypothesis that neuronal level is responsible for this mode of consciousness.

#### Spatial and holistic aspects of cognition

Cognition has besides the linear and temporal linguistic aspects assignable to neural activity - also spatial and holistic aspect.

1. The TGD based vision about MB is as a fractal structure having besides the "large" part also "small" parts in the scale of body and brain. This vision predicts that neurons appear as nodes of magnetic flux tube networks, which can be 2- or even 3-D. Part of these flux tubes can be parallel to axons. These magnetic flux tube networks could relate to the holistic, geometric aspects of cognition. If these flux tubes carry monopole flux, they are stable against splitting. Therefore episodic memories assignable to these networks would be stable.

More probably, the flux tubes are closed looking like very long and narrow parallelograms connecting two systems. These flux tubes could split by reconnection to two pieces forming smaller long parallelograms. These networks could be rather permanent at the scale of the body, and also these networks could have nodes where reconnections can occur. Psychoactive drugs could induce this kind of reconnections over very long distances [L49]. In particular, to the large part of personal MB.

2. In music experience these two aspects combine: rhythm corresponds to the time-local, linear aspect and harmony to the holistic aspect [L46]. It is quite possible that the neural system alone cannot represent the latter aspect. This suggests that neurons - or perhaps glial cells - form 2- or 3-D networks connected by the analogs of axons identifiable as flux tubes in TGD framework [K3, K5] [L97]. Also the meridian system postulated by eastern medicine could relate to this. This system would precede the nervous system and even plants could have it.

These 2- or 3-D structures are stable against the splitting of axon-like units so that the holistic aspects of cognition would be preserved in AD. The AD patient can indeed understand the words of songs. The signaling in this system would take place by dark photons with non-standard value  $h_{eff} = nh_0$  of effective Planck constant, which are photon-like particles transforming to biophotons [L29].

3. The vision about the brain based on the theory of consciousness and living systems [K3] [L188] inspired by Topological Geometrodynamics [K5] [L97, L98] leads to the view that also neural system uses dark photons to the communications in brain. The function of nerve pulse activity would be to build communication lines by combining the magnetic flux tubes accompanying axons to longer structures serving as analogs of wave guides along which dark photons can

propagate [L131, L132]. The information molecule would play the role of a relay element. The analogy with modern electronic communications is obvious.

The evolutionary reasons could be the reduction of metabolic costs and the advantages due to the ability to rapidly modify the topology of the flux tube network. For instance, flux tube structure would make possible topological quantum computation based on the braiding of the flux tubes [K4, K119].

4. TGD leads to a model of genetic code based on the notion of bio-harmony inspired by the attempt to understand the notion of musical harmony. The model relies on the realization of harmony as collection of allowed 3-chords realized in terms of frequency triplets. It turns out that the representation in terms of icosahedral and tetrahedral geometries leads to a large number of harmonies allowing representation of vertebrate genetic code [L39, L40, L156]. Since music creates and expresses emotions, the interpretation is that these bio-harmonies represent emotional states, moods [L132, L138]. Bio-harmony would represent collective aspects of cognition, emotional intelligence whereas neural activity would represent its time-local and linear aspects.
5. Idiot savants are capable of amazing memory feats [J56]. For instance, they can play an entire music piece having heard it just once or draw an entire landscape from memory. This strongly suggests that holistic memories are indeed subjective- re-experiences rather than learned behaviors. Idiot savant would see the landscape that he is drawing. These memories are also holistic, which suggests that subjective memories are assignable to the 2-/3-D magnetic flux tube networks rather than basically linear neural networks.

Could brain chemistry provide tools - say various psychoactive drugs - promoting holistic cognition [L49]. N,N-dimethyltryptamine (DMT) - a psychoactive compound produced by the brain itself - is what comes first in mind [L131]. Idiot savants have severe cognitive defects but are able to perform miraculous feats related to memory, mathematics, and arts. Could holistic cognition replace neural linear cognition in these situations?

#### **Are holistic and geometric aspect of cognition associated with meridian system or glial system?**

MB would give rise to a flux tube network with flux tubes connecting basic units which could be neurons but possibly (also) glial cells. This network would be also fractal appearing in various scales. Axonal network would be only part of this network with axons accompanying flux tubes forming a sub-network with the property that from a given node only a single axonal flux tube emerges which possibly branches later. There is however no reason to assume that the number of flux tubes emerging from a given node is only one. Also flux tubes without accompanying axons are possible.

Therefore non-dynamical 2- or even 3-D magnetic flux tube networks are also possible but not as neural systems. The attractive identification is as correlates of 2- or even 3-D holistic consciousness. Dark photon signals can propagate also along these networks. Key feature is the stability against splitting of a single flux tube distinguishing these systems from 1-D linear systems. If neural transmitters serve as relays connecting flux tubes to longer units for axonal pathways, a subset of information molecules such as DMT could also act in the similar manner in the entire flux tube network.

1. Could holistic aspects correspond to the meridian system with meridians associated with flux tubes and acu points acting as nodes? This kind of networks could be possessed also by invertebrates such as plants. Could glial cells form nodes of this kind of network? Could glial *resp.* neuronal systems forming a coupled pair be responsible for holistic and spatial *resp.* reductionistic, time-local, and linear aspects of consciousness.
2. Is there a connection with AD? Linear language based consciousness associated with nerve pulse activity would degenerate in AD since the axons with plaque would not conduct nerve pulses and the formation of temporary signal networks would fail. The 2- or 3 D holistic consciousness stable under this kind of splitting would however remain [L129].

3. What is the relationship to the right-left dichotomy often assigned with the holistic-reductionistic dichotomy? It is said that the left brain talks and the right brain sings. AD patients understand words, which are sung. How strictly this is true? Should R-L dichotomy be replaced with neural-meridian or neural-glial dichotomy as a realization of holistic-reductionistic dichotomy.

### **Sleep *resp.* awake as holistic consciousness *resp.* linguistic consciousness?**

How the two kinds of consciousness relate to time reversal and left-right division of the brain?

1. Neuronal consciousness dominates during wake-up but during sleep neural activity is suppressed by hyperpolarization. Sleep could therefore correspond to the dominance of holistic, spatial consciousness assignable to the meridian system or glial system.
2. What about the arrow of time for the consciousness during sleep (about which we - at least apparently - would not remember anything). Could the MB for the meridian-/glial system have reversed arrow of time during sleep and have sensory input from the geometric future? This could explain precognitions and prophecies.
3. One can also ask whether right- and left hemispheres have opposite arrows of time in time scales longer than nerve pulse duration  $T$ . This is not possible in the axonal length scale since axonal potential would change its sign in time scales longer than  $T$ .

How these two modes of consciousness relate to EEG and electric fields of brain and body.

1. Cyclotron frequencies characterize the flux tubes. Time reversed part of MB in scales corresponding to "us" does not contribute to "our" consciousness during wake up. We do not remember anything about the sleep period without dreams: could it be that "we" are in time reversed mode so that there are no memories about this time.

During sleep  $f < 10$  Hz dominates in EEG: it does not correlate with "wake-up" consciousness. Could sleep correspond to holistic time reversed consciousness with reduced neural activity (by hyper-polarization) perhaps assignable to meridian or glial network. During wake-up  $f \geq 10$  Hz dominates and correlates with the contents of consciousness. Linear neural consciousness would dominate.

2. How the time reversal reflects itself in EEG? There are indications that EEG consists of slices of duration about 300 ms decomposing to order and chaotic pieces [J79]. Could these pieces correspond to dissipation in standard arrow of time and with opposite arrow meaning effective generation of order [L26]?
3. What about longer spatial and time scales? Could the change of the arrow of time show itself somehow. The direction of velocity and electric field changes opposite in time reversal. Could the propagation direction of say thalamo-cortical EEG waves with 40 Hz resonance frequency in the cortex change. 40 Hz resonance occurs also in the transition to meditative state. What could this mean?

It is known [J160, J34] that the change of the direction of the electric field along the body axis leads to a loss of consciousness (for TGD based model for the direct currents of Becker see [L25]): could this mean actually the change of the arrow of time at the layer of MB controlling the dynamics in this length scale. Same is true concerning the reversal of electric field from frontal lobes to hindbrain. Longitudinal electric fields are also associated with microtubuli and DNA.

Also oscillating electric fields are important in living matter.

1. By Faraday's law oscillating electric fields also accompany oscillating magnetic fields and could generate bio-rhythms as repeating cycles living-alive-living-alive or ...wake-up-asleep-wake-asleep... Cyclotron frequencies, generalized Josephson frequencies, and Schumann resonance frequencies would define various bio-rhythms forcing biochemical rhythms. Rhythm of breathing and of heartbeat would be examples of such bio-rhythms. Also EEG rhythms

would define life-death cycles. For instance, EEG decomposes to pieces with duration of 300 ms having this kind of structure [J79] [L26].

Both quasi-static and oscillating longitudinal electric fields accompany microtubules [I69]. Ghosh *et al* [J110] have found that oscillating electric fields along microtubuli can generate longitudinal ballistic currents (perhaps supra currents) along them at certain critical frequencies: the results are discussed from the TGD perspective in [L38].

2. There is evidence for the healing of cancer by using an extremely weak oscillating magnetic (and thus also electric) field in nanotesla range with frequency of 60 Hz, which is a Schumann resonance frequency [I85]. The TGD inspired model for the finding [L220] missed the interpretation as a re-establishment of a lost life cycle.

## 10.4 Brain science and recalling memories of future

The notion of memory must be defined more precisely first.

1. In neuroscience memory is defined essentially as a learned behavior and reduces to the change of synaptic connections. The episodic and sensory memories are not like this: they are genuine re-experiences. Idiot savants would have this kind of sensory memories. For instance, they can play an entire music piece or draw an entire landscape from memory such that all details come out correctly. Idiot savant sees again the landscape that he is drawing. Neuroscience cannot provide a convincing explanation for these memories, which suggests that something very important is missing from the picture.
2. Subjective memories predicted by the TGD framework are different from learned behaviors. They are indeed genuine re-experiences - direct sensory experiences or symbolic representations of sensory mental images involved. They do not involve the emergence of new behavior or new associations by strengthening of synapses. They would be essentially at the level of the MB and perhaps predecessors of the memories as identified by neuro-scientists.

### 10.4.1 What memories of the future could mean?

What the memories of the future could mean?

1. In TGD framework subjective precognition is not possible since the subjective future does not yet exist: moment of consciousness corresponds to a re-creation of the quantum sub-Universe as zero energy state.
2. In TGD Universe geometric precognition is in principle possible and corresponds to a receipt of objective information - physical signals - from the geometric future and might occur routinely. My subselves (mental images) with an opposite arrow of time can represent geometric memories from my geometric past. Precognition as a recall of future geometric memories would rely on sensory perception with an opposite arrow of time by some subselves assignable to the structures of the brain. The arrow of time would be reversed at some layer of MB and induce effective change of arrow at the level of ordinary biomatter in longer time scales than usual.

**Remark:** At molecular level BSFRs occur very frequently so that the period with fixed arrow of time is very short.

3. Neuroscientists usually interpret memories as learned associations assignable basically to the strengthening of synaptic contacts (Hebb's rules, <https://cutt.ly/os4ckD9>). These memories are like a text carved to stone and should be distinguished from genuine subjective memories. The sensory inputs from the geometric past and perhaps even from geometric future could induce memories in this sense.

The interesting question is what the change of the arrow of time could mean at the level of nerve pulse conduction. Axons realize the arrow of time as a fixed direction of neural conduction. MB in time reversed mode changes effectively the arrow of time as the level of

ordinary matter in long length scales. Does this mean that nerve pulses travel in an opposite direction than usual?

This has also interesting connection with AD [J52] discussed from the TGD point of view in [L129]: the approximately exponential attenuation of signals along axon with plaque would look like exponential amplification in the standard time direction, and the neural signalling with reverse arrow time might be possible! In the TGD framework death would be a universal phenomenon and mean re-incarnation with a reversed arrow of time. In AD death would have already started at the neural level. What would be comforting that death would be accompanied by a re-incarnation.

4. There is an objection against the change of the arrow of time at the level of axons. The behavior of electric field in time reversal suggests that the sign of membrane polarization should change in the time reversal. Time reversal occurs during nerve pulses if they involve BSFR. For the time reversed states the periods of pulse-on and pulse-off would be permuted so that the effect might not be very dramatic during firing. In the absence of firing the sign of membrane potential would be opposite and this cannot occur in long time scales.

The duration of the nerve pulse varies from  $T_1 = 1$  ms (sodium based action potential) to about  $T_2 = 100$  ms (time scale for sensory mental images!) for Calcium based action potentials and can be understood as being due to BSFRs. One could argue that  $T_2$  corresponds to the maximal duration of the time reversal in the axonal length scale. In longer length scales the time reversal periods could be longer and manifest themselves in different manner such as a change of the direction of conduction velocity.

Since the time scale  $T$  and size scale  $L$  for any CD are related by  $L = cT$ , the change of the arrow of time at brain level during sleep should occur in a considerably longer time scale. The ratio of the time scale of sleep period taken for definiteness to be  $T = 6$  hours to  $T_1 = 1$  milliseconds is  $r = T/T_1 \simeq 2 \times 10^7$ . What is the length scale  $L$  assignable to  $T$ . If the length scales assignable to axonal conduction is cell membrane thickness  $L_1 = 10^{-8}$  m, ab one has  $L/L_1 = T/T_1 = r$ , one has  $L \sim .2$  m not far from the size scale of the brain.

A good guess is that the spatial scale associated with  $T_2 = 100T_1 = 100$  ms (no sensory mental images during sleep) is given by  $(T_2/T_1)L_1 = 100L_1 \sim 1\mu\text{m}$  and is thus the length assignable to cell nucleus. For the same value of the scaling factor  $r$ , this would give  $L \sim 20$  m, longer than the length scale of the human body but roughly consistent with the size scale of largest animals.

### 10.4.2 Are memories of the future possible in some sense?

Dr. Reza Rastmanesh asked in personal communications whether the Acetylsalicylic esterase (AChE) inhibitors could promote the formation of memories in the reverse time direction - to precognize in some sense. The mainstream view of neuroscience does not distinguish between future and past memories at fundamental level and the asymmetry can be understood only in terms of thermodynamics postulating a fixed arrow of time.

In TGD framework one can speak about precognition of geometric future - sensory experiences about geometric future possible for time reversed conscious entities with time reversal taking place at the level of MB. Conscious entities cannot have direct subjective memories of the future since subjective future does not exist. If the MB of the sleeping brain has a non-standard arrow of time, its partial wake-up could give rise to a dream, which can but need not be precognitive.

### Two proposals for understanding memories of future

The level of the transcription factor cAMP/Ca(2<sup>+</sup>)-response element binding protein (CREB) is a key factor governing which neurons are recruited for a given memory trace [J68]. Recently a similar role has been proposed for cGMP response element binding (GREB) protein. Inhibition of phosphodiesterase 5 restored cognitive function in scopolamine-induced amnesia mice by activating the cGMP/CREB signaling pathway and attenuating oxidative stress [J87], with promising implications for treatment of AD. Collectively, in addition to cAMP, cGMP and Amyloid  $\beta$  has been proposed as critically important for memory formation [J159].



CREB is a ubiquitously expressed transcription factor expressed in the brain. It regulates neuroplasticity by modulating gene expression [J84], and so loss or dysfunction in CREB is lethal (at least in mice, and presumably embryonically lethal also in humans), and it may not be feasible to modulate CREB in interventional clinical trials. Down-regulation of AChE in the brain [J44] has been considered as the most important pathway by which CREB modulates memory allocation.

It has been argued that we do have memories of the future; we just cannot make sense of them [J45]. In the framework of behavioristic neuroscience, one can ask whether the factors such as CREB, GREB and Amyloid  $\beta$  that enable to memorize the past, meanwhile prevent disable from remembering the future. They would select the arrow of time. Note however that these factors relate to memories interpreted as learned behaviors and it is far from clear that episodic memories are such. In any case, the sensory input from the geometric future can also modify synaptic strengths.

There are two options to consider.

**Option I:** Suppose that also episodic memories reduce to the synaptic strengths as in behavioral approach. Since Ach plays a major role in the formation of memories in this sense [J117], further information about the relationship between AD with memory and precognition would be essential to design a novel and innovative technology to remember the future using specific agents selectively targeting the neural transcription factors or neurotransmitters involved in memory formation. There are numerous factors involved in the memory formation, consolidation and transformation [J136], however, because of its central role, the focus will be on Ach and AChE in this paper, for convenience.

**Option II:** In the picture based on ZEO the MB carrying dark matter bio-chemistry are in a master-slave relationship. The arrow of time is changed in BSFR at the level of MB and induces its effective change at the level of ordinary matter. The most natural reason for BSFR would be however the depletion of metabolic energy sources: during time reversed phase the subself would be able to extract energy from the environment. For this option the technology to remember the future could be rather brutal: a down-regulation of metabolic energy feed! One can however ask whether MB as the wise boss reacts to the pressures from the lower level and for critical concentrations of neural transmitters makes a BSFR changing the arrow of time.

### 10.4.3 Future perspective assuming Option I

It remains to be determined whether our inability to remember the future is a biologic limitation or a physics limitation, but it is scientifically testable. In other words, the ability or disability to re-member the future with this perspective is mostly a matter of information sufficiency or deficiency, respectively, or biologic limitation rather than a limitation imposed by physics. The hypothesis will find enormous technological applications if proves to be true. If there are no means for humans to predict the detailed future of the world, it is not because of physics per se; rather it might be because of information deficiency. Below, we propose two thought experiments to investigate a priori hypothesis

Increased precognitive dreaming following administration of AChE inhibitor (Rivastigmine) in AD patients has been reported before by de Pablos [J57, J58]; however this has not been replicated by other researchers. To investigate the correlation between AChEIs and precognitive dreaming entails meta-analyzing results on experimental dream-ESP studies carried out before.

#### Retrospective design

Independent Data sets about dream-ESP (if there are any) from previous trials that have administered AChEIs to AD patients be re-analyzed retrospectively to attempt to find out any effect from AChEIs on precognitive dreaming. Dream-ESP is defined as a form of extra-sensory perception (ESP) in which a dreaming perceiver seemingly gains information about a randomly selected target without using the logical inference or normal sensory modalities, as described before [J86].

According to the procedure described by Strom *et al* [J86], studies can be categorized into two categories: the Maimonides Dream Lab (MDL) studies, and independent (non-MDL) studies. Mean ES for both MDL dataset and the non-MDL studies should be calculated in order to find a significant or meaningful difference between the two mean values. Using a homogeneous dataset with a sufficient sample size, it is possible to yield a mean  $z$ , with corresponding Stouffer  $Z$ , to

elucidate whether dream content can be used to identify target materials correctly and more often than would be expected by chance. Also, any significant differences between: (i) three modes of ESP (telepathy, clairvoyance, precognition), (ii) senders, (iii) perceivers, or (iv) REM/non-REM monitoring can be measured. For details of the protocol see [J86].

We suggest that trials investigating AChEIs in AD patients, measure appropriate variables such as alterations in sleep architecture, EEG power spectral analysis, and quantitative EEG of rapid-eye-movement sleep to yield preliminary data for future double blinded clinical trials. Retrospective design cannot be used for investigation of causality.

### Controlled design

In a double-blind, placebo-controlled, randomized, study, sufficient sample sizes of patients with mild to moderate AD who are taking stable doses of AChEIs will be enrolled. Within 28 days prior to study drug administration, patients will be screened based on National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer's Disease and Related Disorders Association (NINCDS/ADRDA) criteria with attention to revisits [J68] for probable AD, Mini-Mental State Examination (MMSE) and Modified Hachinski Ischemic Scale (MHIS) scores, medical history, physical examination, neurological examination, vital signs, ECG, laboratory tests and response to Columbia-Suicide Severity Rating Scale (C-SSRS).

Participants will be administered standard precognitive dreaming questionnaires and will be invited to a sleep laboratory. Patients will be asked to dream about a target video they would later view. A blinded judge would rate patients' dreams against the target and decoys. Evidence for dream precognition will be recorded. The study can be accomplished with testing the hypothesis that precognitive dream experiences may occur when an AD patient subconsciously incorporates sensory information into their dream. A sound clip would be played to sleeping patients and a blinded judge would rate the target and decoy clips against the patients' dream transcripts. The correlation between degree of sensory incorporation and prior precognitive dream experience will be measured, as described before [J45].

We suggest that a combined controlled sleep laboratory study and EEG or event-related potential (ERP) indices would be instrumental in AD patients who are taking AChEIs compared with that of AD patients who are taking placebo to find out any effect of AChEIs on EEG and ERP and precognitive dreaming and a possible causal correlation between EEGs and precognitive dreaming and dream content. Cortical AChE activity will be measured in both groups and spearman correlation coefficient will be calculated between the cortical AChE, AChEI and Ach concentrations with dream content/precognitive dreaming.

Also, to test the hypothesis, it would be also useful to investigate whether AD patients who score lower on a Wechsler Memory Scale-III [J67], are more likely to have a higher report of precognitive dreaming. This is especially important in the case that AD patients *premember* an event, but cannot *remember* to report that event.

### 10.4.4 An attempt to relate Option II to biochemistry

The following arguments suggest that the findings about AD patients are consistent with Option II based on ZEO.

#### Consistency with the findings about AD patients

The following represents an attempt to understand these effects assuming **Option II** that is ZEO.

1. Acetylcholine (ACh) is a neutral transmitter involved with synaptic transitions and important for the formation of memories understood as learned associations and behaviors to be distinguished from genuine subjective memories. In TGD framework ACh promotes in a healthy brain the formation of memories basically by allowing connect axonal flux tubes temporarily to longer linear structures so that associations can form.

If the postsynaptic axon becomes dysfunctional neural processing partially fails: this is like cutting a linear chain. This could happen in AD [J52] [L129]. Nerve pulse conduction fails also if Ach is not available so that nerve pulses are not mediated over the synaptic clefts and formation of signal pathways for dark photons signals is prevented.

2. AChE promotes the decay of ACh so that it stays for a shorter time period in the synaptic contact. AChE inhibitor (AChEI) causes an opposite effect. The longer ACh lifetime is in turn expected to promote the formation of short term memories in the behavioristic sense via stronger synaptic strengths and would thus help in AD. This is true if the postsynaptic axon conducts nerve pulses. But doesn't plaque formation effectively cut the axon so that the strengthening of the synaptic connection is useless in AD?
3. If linear memories do not survive in AD due to the failure of nerve pulse conduction along the postsynaptic axons, their formation is a waste of the metabolic energy. If this is prevented, the metabolic energy could be used to form non-linear and holistic right-brain memories as 2- or 3-D structures. These memories would be subjective mental images rather than behaviors. The system behind holistic cognition might come in rescue.
4. Consider now the question of Dr. Reza Rastmanesh. It would seem that AChE could promote the transition to the mode in which holistic subjective memories dominate by shortening the life-times of ACh molecules. Even the reduction of ACh level could favor holistic cognition since ACh is useless if the postsynaptic axons are dysfunctional. AChE inhibitors would favor synaptic transmission but in AD this would not help if axon is not able to conduct. Is the transition to a holistic mood the optimal response?

But if the memories are subjective in this case, it would seem that precognition is not possible - contrary to the reported evidence including prophetic dreams!

5. This paradox disappears if the change of the arrow of time means change of the direction of nerve pulse conduction. The approximately exponential attenuation of signals along an axon with plaques would look like exponential amplification in the standard time direction, and the nerve pulse conduction could be possible! Also now neural transmitters would be needed in the synaptic transmission to connect the flux tubes to longer units.

#### **Precognitive dreams as communications of episodic memories between conscious entities having different arrows of time?**

The precognitive dreams suggest also the subjective memories of future or their analogs are possible. Self as a conscious entity can have only memories of previous experiences of subjective past and direct episodic memories of future are not possible since it does not yet exist for self.

One could perhaps overcome this restriction. Suppose that the MB of the sleeping brain has a non-standard arrow of time. Dreams could correspond to the wake-up of some part of the MB of the sleeping brain by BSFR. It would have the standard arrow of time and would contain information about the sensory mental images of the sleeping brain. Could this information be experienced as a dream? Not all dreams need be precognitive since the sensory input from geometric could come only from the interior of the CD of the sleeping brain.

## **10.5 Appendix: FQA related to the possibility of the memories of future**

In the following we will propose possible answers to some questions posed during the collaboration by Dr. Reza Rastmanesh related to the proposal that memories of the future might be possible as memories in the behavioristic sense and being induced by the non-standard arrow of time at the MB of the system.

### **10.5.1 General questions**

**Q1:** Can we have a thought experiment, by which one can prove the occurrence of time reversal in the human brain?

**A1:** ZEO implying both arrows of time can be justified by a simple thought experiment. Ordinary thermodynamics with a single arrow of time predicts heat death of the Universe since the energy flows between systems making self-organization possible die away by the second law of

thermodynamics. Life must be regarded as a thermo-dynamical fluctuation - and as it seems in cosmological scales and even characterized by evolution. This is nonsensical.

**Q2:** Most skeptics urge that precognition is not possible, could one propose some techniques by which other researchers amend or correct their methodology.

**A2:** I do not believe that proving is possible since all depends on fundamental assumptions. Experimental testing is however possible.

1. The direction for the nerve pulse conduction would change *if the arrow of time is effectively reversed for axons that in length scales about the length of or thickness of the axon*. This is a rather dramatic prediction and could explain the claimed phenomena like reverse writing [J137] and reverse speech (<http://www.reversespeech.com/words.shtml>) discussed from the TGD point of view in [K69].

I remember an article that I read a couple years ago telling that recalled episodic memories have order opposite to that for the actual events. This supports the TGD view about active memory recall.

**Remark:** Real time reversal would occur only at some layer of MB and induce an effective time reversal in shorter time scales.

2. Second prediction is that axonal potential could change sign in the effective time reversal *if it occurs in the length scale defined by the thickness of axonal membrane different from axonal length*. This kind of change of arrow of time would place also for ordinary nerve pulses so that the roles of no-pulse and pulse periods would change. This would occur for ordinary nerve pulse transition in the time scale of nerve pulse varying from ms to 100 ms but not longer scales.

**Q3:** What is the most pronounced weakness of current methodologies which fail to detect or recognize the phenomenon of bilateral time arrow in the human brain? Is it just our ontology and epistemology which is uni-biased over time and history? Is it because of our language which prohibits a bilateral arrow of time?

**A3:** The fundamental weaknesses are in the basic ontology, which postulates a fixed arrow of time already at the level of physics. Science relies on language and this might partially explain even this postulate although there is experimental evidence supporting the possibility of a non-constant arrow of time.

The basic problems of also modern physics are due to the obviously wrong (to my view) philosophical dogmas. For instance, memories are defined as changes of behavior and reduced to changes of synaptic contacts. This has nothing to do with episodic memories, memories as re-experiences about which idiot savants are an excellent example.

**Q4:** Why don't we realize that we have precognition?

**A4:** One can imagine several reasons.

1. Precognition is quite too familiar. We can predict quite well what we will do tomorrow and what the world will look like tomorrow. This is regarded as totally trivial or as an outcome of computations in the brain. It would be interesting to look whether AI can do this precognition easily.
2. Second reason is that we do not remember anything about periods with a reversed arrow of time. Sleep could be such a period and the only memories are from the state in which some brain regions have standard arrow and remaining still the reversed arrow.
3. The time reversed sensory perception would in the TGD picture give rise to memory in behaviouristic sense - not episodic memories. This would mean that synaptic strengths would change and change our behaviour. This change is not manifest to us!

**Q5:** Isn't that partially because our evolutionary biology dictated such a unilateral time arrow?

**A5:** Here I disagree. I understand with "unilateral" that the arrow of time is fixed and always same for both hemispheres always.

1. In TGD framework The period for a fixed arrow of time in atomic scales changes is very short: the average time duration between two ordinary state function reductions, lifetime of self in the atomic scale. This continual living and dying actually gives rise to thermalization.
2. Dark matter as  $h_{eff} = nh_0 > h$  phases at MB makes possible much longer time scales with fixed arrow of time and conscious entities can have long lifetimes. The lifetime depends on the level of the self hierarchy. At brain level it could be perhaps 6 hours - of the order of wake-up - or sleep period. At the higher levels of the self hierarchy it could be longer, say human life-time. At axonal level it corresponds to the duration of the nerve pulse between 1 ms and 100 ms etc.. ZEO - that is geometry of CD- allows to expect that the length scale  $L$  and time scale  $T$  of self are related by  $L = cT$ .

**Q6:** What are the possible benefits of an unilateral time arrow? Is there any way for acquisition of such experiences?

**A6:** I can answer to a question with "unilateral" replaced with "bilateral" meaning that brain hemispheres can have different arrows of time. Even more generally, subsystems of brain can have varying arrow of time. Suppose the system consists of a pair for which magnetic bodies live in opposite arrows of time at some level of self hierarchy - say brain hemispheres. This would make the system able to have geometric memories (sensory perceptions) of both past and future. Anticipation of the future would become possible besides memory and this would certainly be an evolutionary advantage. This prediction does not look so dramatic, when one realizes these memories would be memories in behavioristic sense: changes in the synaptic strengths.

**Q7:** For example, using EEG we can record the frequencies of the brain, is there any technological possibility by which in future humans can differentiate between forward arrow of time and backward arrow of time?

**A7:** Long time ago, I [Pitkänen] had long discussions with two neuroscientists - brothers Fingelkurts - living in Finland. They had observed that the EEG decomposes to segments of about 300 ms [J79] [L26]. The segments seem to have division to order and chaotic pieces. A possible interpretation would be that chaotic piece corresponds to ordinary arrow of time with dissipation causing the chaos and the order piece to opposite arrow of time in which dissipation looks like generation of coherence and order for a human observer.

**Q8:** Option II states that in the wake-up state with standard arrow of time we don't remember the future in the sense of having sensory input from it, but what about our working memory capacity and confabulation? One may argue that we may not remember the future in detail; another person may argue that this is partly because of amnesia. For example, we cannot remember the past as well, even though we have physically experienced it. We forget some true memories and experiences related to the past, we add some fake memories or experiences which never happened, we confabulate some memories that never happened, etc. The fact that we cannot remember the future, in addition to any biological advantage, maybe is partly because of limitation in our working memory capacity. In fact, there is evidence that during sleeping state, working memory is lower compared to that of wake up state [J100], and working memory span is restricted during sleep state compared to that of wakefulness [J1]. There are also inter-individual differences for example, in terms of genetic polymorphisms [J99], age [J144] or time of day [J106] from the stand point of working memory. These seemingly minor variables may partially explain why some studies of testing the implicit processing hypothesis of precognitive dream experiments have failed before [J89]. Therefore, close attention to hidden variables is necessary when designing clinical trials to test precognitive effect of any potential specific agents selectively targeting neurotransmitters involved in memory formation during sleep state.

**A8:** In the TGD framework there are two fundamental reasons for not seeing the future in detail.

1. Zero energy state as a superposition of space-time evolutions changes all the time, in each quantum jump. There is no unique objective reality nor future in classical sense. Only the changing superposition. The prediction of future given by sensory perception with a reversed arrow of time is only a prediction: it holds true only if now further acts of free will re-creating the world or part of it in 4-D sense do not occur.
2. Finite measurement resolution is the key element of adelic approach. The positive aspect of finite cognitive resolution is that it prevents us from drowning to information and selects the

most important digits. This notion has been accepted in theoretical physics but its mathematical description is primitive. In TGD adelic physics leads to a unique discretisation of space-time surface for the given evolutionary level characterised by an extension of rationals. The higher the level, the better the resolution of cognition and sensory perception.

Concerning the amnesia hypothesis.

1. We would not have episodic memories - re-experiences - at all in reverse time direction. Subjective future does not yet exist.
2. We can have sensory percepts of geometric future. They are not episodic memories. These would affect the synaptic contacts and change our behaviours: it is not easy to see changes in one's behavior and even more difficult to assign them to time reversed sensory perception! But of course, our future expectations - precognition - can dramatically affect our behavior!

About confabulation I can only propose what it corresponds in the TGD framework.

1. Confabulation is an interesting phenomenon closely related to imagination. Adelic and p-adic physics can be seen as an attempt to identify physical correlates of imagination, which is indeed confabulation in some sense. p-Adic variants of space-time surfaces are not completely deterministic and could be seen as correlates of imagination of confabulation.

In general the -adic space-time surfaces can only partially correspond to real space-time surfaces since for the latter the determinism is complete. Imaginations could correspond to p-adic space-time surfaces having only partially real counterparts. Say those representing dark photon signals from the brain or even from the MB to the sensory organ and generating virtual sensory input during REM, hallucinations, or psychedelic experiences.

2. In the case of imagination they would never reach the sensory organs and would not give sensory input. Same is true for motor actions: motor commands do not reach muscles during dreams. Imaginations are almost sensory experiences and motor actions. Sensory input strongly bounds imagination and confabulation: in think tanks the constraints are absent and the person starts to hallucinate.

**Q9:** Can you add some applications?

**A9:** Electric fields populate living systems. Both static and oscillating electric and magnetic fields are abundant in living matter. Becker [J160, J34] was one of the first researchers to realize their role for life. If the sign of an endogenous electric field assignable to organelle changes as the arrow of time changes for the corresponding layer of MB, its change might force time reversal. Oscillating electric fields would establish bio-rhythms as life-death cycles. This suggests quite science-fiction sounding applications.

1. Healing by rejuvenation could be one application. Becker *et al* found that in the cleft between wound tissue and CNS and electric potential having a sign opposite to that in the normal situation develops, and after the healing has occurred, the normal voltage is re-established [J160, J34]. Note that nerve pulse is in certain sense a wound but in a shorter scale.

Could this mean that the layer of MB associated with the wound region makes a BSFR - dies and reincarnates with an opposite arrow of time - and eventually returns to the healthy state by a BSFR? If so, external electric fields changing the sign of the appropriate voltage might be used for healing purposes [L25].

2. Healing by re-establishment of lost bio-rhythms could be a second application using oscillating external electric field or magnetic field accompanied automatically by electric field. Year ago we wrote with Dana Flavin an article [L220] about the evidence for a healing of cancer by using an extremely weak oscillating magnetic (and thus also electric) field in nanotesla range with frequency of 60 Hz, a Schumann resonance frequency but did not realize this interpretation [I85]. The interpretation could be as a re-establishment of a lost life cycle.
3. Also the production of germ cells from highly differentiated cells could be based on the time reversal and electric fields might be used to return the diseased cell population to its earlier state: somewhat like returning the computer to its earlier stage when some problem occurs.

4. Chemists Guido Ebner and Heinz Schuerch [J27] have studied the growth and morphogenesis of various organisms in presence of electric fields. 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 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 reported 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 explanation discussed in [L25] would be that the DNA serves as a kind of evolutionary archive realizing "ontogeny recapitulates phylogeny" very concretely. The presence of the electric field would stop the phylogeny by allowing the expression of an older variant of the genome. A more abstract realization would be that the genome experiences phylogeny during ontogeny. The application of an electric field with a proper sign and magnitude could stop the ontogeny to an earlier stage.

One could even imagine changing the arrow of geometric time and producing earlier evolutionary variants of a simple organism or organelle by using electric field: the strength of the electric field needed might relate to that prevailed during the earlier evolutionary stage.

Second application could be a creation of artificial life. Also the relationship to AI is highly interesting. Electronic circuits involve both energy feed as a counterpart of metabolic energy feed, they involve electric and magnetic fields, and also resonance frequencies. This makes self-organization possible and even a self-sustaining situation in which the system experiences a sequence of life-death cycles can be considered.

1. The findings about simple systems having life-like properties involve typically an oscillating electric or magnetic field. One such system consists of plastic balls [I44]: the TGD inspired model for the system is discussed in [L94].
2. It would be interesting to arrange a coupling to the MB of Earth by using Schumann resonance frequencies and by the cyclotron frequencies in endogenous magnetic field  $B_{end} = 2/5 B_E$  explaining the findings of Blackman and others [J47] ( $B_E$  denotes Earth's magnetic field) so that the MB of Earth could become the boss. Plasma structures would be also ideal candidates for living systems and bio-matter is indeed a cold plasma. Ball lightning would be one example about a plasmoid as a primitive life-form.
3. The manipulation of bits induces changes of the electric and magnetic fields and there are oscillating electric fields present such as the computer clock. If MB is involved actively, this could give rise to a living system having even its own intentions and free will. Note however that the MB in questions would be most naturally that of the user! Can one build a computer whose personal MB takes the lead? It might be that the computer is living in some sense which is even related to the program running in it.

### 10.5.2 More questions about the arrow of time

**Q1:** We have to mention energy cost of memory, in its broad meaning (either one considers memory from the standpoint of reductionism and molecular or episodic memory. Also, the issue of memory erasure should be at least briefly discussed or at least mentioned).

**A1:** Creating memories requires an increase of  $h_{eff}$  and keeping it -  $h_{eff}$  tends to decrease by emission of energy. This is why all life requires metabolic energy. Also memory mental images require metabolic energy to survive. They can get it from environment as usual or if not, they can die and reincarnate with opposite arrow of time and later do this again in the original time direction. Very elegant!

Memory erasure tends to take place spontaneously in ZEO. Mental images die if they do not get metabolic energy feed. In BSFR a large fraction of mental images sub-CD associated with active half of CD disappear since the size of CD decreases in BSFR: this means that new self has

childhood and gets rid of the often negative Karma carried by mental images of the later life which is often painful and filled with unpleasant memories. This also means erasure of unpleasant mental images and liberating also metabolic energy usable by the re-incarnate.

**Q2:** So, I understand that you are not happy with the behavioristic point of view in this regard. It is OK, however, you have to justify and explain this with an alternative approach. One can represent this as a question. What is the relationship between the behavioristic and TGD views about memories?

**A2:** Behavioristic picture describes behaviors and learning of them, not episodic memories.

In TGD all memories as re-experiences (also in symbolic form) correspond to earlier mental images created by say sensory input and continuing to shift towards geometric future inside increasing CD and experiencing re-incarnations. If the memory mental images has the same arrow of time as self, self experiences it as memory mental image.

In TGD the generation of *symbolic* memories as modulations of Josephson radiation frequencies by nerve pulses would correspond to their generation at MB by EEG and its possibly existing fractally scaled up variants as mental images consisting of resonance peaks when the modulated frequency equals to cyclotron frequency of flux tube for some charged particle.

The time scale of the memory is proportional to  $\hbar_{eff}$ . Long term memories correspond to rather large values of  $\hbar_{eff}$  and to very large layers of MB. The time span of long term memories directly measures the universal IQ as  $\hbar_{eff}$  and time and spatial scales of quantum coherence. No memories without dark matter.

In ZEO episodic memory recall would naturally correspond to dark photon signals propagating along closed flux loops back to the brain waking up memory sensory mental images - I almost said "in the brain of the geometric past" but actually it is the brain of geometric future, where the sensory mental images shift during sequences of SSFRs as CD increases and its upper part shift to the direction of future. When one sends a signal waking up the memory mental images, the latest memory mental images wake up first as the mentioned article claims.

**Q3:** LTP or long-term potentiation means that if an action and or event etc. is repeated, systemic brain and/or neural network and/or a single neuron learn it, and afterwards, cost lesser energy and consume less time to be remembered and/or summoned or practiced. How can one understand LTP?

**A3:** Nerve pulse patterns create temporary flux tube networks with flux tubes assignable to axons. Dark photons as carriers of the signals propagate along these. Nerve pulse generation costs metabolic energy. LPT means that the more often the network is created, the easier it is to create it again. This is learning of a habit, not episodic memory.

How to understand LPT in ZEO? Does this living network learn to get the energy needed by nerve pulse patterns by making partial transitions to opposite arrow of time - also nerve pulse is such - making possible extracting it from the environment rather than passively waiting to get it. ZEO would allow the network to become self-sustaining. A habit would develop.

**Q4:** What about the durations of wake and sleep (ordinary arrow of time and reverse arrow of time): are they equal or not?

**A4:** The durations of wake and sleep depend on "individual" and depend on the metabolic use: if I use a lot of metabolic energy, I get tired in shorter time and must sleep.

Time reflection is an approximate geometric symmetry of TGD and slightly violated. If the thermo-dynamical reversal of the arrow of time, call it  $T_{th}$ , corresponds to  $T$ , one can guess that the periods of wake-up and sleep are approximately equal as it seems to be the case in our case. One must be however careful here. There is a rather dramatic violation of  $CP$  and therefore  $T$  since matter dominates over antimatter in the Universe.

Does one really have  $T_{th} = T$ ? The dark variant of genetic code [L130] is represented by dark proton sequences with 3-protons defining a codon.  $T_{th} = T$  would replace protons with antiprotons. This cannot be the case. The assumption is indeed that the change of arrow of time changes roles of the boundaries of CD and those of fermionic creation and annihilation operators and  $T_{th} = T$  is not true.

**Q5:** What the addition of MB means from the point of view of metabolism? What about the metabolism during sleep and wake-up?

**A5:** The presence of MB means additional sink of metabolic energy. "Getting tired" means that metabolic energy resources deplete. Whose? BB or MB or both?



1. TGD predicts that generalized Josephson radiation from neuronal membranes in EEG range communicates sensory input to the MB [L6, L10]. This happens during wake-up state but not during sleep.

The flux tubes associated with the Josephson junctions accompanying the lipid membrane-membrane proteins, ion channels and pumps act as sending antennas for dark photons during daytime: what is sent is both sensory information and energy to appropriate parts of MB. The frequency of the generalized Josephson radiation would sum formed from the difference of cyclotron frequencies and ordinary Josephson frequency  $f = ZeV/h_{eff}$ , where  $V$  is membrane potential and giving rise to frequency modulation coding nerve pulse activity representing sensory input. The dark photons at MB would resonantly excite the cyclotron states at flux tubes of the large layers of MB, which would eventually decay and emit dark photon radiation.

Control actions of MB could occur via the dark variant [L130] of genome realized as sequences of dark proton triplets representing codons and activating the gene expression. Motor actions are assumed to correspond to BSFRs changing the arrow of time for the flux tubes involved. This means that the control signals could actually extract energy from BB. No energy storage at MB would be needed.

For the simplest option the only new energy storages would be in the length scales of BB and assignable to the cell membrane and genome and identifiable as cyclotron Bose-Einstein condensates analogous to a population inverted laser. For the cell membrane energy storages would be associated with the flux tube portions at the two sides of the cell membrane. For the genome they could be magnetic flux tubes of the dark genome with codons realized as dark proton triplets and accompanying DNA.

During the wake-up both these energy storages would be depleted by sensory activities and during sleep they would be recharged.

2. The EEG bands above 10 Hz assigned with wake-up state are absent during sleep so that in these bands the energy transfer to MB would occur only during wake-up. The EEG frequencies present during sleep state would correspond to some kind of sensory input to some parts of MB and corresponding motor response. During sleep MB would be awake in longer scales than during wake-up periods.

The challenge of BB is to build these population inverted lasers during sleep - magnetic flux tubes containing charged particles in excited cyclotron states. Dark photon radiation must do this. Where could it come from? Certainly from the molecules responsible for metabolic energy storage but how?

1. Dark photons transform to bio-photons and induce molecular transitions: this makes possible for MB to control the biochemistry.
2. The chemically stored metabolic energy should be transformed to the energy of Bose-Einstein condensates: the energy of these molecules stored to their bonds would be liberated as they return to less energetic states as photons transformed to dark photons.
3. How could this happen? Here ordinary metabolic mechanism would be at work with produced photons transforming to dark photons unless they are dark enough already (increase of  $h_{eff}$  might be required). I have proposed that one has  $h_{eff} = nh_0 > h$  for the valence bonds and  $h_{eff}$  increases towards the right end of the rows of the Periodic Table containing atoms appearing in metabolite molecules [L92]. Molecular transitions during molecular catabolism liberating energy would generate photons and they could be transformed to dark photons with some rate and excite B-E condensates accompanying the Josephson junctions.

By the fractality of the TGD Universe, a similar mechanism is expected to be a work for ordinary cells but in a scaled wavelength range since the value of  $h_{eff}$  is expected to be smaller by the lower evolutionary level: the analog of EEG would be at scaled-up frequency range.

The experimental situation is not yet settled.

1. The mainstream opinion seems to be that the metabolism during sleep is considerably lower than during wake-up. On the other hand, the reduction of energy metabolism during sleep is reported to be surprisingly small [J59]. This would conform with the proposed view about the population inverted cyclotron B-E condensates as an additional energy storage needed by MB.
2. The summary of the introduction [J59] suggests that during NREM sleep the oxidation of glucose is to a some extent replaced by the oxidation of fatty acids and ketone bodies. This would allow roughly similar metabolic rates during sleep and wake-up. The natural guess is that the metabolic energy from these processes is used to excite cyclotron B-E condensates.

According to [J59] the catabolism of glucose and glycogen via aerobic pathway is a hallmark of wakefulness, whereas the transition to sleep is marked by decreased brain lactate levels due to decreased production as well as increased glymphatic clearance. The rise in the oxygen-glucose index during sleep would not be due to a reduced aerobic glycolysis, i.e. more lactate oxidation, but rather to a shift towards utilization of fatty acids and ketone bodies as metabolites.

According to the same reference, the FFA passing from circulation to the brain supports ATP production via mitochondrial  $\beta$ -oxidation ( $\sim 60$  per cent). Astrocytes are the primary cell type carrying out fatty acid oxidation and ketogenesis in the brain, whereas the concurrent ketosis probably occurs in neurons. The increased plasma levels of FFAs during sleep probably support the metabolic shift to lipid metabolism compared with normal wake-up state.

Why this shift? The oxidation of glucose and glycogen are fast processes needed by neural activities occurring in a millisecond time scale and would be naturally used during wake-up periods. Oxidation of fatty acids and ketone bodies are slower processes and could be used to replenish the metabolic energy reservoirs utilized during wake-up to the communications of the sensory data to and control responses by MB. During sleep the time scale for the sensory communications to and control responses by MB at slow EEG waves is a considerable fraction of second and the same energy source could be used.

3. In [J59] glucose and lactate levels are reported to be somewhat similar during REM sleep and waking. The levels are the same for some regions of the brain. The partial wake-up of the MB force wake-up of the brain inducing ordinary metabolism in these regions.

Note that there is empirical evidence that the brain effectively obeys hyperbolic geometry [J75]. The functionally similar neurons in the brain are close to each other in a statistically determined hyperbolic geometry. In the TGD framework the effective hyperbolic geometry could be naturally assigned as a real geometry to the MB of the brain [L178]. The neurons which are functionally similar but possibly far away from each other would send their information along flux tubes to the same part of MB and be near to each other in the hyperbolic geometry. The synchronously firing neurons scattered around the brain and using glucose oxidation could correspond to a region assignable to a mental image corresponding to a connected region of MB.

**Q6:** Can one formulate these questions within the frame of brain waves (EEG) during wake and sleep? I mean to mention REM and propose some explanations or some answers or some hypotheses do we expect that precognition entails energy cost? Or not?

**A6:** Ordinary memory recalls require metabolic energy to wake-up memory mental images. Metabolic energy for memory recall by time reversed self looks like a liberation of energy in the standard time direction.

But these memories should be communicated to the self with opposite arrow of time! How? The memory mental images of self with opposite of arrow time can also die and re-incarnate with our arrow of time giving rise to dreams: this would require metabolic energy from our view point. When self forgets, the self with the opposite arrow of time remembers! Dreams and precognition would thus require metabolic energy.

The electromagnetic signals generated by the earthquakes could explain the ability of the native people to predict them several hours before their occurrence. There are also indications

that the perception of different electromagnetic signals impending to an earthquake do not cost any ATP in animals: rather there is possibility that extremely low frequency oscillations (10–70 Hz) may even enhance ATP synthesis during the earthquake in mammals [J108].

The time reversed signal from the geometric future would generate a sensory mental image - sub-self - of the time reversed self. With respect to the arrow of time of the observer this process would liberate energy as the observations indicate. To become an observer's mental image, this sub-self must experience a BSFR. From the observer's point of view this requires metabolic energy. These two contributions to the energy costs are of opposite sign and could also sum up to negative.

**Q7:** If not, can we consider that the reverse arrow of time is accompanied with negentropy or negative entropy? Why? i.e. if all reverse arrow of time memories or precognitions of the future should correspond with negentropy?

**A7:** Generalized form of the second law applies to subjective time and states that the entropy increases with respect to the subjective time always. It increases also in the reverse arrow of time but to us in wake-up state it looks like decrease: as if negentropy were generated. For us the system indeed seems to develop ordered structures, to self-organize - rather than losing them as ordinary second law would dictate. Self-organization can be forced by feeding energy to the system or system can have subsystems with non-standard arrow of time extracting energy from the external world by dissipating. This could be a self-sustaining order. It might relate to self-organized criticality which is a concept not well-understood. Systems are able to stay around critical state, which conflicts intuitive picture. TGD Universe is actually quantum critical.

**Q8:** What about dreams that already happened in our life and we already have experienced them? For example, consider that Person A has divorced his life two years ago at 2018. On 2020, He may have dreamt that he has divorced his wife. Does such a situation entail an energy cost? The energy is not important per se here, but the physical meaning of such a question is of worth for future implications.

**A8:** If dreams are wake-up of some regions of the sleeping brain creating mental images then they require metabolic energy.

## Chapter 11

# TGD View about Language

### 11.1 Introduction

This chapter has been written together with Reza Rastmanesh, who proposed the topics of the article leading to this chapter. Human languages differ dramatically from their analogs for animals. Animal languages consist mainly of simple signals, warnings and threats for instance; emotional expression dominates and grammar is lacking. Birds can have impressive repertoire of different song patterns and monkeys have gesture language.

There is a huge variety of human languages: speech and written language, sign languages based on gestures, the language of mathematics and computer languages in which emotional expression is absent. One can also regard music as a kind language expressing emotions and creating them. Also pictures define linguistic representations. Children and animals learn language by mimicry and also learn the grammar and syntax without conscious efforts. Adults can learn a foreign language by learning the vocabulary and the rules of grammar. Human language is also special in that it involves conceptualization, metaphors, and analogies representing abstract concepts in terms of objects and actions of the external world.

One might understand the semantic aspect of language in terms of association and conditioning. Language acquisition involves showing the object and saying the word describing it. This suggests that conditioning and association happens so that mere word generates an imagined percept of the object. Conditioning and formation of associations is a very general form of learning assumed to relate to the increase of synaptic strengths leading to a generation of association pathways. In computer science pattern recognition and completion models it mathematically. One can ask whether the learning of language and language understanding is something more than this.

For more detailed approaches of language theories, interested readers may be referred to references [J139, J150, J146, J178]. The article of Kempe and Brooks [J176] and the review article "From Molecule to Metaphor: A neural theory of language" about the language theory of Jerome A. Feldman by Stefan Frank [J165] gives a deeper perspective to language theories. The notion of embodiment is in key role in these theories and will be in a key role also in the proposal to be discussed.

#### 11.1.1 About language genes

Forkhead box protein P2 (FOXP2) encodes a transcription factor involved in language acquisition and speech [J66]. In addition to FOXP2 a limited number of genes are involved in speaking [J93]. All vertebrates possess FOXP2, however it is estimated that some 120,000-200,000 thousand years ago, some mutations occurred only in humans which aided humans to start initial forms of speaking [J139]. Animals have their own primitive language; both voices and gestures with meaning make communications possible. They mainly recognize each other and communicate with pheromones. As for vocabulary, a short review of the Old Testament, cuneiform writings, glossary of old books, and hieroglyphs clearly shows that the number of entries was quite limited in the past. Therefore, a further progression of language could be almost a matter of cultural communications and technological advances.

However, today it is clear that crucial mutations occurred in the non-coding part of the genome controlling the expression of genes coding for proteins [J93] which lead to language evolution. Therefore, the evolutionary step was associated with control of existing genes. Humans are also distinguished from animals by their learning abilities.

Language acquisition must rely on conditioning/associations between language expressions and experiences. It seems that embodiment is the mechanism, which associates to a linguistic expression an imagined sensory percept and/or motor action making the emergence of meaning. What is needed is long term memory and also some kind of standardization of percepts so that they consist of standardized mental images. Pattern recognition and completion could give this standardization.

Since sensory and motor imagination could be seen as almost sensory experiences and almost motor actions, this suggests that new communications between auditory organs and sensory and motor areas emerged. Even more generally, this kind of communication could have emerged quite generally. This would be essentially a new form of conditioning and the same mechanism could apply to all kinds of conditionings.

### 11.1.2 How the mutation of only a few genes led to cultural evolution?

Amazingly, only a few mutations for relatively few genes seems so have led to human languages. Why few point mutations of relatively few genes could have transformed biological evolution to cultural evolution? What happened for these genes? In the biochemistry framework it is difficult to imagine an answer to this question. Here TGD could come in rescue.

Number theoretic physics is part of quantum TGD and essential for understanding evolution as an increase of algebraic complexity. Evolutionary hierarchies would correspond to hierarchies of algebraic extensions of rationals. The dimension  $n$  of extension defines effective Planck constant  $h_{eff}/h_0 = n$ , the larger the dimension, the larger the scale of quantum coherence at corresponding level of magnetic body (MB) associated with the system. One can also say that  $n$  is analog of IQ. One can assign a value of  $h_{eff}$  characterizing their evolutionary level also to genes. The genes with larger  $h_{eff}$  would serve as control genes. The increase of  $h_{eff}$  for genes would mean an evolutionary step. Perhaps a dramatic increase of  $h_{eff}$  occurred to FOXP2 and some other genes as human language emerged.

Second mechanism could be energy resonance in the coupling of the analogs of DNA, RNA, tRNA, and amino acids consisting of dark proton triplet with their chemical counterparts. The coupling would be between the entire gene and its dark analog and codon sequence would play a role of address. In both cases small changes of the gene could spoil or produce an energy resonance. This sensitivity would make genes an ideal control tool but would also serve as a general mechanism also for genetic diseases. The increase of  $h_{eff}$  accompanied by a small mutation to guarantee energy resonance could be the mechanism explaining the importance of FOXP2 and similar control genes.

**Note:** This chapter was prepared in collaboration with Dr Reza Rastmanesh who provided a lot of biological and neuroscientific knowhow and made inspiring questions.

## 11.2 Number theoretical aspects of quantum biology

The basic ideas about consciousness and life are discussed in Appendix. Here the aspects relevant for the recent work are discussed.

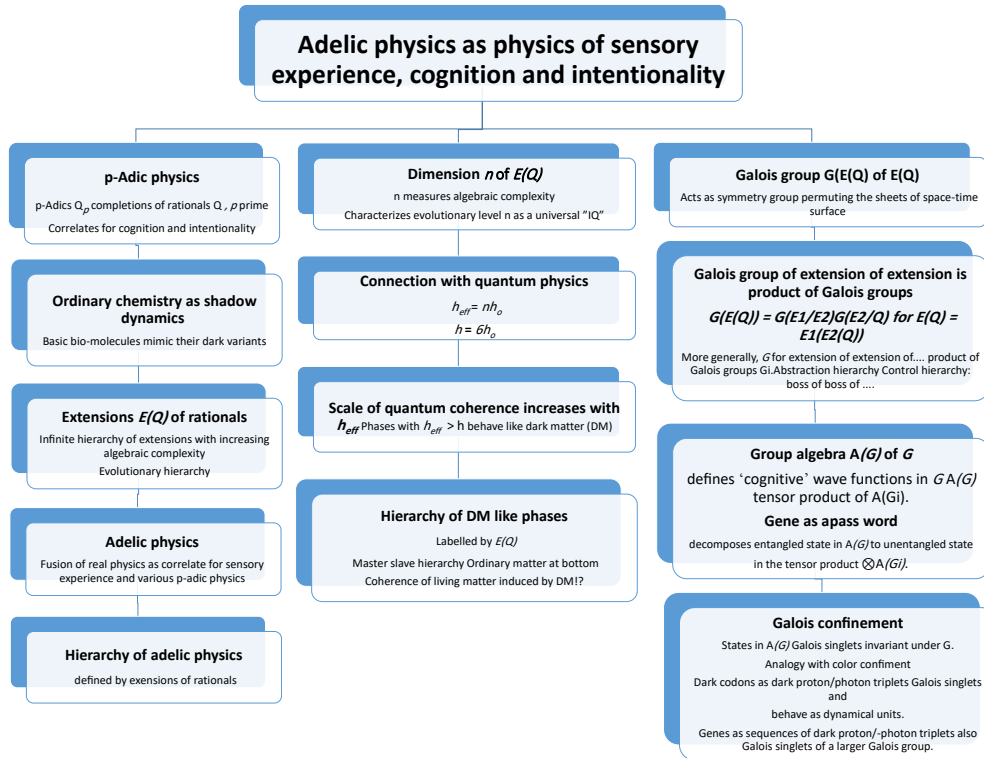
**Fig. 11.1** summarises the role of number theory in the TGD inspired vision concerning consciousness, cognition, and quantum biology and **Fig. 11.2** the role of dark matter in TGD inspired quantum biology.

### 11.2.1 Dark proton representation of genetic code

**Fig. 11.3** summarizes the TGD based vision about genetic codes.

#### Codons as dark nucleons?

The model for codons of genetic code emerged from the attempts to understand water memory [?] The outcome was a totally unexpected finding [?] the states of dark nucleons formed from three



**Figure 11.1:** Adelic physics as physics of sensory experience, cognition and intentionality

quarks connected by color bonds can be naturally grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, 20 amino acids, and tRNA and there is natural mapping of DNA and RNA type states to amino acid type states such that the numbers of DNAs/RNAs mapped to given amino acid are same as for the vertebrate genetic code.

The basic idea is simple. The basic difference from the model of free nucleon is that the nucleons in question - maybe also nuclear nucleons - consist of 3 linearly ordered quarks - just as DNA codons consist of three nucleotides. One might therefore ask whether codons could correspond to dark nucleons obtained as open strings with 3 quarks connected by two color flux tubes or as closed triangles connected by 3 color flux tubes. Only the first option works without additional assumptions. The codons in turn would be connected by color flux tubes having quantum numbers of pion or  $\eta$ .

This representation of the genetic would be based on entanglement rather than letter sequences. Could dark nucleons constructed as a string of 3 quarks using color flux tubes realize 64 DNA codons? Could 20 amino acids be identified as equivalence classes of some equivalence relation between 64 fundamental codons in a natural manner? The codons would not be separable to letters but entangled states of 3 quarks anymore.

Genetic code would be defined by projecting DNA codons with the same total quark and color bond spin projections to the amino acid with the same (or opposite) spin projections. The attractive force between parallel vortices rotating in opposite directions serves as a metaphor for the idea. This hypothesis allows immediately the calculation of the degeneracies of various spin states. The code projects the states in  $(4 \oplus 2 \oplus 2) \otimes (5 \oplus 3)$  to the states of  $4 \times 5$  with the same or opposite spin projection. This would give the degeneracies  $D(k)$  as products of numbers  $D_B \in \{1, 2, 3, 2\}$  and  $D_b \in \{1, 2, 2, 2, 1\}$ :  $D = D_B \times D_b$ . Only the observed degeneracies  $D = 1, 2, 3, 4, 6$  are predicted. The numbers  $N(k)$  of amino acids coded by  $D$  codons would be

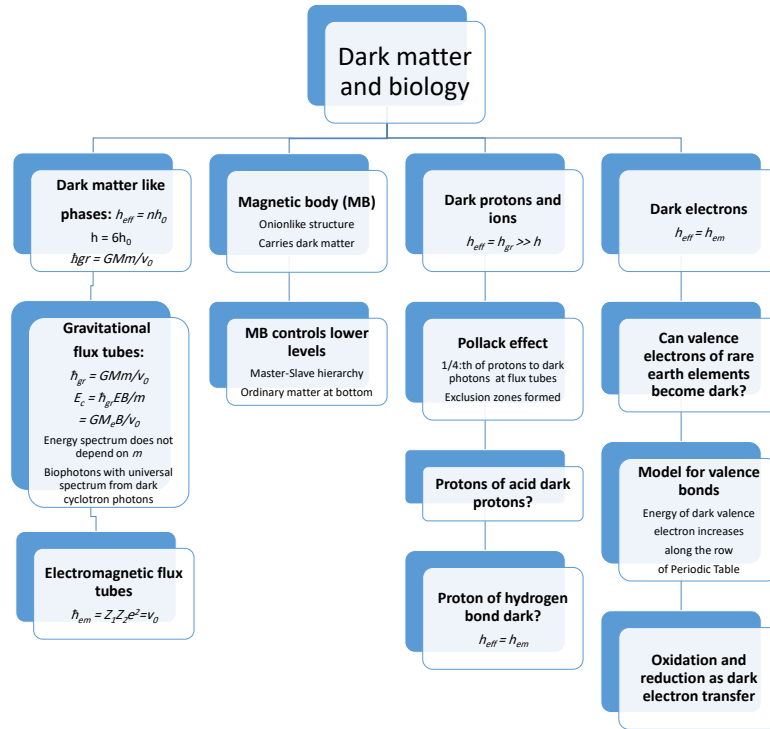


Figure 11.2: Dark matter in TGD inspired quantum biology

$$[N(1), N(2), N(3), N(4), N(6)] = [2, 7, 2, 6, 3] .$$

The correct numbers for vertebrate nuclear code are  $(N(1), N(2), N(3), N(4), N(6)) = (2, 9, 1, 5, 3)$ . Some kind of symmetry breaking must take place and should relate to the emergence of stopping codons. If one codon in the second 3-plet becomes stopping codon, the 3-plet becomes doublet. If 2 codons in 4-plet become stopping codons it also becomes doublet and one obtains the correct result  $(2, 9, 1, 5, 3)$ !

### Codons as dark proton triplets?

The model of codon as dark nucleon predicts analogs  $\Delta$  resonances whose masses differ from those of nucleons.

The hint comes from the fact that DNA nucleotides have a negative charge, which is problematic from the point of view of DNA stability. This suggests that dark codons should have a charge of 3 units screening the charge of the ordinary DNA codon. Pollack effect [?] means formation of negatively charged exclusion zones as protons are transferred to dark protons at magnetic flux tubes. Could DNA be formed by Pollack effect? Could codons be represented as dark proton triplets?

The problem is that protons however have only 2 spin states: 4 states would be needed as in the case of quarks having also color. Where could the counterparts of spin and color come from?

One could consider adding a neural pion-like and/or  $\rho_0$  meson-like bond connecting neighboring protons. Since  $\rho_0$  has spin 1, this would give  $1+3=4$  states per bond. However, 2 states are enough and one must get rid of 2 states. The string-like structure of the proton triplet

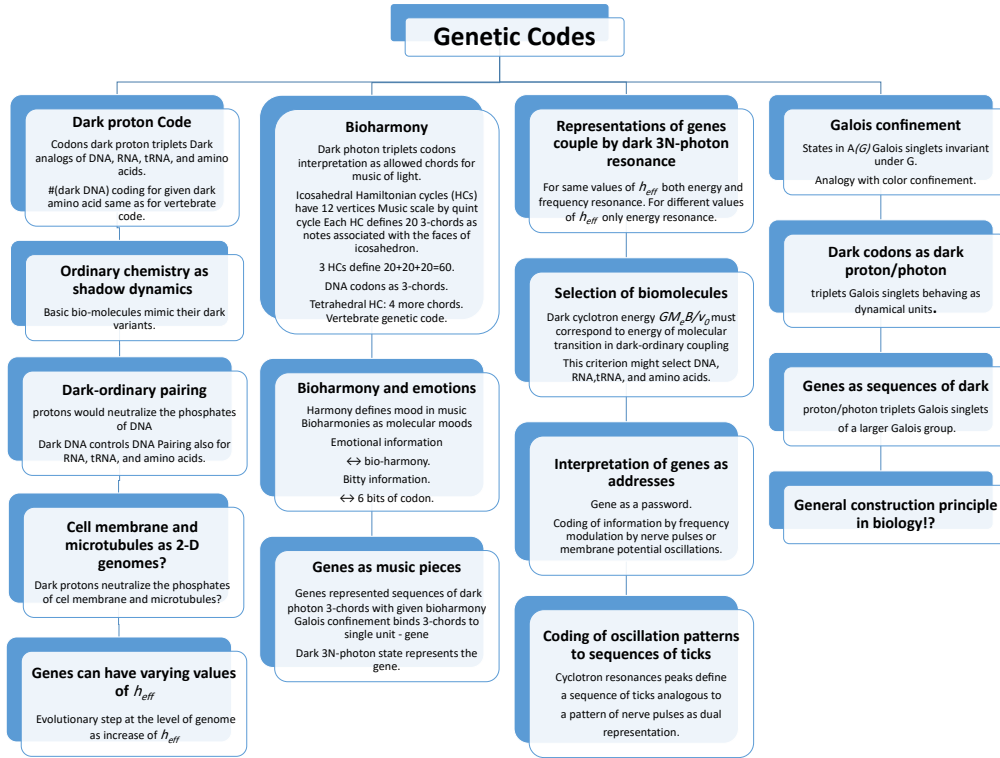


Figure 11.3: Genetic codes in TGD framework

suggests that the rotation group reduces to  $SO(2) \subset SO(3)$  so that  $\rho$  meson states split into singlets with helicities 0,1,-1. The doublet (-1,1) would serve as the analog of the isospin doublet (u,d) for baryons and enough to achieve a correct effective number  $N = 4$  of states per single DNA codon. Helicity would replace isospin and the tensor product states could be constructed effectively as tensor products of 3 representations  $2 \otimes 2$ .

There is also an issue related to the fermionic statistics. Protons are fermions and the total wave function for them must be antisymmetric. For baryons color singlet property allows this. Can one require statistics in the ordinary sense also now? Or could the effective 1-dimensionality of the magnetic flux tube allow braid statistics?

The following variant gives good hopes about the ordinary statistics.

1. Adelic physics [?]rings in additional discrete degrees of freedom assignable to the group algebra of Galois group of extension of rationals inducing the extensions of p-adic number fields appearing in the adele [?]
2. Galois group acts on the space of space-time surfaces, and one can say that one has wave function at the orbit of the Galois group consisting of space-time sheets. At quantum level quantum states correspond to wave functions in the group algebra of Galois group of extension.
3. The role of color degrees of freedom in helping to achieve correct statistics in the case of baryon could be taken by Galois degrees of freedom. One can even consider the notion of Galois confinement as a generalization of color confinement [?]inding codons as dark proton triplets to dynamical units. Codons should be antisymmetric under exchange of dark



protons in Galois degrees of freedom. Also genes as sequences of codons could be bound to dynamical units as Galois singlets. Could this allow ordinary statistics.

If this picture is correct, genetic code would be realized already at the level of dark nuclear physics or even at the level of ordinary nuclear physics if the nuclei of ordinary nuclear physics are nuclear strings. Chemical realization of genetic code would be induced from the fundamental realization in terms of dark nucleon sequences and vertebrate code would be the most perfect one. Chemistry would be a kind of shadow of the dynamics of positively charged dark nucleon strings accompanying the DNA strands and this could explain the stability of the DNA strand having 2 units of negative charge per nucleotide. Biochemistry might be controlled by the dark matter at flux tubes.

### 11.2.2 Bio-harmony as a realization of genetic code

TGD leads to a notion of bio-harmony in terms of icosahedral and tetrahedral geometries and 3-chords made of light assigned to the triangular faces of icosahedron and tetrahedron [L39, L40, L156]. The surprise was that vertebrate genetic code emerged as a prediction: the numbers of DNA codons coding for a given amino acid are predicted correctly. DNA codons correspond to triangular faces and the orbit of a given triangle under the symmetries of the bio-harmony in question corresponds to DNA codons coding for the amino acid assigned with the orbit.

Codon corresponds to 6 bits: this is information in the usual computational sense. Bio-harmony codes for mood: emotional information related to emotional intelligence as ability to get to the same mood allowing to receive this information. Bio-harmony would be a fundamental representation of information realized already at molecular level and speech, hearing and other expressions of information would be based on it. For emotional expression at RNA level possibly involved with conditioning at synaptic level see [L113].

Does the generation of nerve pulse patterns by a gene mean at the cell membrane from dark DNA to dark protein map to dark protein (it could be also dark RNA or dark DNA even) associated with the cell membrane. What about communications with RNA and enzymes involved with transcription and translation. Do all basic biocatalytic processes involve them.

What about a generalization of Josephson currents? Dark ions certainly define them but could also dark proton triplets and their sequences associated with proteins give rise to oscillating Josephson currents through cell membrane and therefore to dark Josephson radiation with  $3N$  dark photon units! Proteins themselves need not move much!

The universal language could be restricted to the genetic code which would be realized by dark proton triplets. The 64 codons are formed from 3 20-chord harmonies associated with icosahedron and the unique 4-chord harmony associated with tetrahedron. Bio-harmonies are associated with the so-called Hamiltonian cycles, which go through every vertex of Platonic solid once. For icosahedron the number of vertices is 12, the number of notes in 12-note scale.

Also tetrahedron, cube, octahedron and dodecahedron are possible and one can consider the possibility that they also define harmonies in terms of Hamiltonian cycles. Dodecahedron would have 5-chords (pentagons as faces) as basic chords and there is only single harmony. Same mood always, very eastern and enlightened as also the fact that scale would have 20 notes.

Also octahedron gives 3-chords (triangular faces) whereas cube gives 4-chords (squares as faces). One can of course speculate with the idea that DNA could also represent this kind of harmonies: sometimes the  $3N$  rule is indeed broken, for instance for introns.

Galois confinement [L174] allows the possibility to interpret dark genes as sequences of  $N$  dark proton triplets as higher level structures behaving like a single quantal unit. This would be true also for the corresponding dark photon sequences consisting of  $3N$  dark photons representing the gene in bio-harmony as an analog of a music piece consisting of 3-chords and played by transcribing it to mRNA.

The picture can be viewed even more generally. Any discrete structure, defining graph, in particular cognitive representation providing a unique finite discretization of space-time surface as points with the coordinates of the 8-D embedding space coordinates in the extension of rationals, defines harmonies in terms of Hamiltonian cycles. Could also these harmonies make sense? The restrictions of the cognitive representations to 2-D partonic 2-surfaces would define something

analogous to bio-harmony as Hamiltonian cycle of 2-D graph (Platonic surfaces solids can be regarded as 2-D graphs). The interpretation as representations of Galois groups and the notion of Galois confinement is possible although one loses the symmetries of the Platonic solids allowing to identify genetic code.

### About the details of the genetic code based on bio-harmony

TGD suggests several realizations of music harmonies in terms of Hamiltonian cycles representing the notes of music scale, most naturally 12-note scale represented as vertices of the graph used. The most plausible realization of the harmony is as icosahedral harmony [L31] (see <http://tinyurl.com/yad4tqwl> and <http://tinyurl.com/yyjpm25r>).

1. Icosahedron (see <http://tinyurl.com/15sphzz>) has 12 vertices and Hamiltonian cycle as a representation of 12-note scale would go through all vertices such that two nearest vertices along the cycle would differ by quint (frequency scaling by factor  $3/2$  modulo octave equivalence). Icosahedron allows a large number of inequivalent Hamiltonian cycles and thus harmonies characterized by the subgroup of the icosahedral group leaving the cycle invariant. This group can be  $Z_6$ ,  $Z_4$ , or  $Z_2$  which acts either as a reflection group or corresponds to a rotation by  $\pi$ .
2. The fusion of 3 icosahedral harmonies with symmetry groups  $Z_6$ ,  $Z_4$  and  $Z_2$  gives  $20+20+20=60$  3-chords and  $3+1+5+10=19$  orbits of these under symmetry group and almost vertebrate genetic code when 3-chords are identified as analogs of DNA codons and their orbits as amino acids. One obtains counterparts of 60 DNA codons and  $3+1+5+10=19$  amino acids so that 4 DNA codons and 1 amino acid are missing.
3. The problem disappears if one adds tetrahedral harmony with 4 codons as faces of tetrahedron and 1 amino acid as the orbit of the face of tetrahedron. One obtains 64 analogs of DNA codons and 20 analogs of amino acids: this harmony was coined as bio-harmony in [L39, L40]. The predicted number of DNA codons coding for given amino acid is the number of triangles at the orbit of a given triangle and the numbers are those for genetic code.
4. How to realize the fusion of harmonies? Perhaps the simplest realization found hitherto is based on the union of a tetrahedron of 3 icosahedrons obtained by gluing tetrahedron to icosahedron along its face which is a triangle. The precise geometric interpretation of this realization has been however missing and some possibilities have been considered. The model could explain the two additional amino acids Pyl and Sec appearing in Nature [L39, L40] as being related to different variant for the chemical counterparts of the bio-harmony.

There is also a slight breaking of symmetries: ile 4-plet breaks into ile triplet and met singlet and trp double breaks into stop and trp also leu 4-plet can break in leu triplet and ser singlet (see <http://tinyurl.com/puw82x8>). This symmetry breaking should be understood.

### Cell membrane and microtubules as a higher level representation of genetic code?

Also the representation of genetic code at the level of cell membrane can be considered [L130]. This kind of proposal have been made with different motivations by Okecukwu Nwamba [I63]. The motivation for the current proposal is that the lipids have at their ends negatively charged phosphates just as DNA nucleotides have. The generalization of DNA as a 1-D lattice like structure to a 2-D cylindrical lattice containing nucleotide like units - letters - possibly assignable to lipids and realized as dark protons. Single lipid could be in the role of ribose+nucleotide unit and accompanied by a neutralizing and stabilizing dark proton. For axons one would have cylindrical lattice dark DNA lattice. The two lipid layers could correspond to two DNA strands: the analogs of the passive and active strand.

The finding is that membrane affects protein's behavior. This would be understandable in the proposed pictures 2-D analog of 1-D nucleotides sequences with codons replaced with counterparts of genes as basic units. That lipids are accompanied by phosphates with charge -1 gives the hint. Phosphate charge is neutralized by a dark proton as an analog of a nucleotide.

The notion of Galois confinement identifying genes as units consisting of  $N$  dark proton triplets representing genetic codons suggests that genes possibly assignable to the lipid layers of

the cell membrane could communicate using dark  $3N$ -photon sequences with the proteins, genome, RNA and DNA. Dark variants of the control genes could initiate a nerve pulse pattern. An interesting possibility is that ganglions, nucleus like structures assignable to sensory organs and appearing as basal ganglia in brain [138] (<https://cutt.ly/zfWoBFt>) could communicate with genes.

Also microtubules have GTPs with charge -3 bound to tubulins. In dynamical instability known as treadmilling the transformation of  $GTP \rightarrow GDP$  bound to  $\beta$  tubulin by hydrolysis induces the shortening of the microtubule at minus end whereas the addition of tubulins bound to GTP induces the growth at plus end. Also actin molecules bound to ATP show a similar behavior. Could they be accompanied by dark DNA codons? Are all codons allowed or does the absence of XTP, X= T,C,G mean that only codons of type GGG would be present?

For the dark codons for the cell membrane the p-adic length scale  $L(151) \simeq 10^{-8}$  m would correspond to the lipid's transversal size scale and would be the distance between the dark protons. The scale of dark nuclear energy would be proportional to  $1/L(151)$  and scaled down by factor  $\sim 10^{-3}$  from that for DNA. The energy scale should be above the thermal energy at room temperature about .025 eV. If the energy scale is 2.5 eV (energy of visible photon) for DNA, the condition is satisfied. Note that 2.5 eV is in the bio-photon energy range. For p-adic large scales longer than  $L(151)$  thermal instability becomes a problem.

It is interesting to compare the number of codons per unit length for ordinary genetic code (and its dark variant) and for various membranes and microtubules.

- For the ordinary genetic code there are 10 codons per 10 nm defining p-adic length scale  $L(151)$ . This gives a codon density  $dn/dl = 10^3/\mu m$  in absence of coiling. The total number of codons in human DNA with a total length  $L \sim 1$  meter is of order  $N \sim 10^9$  codons. The packing fraction of DNA due to coiling is therefore huge: of order  $10^6$ .
- If each lipid phosphate is accompanied by a dark proton and if lipid correspond to square at axonal cylinder with side of length  $d = L(151)$  and the radius  $R$  of axon corresponds to the p-adic length scale  $L(167) = 2.5\mu m$  (also of the same order as nucleus size), there are about  $dn/dl = 2\pi(R/d)^2 \sim (2\pi/3) \times 10^4 \sim 1.3 \times 10^5/\mu m$ . Axon should have length  $L \sim 1$  cm to contain the entire genome.

The same rough estimate applies to microtubules except that there would be one codon per GTP so that the estimate would be 3 times higher if GTP corresponds to length scale  $L(151)$  of tubulin molecule. It has been proposed that genetic code is realized at the microtubular level.

- The nuclear membrane assumed to have a radius about  $L(167) = 2.5\mu m$  could represent  $N \sim (4/3)R^2/d^2 \sim .8 \times 10^5$  codons. This is a fraction  $10^{-5}$  about the total number of codons. For a neuronal membrane with radius  $R \sim 10^{-4}$  meters assignable to a large neuron the fraction would be roughly  $10^{-1}$ . The fraction of dark codons associated with membranes could correspond to genes involved with the control and communication with genome and other cell membranes. Note that the non-coding intronic portion dominates in the genome of higher vertebrates. One can ask whether the chromosome structure is somehow visible in the membrane genome and microtubular genome.

### 11.2.3 Galois group of space-time surface as new discrete degrees of freedom

#### Galois confinement

The problem is to understand how dark photon triplets occur as asymptotic states - one would expect many-photon states with a single photon as a basic unit. The explanation would be completely analogous to that for the appearance of 3-quark states as asymptotic states in hadron physics - the analog of color confinement [L177]. Dark photons would form  $Z_3$  triplets under the  $Z_3$  subgroup of the Galois group associated with corresponding space-time surface, and only  $Z_3$  singlets realized as 3-photon states would be possible.

The invariance under  $Gal(F)$  would correspond to a special case of Galois confinement, a notion introduced in [L172] with physical motivations coming partially from the TGD based model of genetic code based on dark photon triplets.

### Cognitive measurement cascades

Quantum states form Galois group algebra - wave functions in Galois group of extension  $E$ .  $E$  has in general decomposition of extension  $E_1$  as extension of  $E_2$  as extension of ... to a series . Galois group of  $E$  has decomposition to product of  $Gal(E) = Gal(E/E_1)Gal(E_1)$  and same decomposition holds true for  $Gal(E_1)$  so that one has hierarchy of normal subgroups corresponding extension of extension of...hierarchy defined by a composite polynomial  $P(x) == P_1(P_2(x))$  with  $P_2$  having similar representation.  $P$  defines in  $M^8$  picture the space-time surface. This maps a tensor product composition for group algebra and the factors of group algebra entangle. SSFR corresponds to a quantum measurement cascade: SSFR in  $Gal(E/E_1)$ , SSFR in  $Gal(E_1/E_2)$  etc.

Could this cascade relate to the parsing of a linguistic expression? It would certainly correspond to a sentence  $S_1$  about a sentence  $S_2$  about ... such that one substitutes a concrete sentence for  $S_1$  first, then to  $S_2$ , etc.... The sentences in the sequence indeed have  $h_{eff}$  which decreases. This is the case in the cascade of SSFRs since  $h_{eff}/h_0 = n$  is the dimension of  $E_n$ .

I also mentioned the number theoretic measurement cascades for purely number theoretic Galois degrees of freedom. [http://tgdtheory.fi/public\\_html/articles/SSFRGalois.pdf](http://tgdtheory.fi/public_html/articles/SSFRGalois.pdf).

Could cascade of flux tubes decaying to smaller flux tubes with smaller value of  $h_{eff}$  should correspond to this hierarchy. Certainly this is linguistics but the sentence as argument could correspond to several sub-sentences - different flux tubes. Could a neural pathway defined by the branching axon correspond to a concretization of this kind statement about statement (or multistatement, perhaps nerve pulse pattern generated by nerve pulse patterns arriving to a given neuron) about...

### 11.2.4 Energy and frequency resonance as basic elements of dark photon communications

Dark photon realization of genetic code leads to a view about fundamental linguistic communication based on resonance and we will write a separate paper connecting TGD with language soon. Two systems can be in communication when there is resonance.  $E = h_{eff}f$  and energy conservation implies

$$h_{eff,1}f_1 = h_{eff,2}f_2 .$$

For  $h_{eff,1} = h_{eff,2}$ , energy conservation implies that both energies and frequencies are identical:  $E_1 = E_2$  and  $f_1 = f_2$ . Both energy and frequency resonances in question.

In the general case one has  $f_1/f_2 = h_{eff,2}/h_{eff,1}$  and frequency scaling takes place. The studies of water memory lead to the observation that this kind of phenomenon indeed occurs [J43]. The communications of dark matter with ordinary matter and those between different values of  $h_{eff}$  involve only energy resonance. Frequency and wavelength scaling makes it possible for long scales to control short scales. Dark photons with EEG frequencies associated with the big part of MB transform to bio photons with a wavelength of say cell size scale and control dynamics in these short scales: for instance, induce molecular transitions. This is impossible in standard physics.

The resonance condition becomes even stronger if it is required there is a large number of biomolecules in resonance with dark matter realized as dark variants of biomolecules and dark ions. Cyclotron resonance energies are proportional to  $\hbar_{eff}$  characterizing magnetic flux tubes and to the valued of the magnetic field strength dictated by the quantization of the monopole flux quantization by the thickness of the flux tube which can be do some degree varied by varying the thickness of the flux tube giving rise to frequency modulation.

The findings of Blackman *et al* [J47] suggest that  $B_{end} = 0.2$  Gauss defines an important value in the spectrum of  $B_{end}$  values. It could correspond to the field strength for the monopole flux part of the Earth's magnetic field: besides this there would be a non-monopole flux part allowed also in the Maxwellian theory.

There are however indications that the value  $B_{end}$  is quantized and is proportional to the inverse of a biologically important p-adic length scale and thus would be quantized in octaves.

This could relate directly to the octave equivalence phenomenon in music experience. The model of bio-harmony [L39, L40, L156] suggests a further quantization of the octave to Pythagorean 12-note scale of music. This would not be only essential for the music experience but communications of emotions and molecular level using the music of light.

### Selection of basic biomolecules by energy resonance

The dark particles must have energy resonance with bio-molecules in order to induce their transitions. This seems to pose extremely strong conditions possibly selecting the bio-molecules able to form interacting networks with dark matter and with each other. One expects that only some amino acids and DNA type molecules survive.

Nottale's hypothesis provides a partial solution to these conditions. Nottale proposed the notion of gravitational Planck constant

$$\hbar_{gr} = GMm/v_0$$

assignable in TGD to gravitational flux tubes connecting large mass  $M$  and small mass  $m$  and  $v_0$  is velocity parameter. The gravitational flux tube presumably carries no monopole flux. The TGD based additional hypothesis that one has equals to

$$\hbar_{gr} = \hbar_{eff} = n\hbar_0 .$$

This implies that the cyclotron energy spectrum

$$E_c = n\hbar_{gr} \frac{eB}{m} = n \frac{GM}{v_0} eB$$

of the charged particle does not depend at all on its  $m$ . Therefore in a given magnetic field, say  $B_{end}$ , the cyclotron resonance spectrum is independent of the particle.

The energy resonance condition reduces to the condition that the charged ion or molecule has some cyclotron energy coming as a multiple of fundamental in its spectrum in the spectrum of its transition energies. Even this condition is very strong since the energy scale for cyclotron energy in  $B_{end}$  is in the bio-photon energy range containing energies in visible and UV. The fact that bio-photons have a quasi-continuous spectrum strongly suggests that  $B_{end}$  has a spectrum. The model of bio-harmony [L31, L140] suggests that the values of  $B_{end}$  correspond to Pythagorean scaling constructible by quint cycle.

The above simplified picture is formulated for single dark photon communications. The dark proton and dark photon realizations of the genetic code requires 3-resonance that is a simultaneous energy resonance for the 3 members of dark photon triplet. In dark-dark pairing also frequency resonance is possible. In dark-ordinary pairing frequency increases and couples long scales with short scales. Also resonant communications between genes with  $N$  codons involving  $3N$  dark photon frequencies must be possible. This requires new physics provided by number theoretical vision.

### What happens in the cyclotron resonance?

3 cyclotron energies for flux tubes characterize dark 3-proton triplet and Nottale's hypothesis predicts that they depend on the values of  $B_{end}$  for the flux tubes only. Bio-harmony suggests that the spectrum of frequencies and thus  $B_{end}$  corresponds to Pythagorean 12-note scale for a given octave. The allowed chords of bioharmony would characterize the emotional state at the molecular level and correspond to the holistic emotional aspects of the communication beside the binary information.

The resonance would require that the dark cyclotron energy changes are equal to corresponding energies in molecular transitions. Galois confinement [L172] makes possible also 3-N resonance. The resonance condition would select basic biomolecules and the ability of dark analogs of biomolecules to simultaneously resonate with several biomolecules would give additional conditions. In particular this would select DNAs and amino acids.

An open question is whether the coupling to ordinary biomolecules involves a transformation of a dark photon triplet or an N-plet to a single ordinary photon. For instance, does the sum of

the 3 cyclotron excitation energies appear in the coupling of dark 3-proton state to amino acid in protein? This would have an analog as 4-wave coupling in laser physics allowing in biology the transformation of dark photon triplet to single biophoton/or 3 bio-photons or vice versa. 6-wave coupling of laser physics would be analogous to the coupling of ordinary 3-photon state to dark 3-photon and back to ordinary 3-photon state.

The resonance itself would mean a process in which dark 3-proton cyclotron excitation returns to the ground state and generates dark 3-photon transforming transforming to ordinary photon (or 3-photon) and absorbed by the ordinary codon or amino acid excitation to hither energy state. This state would in turn emit an ordinary photon transforming to dark 3-photon absorbed by dark codon. This mechanism generalizes to 3N-proton states representing genes or dark proteins.

## 11.3 TGD based view about brain

### 11.3.1 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 caused by the phantom limb. The pain in the phantom limb is a sensory memory of pain.

The stimulation of temporal lobes indeed generates sensory memories, and people with a cognitive impairment are known for memory feats such as being able to draw a building seen in the past with every detail or to learn music pieces with single listening. These feats can be understood if the memories correspond to “seeing” in time direction with a beam of dark photons travelling to the past reflected back. ZEO allows this.

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 the brain or via the 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 the brain. They would only build short connections between existing flux tube connections parallel to axons. Same happens in an 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 nerve pulse 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 perceptions as near as possible to the sensory input and representing only the essential features. Dark photons could transform in an 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 [K23, K14].

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 a 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 unnecessary 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 for a century ago. Same applies to homeopathy and water memory [K48], 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 a 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 the brain to its MB from axonal membranes serving as Josephson junctions. EEG would code the nerve pulse patterns as frequency modulated Josephson radiation [K33].

The view about sensory perception and function of nerve pulse transmission differs from the standard view. Nerve pulse transition would not be communication between parts of CNS but building of the communication line for dark photons making possible communications with maximal signal velocity [L87] [K86].

1. This would allow generation of sensory mental images at sensory organs by an iteration involving virtual sensory input from brain to sensory organs. Pattern recognition would be realized as a build-up of an artwork representing standardized mental image as near as possible to the original sensory input.
2. Neurotransmitters and all information molecules would be bridges needed to construct connected communication lines. Learning as formation of permanent synaptic connections would be generation of permanent bridges of this kind.
3. Cell membrane and perhaps also other structures serve as generalized Josephson junctions [K33]. The (generalized) Josephson radiation generated by nerve pulses would give rise to EEG (and perhaps also to its fractal counterparts) as communication of neural information from brain to MB via Josephson frequency modulation. The size scale of the layer of MB would be rather large, of the order  $1/f_c$ , of the order Earth size in alpha band ( $f_c \simeq 10$  Hz).

This view allows to understand imagination as virtual sensory inputs *resp.* motor actions from MB via brain which do not reach actual sensory organs . muscles but virtual sensory organs inside brain for which a good candidates are basal ganglia - ganglions are also associated a with sensory receptors. Dreams (REM), hallucinations, and psychedelic experiences (motor activities during sleep) could be understood as virtual sensory input reaching the sensory organs (muscles).

Also memory recall could involve virtual (real in the case of sensory memories) sensory input from MB at which memory mental images are realized [L188] [L145].

### 11.3.2 Binaural beat as a support for TGD view about brain

The phenomenon known as binaural beat [J82] provides support for the TGD view about the brain. Binaural beat occurs when sound waves with slightly different frequencies arrive in both ears. The beat can be understood as interference due to the time-varying phase difference of the waves. What is heard is the difference frequency, even when it is below 20 Hz - for instance 10 Hz-, and therefore not audible. The amplitude modulation with 10 Hz would be perceived, not the 10 Hz frequency. Strangely, the binaural beat occurs also when the signals arrive only to separated ears so that interference is not possible.

The TGD based explanation could be that the sound waves generate dark photon signals propagating along flux tubes and having classical em waves as correlates. The waves from different ears would interfere if the flux tubes meet at some point in the brain located at auditory areas perhaps. The first option is that this interference gives rise to the experience of the binaural beat and superposes with the sensory input assigned to ears (one cannot exclude the possibility that the sensory qualia are assigned to virtual sensory organs in the brain). Second option is that the virtual sensory input as feedback sent back to ears as dark photons superpose to the sensory input from ears.

### 11.3.3 The roles of nerve pulses and oscillations of neuronal membrane in the TGD picture

1. Nerve pulses - or more precisely, the transmitters emitted at synaptics contacts - connect flux tubes to longer pathways along which dark photons signals travel. Biophotons are dark photons transformed to ordinary so that there is empirical basis for this. Dark photons are an optimal tool for communications: light velocity and coherence.

This allows the build of percepts as standardized sensory mental images by feedback. Nanosecond is the time scale for a single feedback loop so that there is a lot of time for this. This also explains dreams as virtual sensory input from the brain of MB to sensory organs in particular eyes (REM).

Imagination can be understood as virtual sensory input which does not reach sensory organs or muscles but stops before it. Imagination is almost sensory experience with input from MB or brain. The notion of virtual sensory input is central for understanding speech comprehension and also inner speech.

2. Nerve pulses patterns modulate generalized Josephson frequencies for the membrane proteins (ion channels and pumps, etc...) and Josephson radiation to big part of MB codes for the sensory input.

Motor output is from MB in reverse time direction induced by BSFRs. A good guess is that it is via genes and induces gene expression by producing proteins but possible are also other forms of gene expression such as as dark photon signals to cell/neuronal membrane inducing nerve pulse patterns building connected wave guides for motor output as dark photons signals to propagate

### 11.3.4 Memories

To understand what memories and memory recall could be in ZEO one must specify what the geometrical correlate of subjective "Now" have?

1. The first proposal was that it corresponds to the active boundary of causal diamond (CD). It however turned out that the subjective "Now" could more naturally correspond to the  $t = T$  slice of CD with maximal size located in the middle of the CD. Here  $t$  corresponds to a linear Minkowski time axis connecting the tips of the CD. If one accepts  $M^8 - H$  duality [L158], this picture can be made precise.

The moments "Now" would correspond to "special moments in the life of self" [L158, L187] identifiable as intersections of 6-spheres, which are brane-like entities (branes are encountered in M-theory) appearing as universal special solutions of algebraic equations determining the space-time surfaces in  $M^8_c$ . The values of  $T$  correspond to the roots of the real polynomial defining the space-time surface so that the values of "Now" are quantized.

2. During the sequence of state function reductions the active boundary of CD would shift towards the geometric future and the size of CD would increase (in statistical sense). The sub-CDs accompanying sensory and other mental images would shift to the direction of geometric future as CD increases and become potential memory mental images suffering BSFRs in a shorter time scale.

The self would experience a memory mental image as a sub-self in memory recall to be discussed below. The time=constant snap-shots at the upper half of CD assignable to the memory mental images are ordered with respect to the Minkowski time  $t$  but the order is opposite to that for the subjective experiences. This was a great surprise to me. They would correspond to subelves to which memory recall builds a connection by entanglement quantally or by sending a signal, which is reflected back in BSFR for the memory mental images.

What about recall of episodic memories in ZEO?



1. Spontaneous memory recall could correspond to a death of a memory mental image with an opposite arrow of time and re-incarnation with the same arrow of time as self. This could be accompanied by emission of a past directed "negative energy" signal received by self associated with the moment "Now". The interpretation would be in terms of extraction of metabolic energy: memory recall indeed requires metabolic energy. Active memory recall could correspond to a receipt of future directed "positive energy" signal coming from "Now" having interpretation as metabolic energy feed. Energy conservation would force the memory mental image to change the arrow of time.
2. The prediction would be that in active memory recall by a "positive energy" signal received by the memory sub-CDs, the order of recalled memories is opposite to that for the real experiences. There is evidence for this kind of change [J138] (see also the popular article "*The human brain works backwards to retrieve memories*" at <http://tinyurl.com/y7hbqmgug>).

### 11.3.5 Associations at quantum level

How associations could be formed at quantum level? Certainly memories and memory recall are involved and ZEO provides a universal model of memories.

1. In contrast to the naïve expectations, in ZEO the memory mental images would be sub-selves and would comove with the active boundary of causal diamond (CD identified as an intersection of future and past directed light-cones) and shift to the direction of the geometric future after their creation at  $t = T$  hyper-plane of CD at which upper and lower light-cones of CD are glued to together. This is the largest time slice of CD and assumed to define the geometric correlate for the subjective moment "Now".

Memory mental image (associated with sub-CD) continues its Karma's cycle having as basic unit a birth in BSFR, a life consisting of a sequence of analogs of unitary time evolutions followed by SSFRs, death in BSFR and living a life with opposite arrow of time. Memory mental images can live in the brain of the geometry future being connected to the brain "Now" by long flux tubes.

2. Memory recall wakes up the memory mental images by sending a message using dark photons received by the memory mental image. The universal model of language suggests that the signal is biological system coded genes serving also as addresses.
3. Conditioning in its simplest form should associate two mental images. The classical example about conditioning is a dog, which learns to expect food after it hears the sound of a bell. The primary experience involves both the sound of the bell and getting the food. After the conditioning the mere sound of the bell stimulates activities like salivation. Positive or negative emotions facilitate conditioning. In ZEO framework the learning of the conditioned response would involve two mental images: imagined experience about obtaining the food and the sound of a bell.

They should fuse to a composite mental image, perhaps by entanglement. These primary memory mental images and their almost copies produced later and involving only the bell and the imagined food would form a population of memory mental images in the geometric future shifting farther away. As the dog hears the sound of the bell, a message to the memory mental images in the geometric future is sent. It is realized as frequency modulated dark Josephson radiation from say basal ganglia of sensory organs.

4. A naïve guess is that the modulated Josephson frequencies correspond to a period larger than the temporal distance of the memory mental image from "Now" and defining its age. Rather low frequencies are involved for long term memories and the values of  $h_{eff}$  must be scaled correspondingly. The longer the time span of the memory, the larger the value of  $h_{eff}$ . The emergence of language is therefore accompanied by the emergence of long term memory. The memory mental images about expectation of food +sound of bell have however a shorter time span. These signals wake-up the memory mental images but they are however not conscious to self - and as they die they send a signal back to the brain inducing an imagined mental image involving also the promise of food.

5. In some cases the signal can reach the sensory organs and a sensory memory mental image is generated. This picture applies also to the acquisition of the language. The larger value of  $h_{eff}$  associated with language genes (the value of  $h_{eff}$  could vary for a given language gene) meaning larger layers of MBs and a possible fusion of MBs of the communicators, and therefore the ability to remember the associations of the words to sensory mental images for a long time. Hearing of the linguistic expression would also generate internal speech as a particular virtual motor action.

## 11.4 A TGD inspired vision about language

### 11.4.1 The role of MB

The proposal is that new layer of MB assignable to larger part of MB outside body was involved with the emergence of language. There are several arguments in favor of this proposal.

1. The model for how mutation of few genes like FOXP2 lead the evolution of human languages to be discussed relies on the idea that the value of  $h_{eff}$  assignable to dark variants of language genes increases. This means the emergence of new layer of MB having onion-like structure. What emerged was grammatics and syntax as hierarchical structures represented as many-sheeted space-time structures distinguishing humans from other animals could have emerged: these structures can be assigned to MB and they have also interpretation in terms of extension of rationals leading to n-sheeted structures. The new level of hierarchy would have emerged at the level of the MB including also dark gene first: flux tubes inside flux tubes inside labelled by values of  $h_{eff}$ .
2. The development of language led to a cultural evolution and could have been a quantum leap in the evolution of collective levels of consciousness: emergence of new levels in the hierarchy of extensions of rationals. Maybe the emergence of gene with large  $h_{eff}$  meant that it receives control commands from this collective level of consciousness possibly assignable to communications, social group, or even larger structure. Recall that the size scale of MB assignable to EEG frequencies is of order Earth size. The basic structure of language are indeed very "social". Subjects, objects, verbs expressing what they do to each other, relations between these entities, attributes (adjectives) characterizing their states. Also the notions of plural and singular.
3. One can also ask how it is possible to distinguish between sensory input created by living beings and having meaning from that produced to dead matter. Also humans give emotional meaning to bird's song and vocal signals and gestures of animals but not to the sounds of dead Nature. For autists this ability might be very weakly developed. The natural answer to the question is that all communications are also communications between magnetic bodies, quite concrete touching, makes it possible to distinguish natural sounds from speech and signals with represent communications. Communications require attention and the flux tube connections between communicators would be correlates for the attention.

Mere mimicry does not require interpretation of the signal as communications. Some birds can mimic the sound of even a car. I remember my astonishment when Finnish bird "talitiainen" mimicked the fate motif of Beethoven's symphony No. 5. My neighbours listened to classical music!

There should be also a fundamental difference between the communications of ordinary sounds and speech to brain. The communications of speech could be via the large part of MB outside body whereas ordinary sensory data would be communicated via small part of MB to brain.

4. In language acquisition the role of parents, in particular mother, is crucial. One might of course argue that just mimicry and rewards are enough. But how the child knows that mother is trying to teach her that the word "apple" corresponds to the object that the mother is holding at her hand. Is the fusion and entanglement of MBs needed?

The acquisition of language by child might also involve the MBs of child and Mother at least fusing to a larger structure. This might help the child to understand that the purpose is to learn to reproduce the word associated with the object that word describes. It could also make possible to learn the grammatics and syntax by becoming a part of larger self already learned these notions.

5. Speech communications happen magically in a good company when people are friendly and benevolent. As a young man I was extremely shy in a company of people who were not my friends. When I had intention to say something, I tried to form sentences in my mind as internal speech before possibly getting courage to talk but found it extremely difficult and I remained usually silent. In a company of good friends I realized that it was not so difficult at all: someone talked through me using me as an instrument.

### 11.4.2 Genes and language

#### What is the role of FOXP2 and other control genes?

The question that led to the writing of this article was whether the mutation of the genome leading to FOXP2 gene and other similar genes responsible for control of the genome did lead to the evolution of human language. How? The above mechanism does not distinguish in no manner between linguistic and ordinary associations. What happened?

Evolution in TGD framework means the increase of number the increase of the complexity of extension of rationals and thus increase of its dimension  $h_{eff}/h_0 = n$  defining a universal measure of intelligence and also a measure for the temporal and spatial scale of quantum coherence. A possibly dramatic increase of  $h_{eff}$  for FOXP2 gene and other key genes is a natural hypothesis explaining why the complexity of the language evolved and led from signals to sentences requiring longer time scale of quantum coherence and also the emergence of complex hierarchical structures naturally assignable to the new extension as extension of the original one.

The larger the value of  $h_{eff}$ , the larger the scale of the layer of MB. This suggests that a new level of collective consciousness essential for communications emerged. This layer would be associated with the system formed by the systems communicating using language. This would explain the ability to distinguish between sounds produced by inanimate systems and sounds produced by living systems and having meaning.

The emergence of this new level would have meant emergence of many new things: of speech, of longer time scales of memory and planned action, of a new level of cognition, of imagination in longer time scales, and of cultural evolution.

Second mechanism related to the emergence of FOXP2 and other similar control genes could be energy resonance in the coupling of the analogs of DNA, RNA, tRNA, and amino acids. The coupling would be between the entire gene and its dark analog. Whether the energy resonance occurs for all cyclotron energies of codons separately or for their sum remains an open question. For both scenarios small changes of the gene can spoil or produce an energy resonance. This sensitivity would make genes an ideal control tool but would also serve as a general mechanism also for genetic diseases. The increase of  $h_{eff}$  accompanied by a small mutation to guarantee energy resonance could be the mechanism explaining the importance of FOXP2 and similar genes.

#### What about the development of speech organs and brain areas related to speech?

The development of speech required development of speech organs and brain areas for understanding of language and language production. How important was their role or was the mutation of certain genes responsible for language control enough to initiate the evolution leading to the development of speech organs and needed brain areas?

One can consider the emerge of a layer of MB with a considerably longer scale perhaps assignable to some collective level of consciousness - perhaps even the entire species. MB as a TGD counterpart for magnetic fields in Maxwellian theory indeed has layers or order of Earth size and even much larger. The proposed emergence of a big layer of MB with a large value of  $h_{eff}$  could relate closely to Sheldrake's proposal [I76] about learning at the level of species. How this new layer could have affected the evolution of speech organs and new brain regions.

1. MB is the key player in TGD. The TGD Universe allows conscious entities and they tend to have ideas as we know. Did MB at some level of hierarchy get an idea about expression of information using temporal sound patterns coupling to dark photons with specific frequencies? That would be a representation of bio-harmony in a new much longer spatial and time scale: did this evolutionary step correspond to the emergence of a new even larger value of  $h_{eff}$  to the dark matter hierarchy. Maybe the realization of this new faculty would have been a fractally scaled up variant of earlier realizations making this easier. Did MB make a plan which was eventually realized after a lot of trials and errors?
2. What this plan could correspond to? Here p-adic physics enters into the game. p-Adic dynamics for p-adic variants of space-time sheets obeys the same field equations as real space-time sheets. It however allows breaking of a strict determinism of real number based field equations: this non-determinism would correspond to the freedom of imagination.  
  
p-Adic data could give rise to full space-time surface as dynamical patterns but they could correspond only to a piece of its real counterpart. Imagination would be non-realistic. Imagined motor actions and sensory inputs would correspond to this kind of partially fulfilled intentions: signals would not reach sensory organs or muscles.
3. How this would apply to MB's plan to create sound producing organs? This plan could proceed by trial and error to become more realistic and gradually find a complete realization. The reduction of the planning to trial and error at dark gene level - would be an enormous simplification and could have meant mutations increasing the value of  $h_{eff}$  bringing in larger layers of MB related to the brain areas and speech organs.

### 11.4.3 Meaning from embodiment in the TGD framework

The notion of embodiment is central for the understanding of how speech gets its meaning. The simplest sentences represent sensory inputs or motor actions. But also very abstract expressions have metaphoric representations in terms of subject and objects and verbs representing actions. Embodiment means that language expressions are transformed to virtual sensory inputs and virtual motor actions creating imaginations of the real ones. This requires formation of associations as generation of sensory and motor mental images.

For instance, the sentence "A does something to B" creates virtual sensory and motor mental images in which A indeed does something to B. Mental images representing A and B and "does something" are generated and could correspond to interaction between two mental images. Basically remembering sensory percept in which A does something to B is enough to provide the meaning and the linguistic decomposition is a model. For instance, the heard speech generates internal speech helping in understanding.

The experience or imagined experience as virtual almost experience with input from MB rather than environment is associated with the expression of language. When the language has been learned, a mere language expression generates memory mental images about the experience associated with the expression. The mechanism is naturally pattern recognition and completion as a general mechanism of association and conditioning also in neuroscience and artificial pattern recognition.

### Questions

In the TGD framework the questions are the following ones.

1. How memories are represented and how they give rise to conscious memory mental images? ZEO leads to a general proposal for how memory mental images are represented. First communication of sensory input to the part of MB containing a subself representing memory mental image, call it M. M receives the signals and experiences BSFR analogous to motor action involving a signal to the direction of geometric past to subself representing "Me Now". This signal is transformed to a nerve pulse pattern generating a virtual almost sensory mental image.

The general proposal is that in biology at cellular level motor actions are generated as time reversed signals from MB to dark genome inducing neural activity by a signal to cell membrane. The signal from MB to genome would take place by dark photon representation of genetic code and induce BSFR. This mechanism would be quite general.

Genes with  $N$  codons must be represented as a dark 3N-photon signal behaving like a single particle like entity. This is not possible in standard physics but adelic physics relying on number theory makes this possible. The notion of Galois confinement [L177] allows dark photon 3N-plets representing genes as sequences of  $N$  3-chords of bio-harmony - kind of music pieces - serving as dynamical units analogous to baryons as color confined units formed from 3 quarks and thus behaving as dynamical units.

The signal would generate a sequence cyclotron resonance peaks at the genome giving rise to a sequence of ticks at dark genome. They must in turn generate a signal to the cell membrane received as a sequence of ticks inducing the sequence of nerve pulses. This seems to require realization of genetic code at the level of the cell membrane level proposed [L110]. The general principle would be the same as in computer language LISP manipulating lists: only identical genes serving as addresses can be in communications by cyclotron resonance. Not only the notion of cyclotron radiation but also the notion of generalized Josephson radiation [L37] must be further generalized: dark Josephson photons are replaced with dark 3N-photons.

2. Where the sensory signal to MB is generated? Its generation at neuronal or cell membranes as generalized Josephson radiation is not plausible since the time scales do not fit together. The modulation of Josephson radiation by nerve pulses patterns produces ripples rather than slow frequency modulation. A more plausible proposal is that the sensory signal to MB is generated at the basal ganglia of sensory organs as a generalized Josephson radiation with frequency modulation generated by the sensory input.
3. What is the basic quantum mechanism of association of the memory mental image B to a sensory input A? In the neuroscience framework it would happen in the associative regions of the brain by new pulse patterns and by learning based on changes in synaptic contacts. Now this would take place at analogous regions of MB to which sensory input is sent as a signal and induced cyclotron resonance for 3N-chords.

A pattern recognition at the level of MB would be in question. This involves a completion of the sinput pattern - sensory mental image - to a pattern representing memory mental image associated with it. This requires a generalization of the existing view about pattern recognition to quantum level. Also this step could involve resonance leading to a fusion of the associated mental images by entanglement. This fused pair of mental images would generate a dark 3N-photon signal propagating to the brain as a generalized cyclotron radiation.

#### Association to memory mental images gives meaning to linguistic expressions

Association of the auditory input to memory mental images would provide linguistic expressions with meaning.

1. Association is a way to assign meaning to linguistic expressions by embodiment. Language expression is associated with an imagined sensory experience or motor activity. Also internal speech is imagined speech as imagined motor activity and generated by written text.

Association requires wake-up of memory mental image by the speech signal, which in turn generates a virtual sensory brain or lower level of layers of MB . In ZEO memory mental images are in the geometric future of "me Now" so that BSFR must take place: the memory self "dies" when it sends the message as a dark photon signal. The signal eventually arrives in the brain and generates a nerve pulse pattern needed by dark photon communications generating the virtual sensory to virtual sensory organs.

Memory mental images at MB are woken up in ordinary memory recall presumably taking place at the hippocampus [J49]. The frequencies involved are theta frequencies suggesting that the layers involved of MB have the size scale of Earth. In the case of speech the

frequencies are in the range 150-300 Hz which suggests that layers corresponding to these frequencies are involved. Also longer time scales such as minute time scale are involved and much bigger layers of MB could be involved.

2. The signals could be sent to the MB from sensory organs:

- (a) Ganglions associated with sensory organs are analogous to brain nuclei and would be the primary receivers of the sensory input. Nerve pulses are generated by neurons above then. Ganglions must play an important role in the generation of sensory experience and motor activities. Ganglions in the brain are called basal ganglia. They could serve as receivers of virtual sensory input and motor output from the brain.

The neuron structures above ganglions also generate nerve pulses and these give rise to communications to the brain along flux tubes associated with neural pathways by dark photons signals. These communications would represent ordinary sensory communications, in particular sounds as mere sounds without meaning. They would also give rise to language acquisition via association.

- (b) The view about communications to MB as Josephson radiation modulated by membrane voltage variations suggests that the frequency modulations of membrane potential at frequencies of speech are involved. The earlier proposal that nerve pulse patterns could induce this modulation. They however would correspond to ripples of long wavelength waves. Of course, also axonal membranes involve oscillations of the membrane potential inducing the modulation but this modulation of generalized Josephson energy involving also difference of cyclotron energies is much smaller than that caused by nerve pulses. The oscillations ganglion membrane potential induced by sound waves could be involved. Frequency modulated Josephson radiation modulated by sounds would propagate to some part of MB. One can consider even the possibility that dark genes such as FOXP2 generate dark 3N-photon radiation. These dark genes could be also realized at the level of cell membrane.

What could be the radiation in the case of dark genes. Could it be generalized Josephson radiation assignable to an array of Josephson junctions defined by dark genes and their conjugates. Sound waves could induce frequency modulations of oscillations of the voltage between the dark genes just by putting them into motion. Does the distance matter.

- (c) The signals would be received by frequency resonance by some layer of MB responsible for memories representing word-sensory/motor associations. What this layer of MB is and where it is located? The flux tubes should allow 3-N dark photon sequences. Their realization outside the biological body does not look realistic. This suggests that the part of MB can be assigned with the brain of the geometric future. Magnetic loops would return back to the brain of the geometric future. The longer the time scale of the memory, the longer the loop. The realization of sensory or in part of MB analogous to associative cortex. What happens in the part of the MB of the future brain representing the memory about association. The analogy of pattern completion of incoming sound signal to sensory input should take place and generate a virtual sensory input to the geometric past as a response along flux loops arriving at the virtual basal ganglia defining virtual sensory organs. Two long loops would be involved. From sensory basal ganglia to the highest motor and sensory areas? And from these to virtual sensory and motor organs.
- (d) The branching of axons suggests a branching of corresponding flux tubes. What could happen in this process? In branching the value of  $h_{eff}$  could be reduced for dark photons - for instance by frequency doubling. Frequency doubling would transform audible frequencies to patterns of nerve pulses with much higher frequencies. From long to short scales.  $h_{eff}$  hierarchy would be essential.

A possible interpretation as a cognitive quantum measurement is possible. Cognitive quantum measurement as a cascade of measurements in the group algebra of the Galois group of extension would give rise to a gradual reduction of effective Planck constants for the factors of the tensor product.

This cascade could correspond to the branching of axons leading to the reduction of biophoton energy in visible or UV to energy above thermal energy and assignable to cell membrane. What happens in branching of the flux tube? Is energy shared to that of  $n$  dark photons with the same frequency and smaller  $h_{eff}$ . Or does a localization to a single branch occur.  $h_{eff}$  would be reduced and  $f$  would increase.  $E$  would be conserved. Also both processes can occur. Division into  $n$  dark photons with  $h_{eff} \rightarrow h_{eff}/n$  with  $f$  preserved plus a reduction  $h_{eff}/n \rightarrow h_{eff}/nm$  and increase  $f \rightarrow mf$  increasing by factor  $m$ .

- (e) The communication via long flux loops to the small part of MB at the brain cannot correspond to this kind of process since the value of  $h_{eff}$  assignable to FOXP2 genes should be preserved. The communication could be to dark control genes such as dark FOXP2 generating signal to neuronal membrane - perhaps dark control gene also there - giving rise to nerve pulse pattern generating virtual almost sensory experience at the virtual sensory organs defined by basal ganglia.

This feedback should have been present already before the emergence of language but in shorter scales and leading to lower layers in the hierarchical structure of the brain ordered by evolution. They would correspond to a hierarchy of increasing values of  $h_{eff}$  realized at the level of genome.

These long feedback loops could end also at lower layers inside the brain and also the hierarchy of cortical layers could relate to this kind of feedback hierarchy. The virtual sensory input to the basal ganglia inside the brain would give rise to imagined sensory perceptions and motor actions.

- (f) The interpretation as analog of Fourier transform [A4] is suggestive. The cyclotron resonance peaks would generate a sequence of ticks analogous to a Fourier transform of the incoming waves. Music-speech dichotomy suggests itself strongly. Speech could be analogous to a sequence of SFRs - ticks - and singing to superpositions of classical time evolutions connecting them. It is said that the right brain sings and the left brain talks. Could some brain regions sing in the sense that they receive or send the signal as dark cyclotron radiation and could some brain regions talk in the sense that this radiation would induce or be induced by internal speech as virtual motor action.

A holistic representation in terms of frequencies would be transformed to "reduction-istic" representation as time series. The correlation function for ticks would have the frequencies in its Fourier transform: stochastic resonance or its analog. Eventually this association to a sequence of ticks could generate a nerve pulse pattern creating a neural pathway making possible virtual sensory input in various sensory areas.

Given language expression corresponds to a huge number sensory percepts and one could argue that this requires a huge number of associations. In the computationalistic framework this would mean a huge amount of computer storage. The model for the generation of mental images predicts that the sensory mental images are standardized mental images generated by a feedback loop giving rise to a pattern recognition. Standard mental images allow also abstraction and conceptualization. One can even consider a quantum counterpart of the classical notion of concept. Concept as the set of its instances would be replaced by wave function in the set of instances giving a large number of different views about the concept.

#### 11.4.4 Bio-harmony as a universal language

Bio-harmony [L31, L140] realizing genetic code for communications is an ideal candidate for a universal language: codon would represent 6 bits and the allowed 64 chords would represent mood at molecular level. There is quite a large number of fundamental moods. Both dark codons and 3-chords bound to units by Galois confinement [L172] can be combined to dark genes by Galois confinement. This language would be minimal. The contents of the message would be minimal - the address of the receiver same as that of sender - so that LISP like language would be in question. The communications would be based on 3N-resonance. U-shaped flux tubes from receiver and sender forming bridges by reconnection would be the topological aspect of the communications.

The space-time surface associated with  $n$ :th order polynomial in  $M^8$  defining the extension of rationals has  $n$  sheets corresponding to the roots of the polynomial [L146, L145]. These many-sheeted structures would give rise to a geometric representation of hierarchical linguistic structures.

There is also an abstraction hierarchy defined by the functional composition of polynomials giving rise to representation of the Galois group of extension in terms of inclusion hierarchy of normal subgroups. Flux tubes within flux tubes within.... are possible. For extension of extension of ... with extensions having dimensions  $n_1, n_2, \dots$  one would have  $n_1$ -sheeted structure with sheets replaced with  $n_2$  sheeted structures replaced with..... Substitution of  $x$  in  $P_{n_1}(x)$  with  $P_{n_2}(x)$  with  $x$  replaced with....would correspond to this replacement.

Cascades of quantum measurements for the states of the Galois group algebra to a product state in the tensor product of Galois group algebras of the hierarchy of normal subgroups would define cognitive measurements which could be crucial for understanding of language by analysis [L174].

### Speech is only one form of communication of binary and emotional information

Concerning production and understanding of speech, one must see the situation more generally in TGD framework.

1. Speech is only one form to communicate information and emotions. Also gestures define a language being based on motor expression. An interesting test is how complex gestures developed before speech and whether FoxP2 has anything to do with sign language. Does sign language have grammatics and syntax characterizing formal languages?
2. Music and singing is the second form of language and expresses emotions rather than bits. Here harmony is an essential notion. Some basic chords define the harmony expressing the mood. Bits/words do not matter, only the chords used.

This leads in TGD to the model of bioharmony in terms of icosahedral and tetrahedral geometries and 3-chords made of light assigned to the triangular faces of icosahedron and tetrahedron. The surprise was that vertebrate genetic code emerged as a prediction: the numbers of DNA codons coding for a given amino-acid is predicted correctly. DNA codons correspond to triangular faces and the orbit of a given triangle under the symmetries of the bioharmony in question corresponds to DNA codons coding for the amino-acid assigned with the orbit.

Codon corresponds to 6 bits: this is information in the usual computational sense. Bioharmony codes for mood: emotional information related to emotional intelligence as ability to get to the same mood allowing to receive this information. Bioharmony would be a fundamental representation of information realized already at molecular level and speech, hearing and other expressions of information would be based on it.

The surprising findings that RNA is central in conditioning [?] suggest that RNA somehow represents emotions crucial for conditioning [?] Dark DNA and bioharmony for which emotions would be realized at molecular level would make it possible.

### What does Universality mean?

There are two views about language: Universality (or computationalism involving only grammar and syntax) concentrates on the formal aspects whereas connectionism concentrates language as a conditioning. For the first option one speaks of language learning as learning of formal rules and this applies to written language and language of mathematics. For the latter option one speaks of language acquisition as an almost unconscious process of imitation. These two views would be fused together in TGD view.

1. There would be only one universal language at the fundamental level. For communications it would be defined by genetic code realized as 3-chords of dark photons forming in turn 3N-frequency composites serving also as units. This code has both the bitty aspect: codon corresponds to 6 bits and the emotional aspect defined by given bio-harmony characterizing



that is by the 3-chords defining the bio-harmony and in this manner mood. Genome would define genotype of language and specific languages would be phenotypes.

This code is used in communications between various levels of the hierarchy. At least in control commands arriving from MB to genome. The analog of Josephson radiation from cell membrane mediating sensory data to MB would consist of a sequence of notes but if cell membrane realizes genetic code, also Josephson radiation could consist of 3N-frequency dark photon composites representing genes. Note that the notion of tick makes sense also for 3N-chords. The message would be sent as Josephson radiation or cyclotron radiation and received as ticks corresponding to state function reductions.

Of course, one cannot exclude the single note option - mere temporal pattern of ticks with varying time separations - for the messages to the genome could be the case of speech having constant pitch. For singing and speech mediating emotions the situation melody or sequence of 3-chords would be needed.

Since the language would be realized at DNA level, even plants could communicate using it. Plants are known to communicate and there is evidence that plants can cognize and even count [123](<https://cutt.ly/ffRYXH8>). In TGD framework also hormonal communications thought to be chemical would take place by biophotons: the hormones connected by flux tube to molecule in say hypothalamus would build the waveguides to second molecule in body for dark photons to propagate.

The basic new physics building bricks in this picture would be 3N-frequency cyclotron resonance transforming the oscillating signal from basal ganglia membranes to a sequence of ticks in turn inducing a sequence of nerve pulses generating the virtual sensory experience using stochastic resonance coding the frequencies of original signal to peaks in the frequency spectrum of the correlation function for the sequences of nerve pulses. Also dark 3N-photon Josephson radiation assignable to genes represented also at cell membrane level would emerge as a new concept.

2. The universal aspects of the language would be realized as a basic expression of dark genes realized in terms of 3N dark photon composites propagating along flux tubes. The content of the packet is the address to which it sent! This would be just like in computer language LISP. This would be the genotype of language, the universal language based on 3N-frequency-resonance between sender and receiver genes.

This would completely separate the meaning of language expressions from the basic communication mechanism. This is of course true also for kinds of communications. The sender and receiver provide the meaning for language expressions by sensory perceiving them. Understanding of how the meaning is generated is the key problem. This requires theory of consciousness and a new view about the conscious brain.

3. TGD view is based on dark 3N-photon resonance communications between genomes and possibly also the genomes associated with the cell membranes and microtubules realizing the genetic code. The sensory input together with the language expression would provide the primary sensory percept - just as in learning by example. When communicated to the brain and even MB a secondary virtual almost sensory percept and virtual almost motor action would be generated as imagined sensory inputs.

This would be the fundamental association giving meaning to the language. Conditioning would occur and when the mere linguistic input is received, the virtual sensory precept and motor output are generated. Does this require anything new: for instance, does it require that the associations are remembered in some sense or are the associations realized as in neuroscience in terms of synaptic strengths? One would have memory as a learned behavior.

First the sensory input generated by linguistic expression is communicated from the basal ganglia of sensory organ or virtual sensory organ to the sensory and motor cortices by using dark 3N-photon resonance. After this the virtual sensory input and almost imagined) perception is generated. How?: as dark 3N-photon signals propagating in opposite spatial direction to sensory organs. The fact that nerve pulse conduction is in a single direction only suggests that also time reversal occurs in BSFR.

4. This general picture applies to the formation of associations and conditioning quite generally. This would be also the mechanism of imagination, which also sharply distinguishes humans from animals. The special ability of the humans to imagine would have emerged at the same time as the complex language. This could be due to the mutations of certain language genes like FOXP2 acting as genes for which the 3N-photon resonance is realized and one must understand how this could be the case.

The proposed notion of universality is not in conflict with the fact there exist large number of languages. The development of different languages is actually easy to understand as reflecting the fact that there is underlying universal language which is minimal in the sense that the content of the message is the address of the receiver. Language acquisition is a conditioning process associating sensory inputs and motor outputs to language expressions at a more fundamental level and the words are just labels for them. This is like general coordinate invariance in general relativity. Points of space-time can have infinite manner of different labelings in terms of numbers (now words).

#### 11.4.5 Geometrization and topologization of the grammar and syntax in terms of many-sheeted space-time

These aspects of speech make understanding of speech acquisition possible but what about intentional learning of speech involving learning of grammar and syntax, which have nothing to do with contents of speech? In computer languages and mathematics as language this aspect would dominate.

#### Fractal flux tubes networks and structures of language

The TGD proposal is that magnetic flux tube networks - possibly trees in case of speech and associated with nerve pulse patterns are in an essential role. Flux tubes are effectively 1-D and have orientation which corresponds to temporal direction of speech and spatial direction of written language. There are flux tubes inside flux tubes flux tubes giving rise to hierarchical structures corresponding to the parsing of language expressions. MB would as many-sheeted structure would geometrize/topologize grammar and syntax.

There are also 2-D and even 3-D flux tube networks but not accompanied by neural networks. These would be essential for the geometric and holistic aspects of cognition: visual cognition in particular. The meridian system of Eastern medicine could be associated with the MB. These flux tube networks would have been present before the emergence of the neural system and would be possessed even by plants. TGD could reduce the structures of language to purely geometric structures. Sentences would correspond to many-sheeted space-time surfaces with their topology representing the parsing structure. Basic space-time sheets would represent words, and the gluing of them to larger space-time sheets by topological sum operation would build sentences. Topological sum of surfaces  $A$  and  $A_0$  essentially means that  $A$  is inside  $A_0$ . Also the ordering of the words matters:  $AB$  and  $BA$  are not the same thing. When  $A$  and  $B$  are inside an effectively 1-D magnetic flux tube  $A_0$ , the ordering of the positions inside the flux tube makes it possible to tell whether  $A$  is before  $B$  or vice versa.

Non-associativity forcing use of brackets in mathematical expressions would be also important ( $(A+B)C \neq A+BC$ ). For instance,  $(AB)C$  would correspond to the structure formed from a pair  $A_0C$  of flux tubes by putting  $AB$  inside flux tube  $A_0$ .  $A(BC)$  would be obtained from the  $AA_0$  by putting  $BC$  inside  $A_0$ . Putting inside brackets means gluing at a larger space-time sheet. The reader is encouraged to imagine what these examples look like when represented in terms of flux tubes within flux tubes.

The hierarchy of extensions of rationals realized in terms of functional composition of polynomials defining space-time surfaces in  $M^8$  as  $n$ -sheeted structures provides a number theoretical view about linguistic structures [L158]. The functional decomposition  $P_1 \rightarrow P_1 \circ P_2(x)$  replaces each space-time sheet of the  $n_1$ -sheeted structure with an  $n_2$ -sheeted structure associated with  $P_2$ . This is like fractal zoom each sheet to  $n_2$  sheets.

This is due to the fundamental theorem of algebra stating that a polynomial  $P_n$  of complex argument with degree  $n$  obtains all its values  $n$  times. The argument  $y = P_{n_2}(x)$  of  $z = P_{n_1}(y)$  has the same value for  $n_2$  points  $x_k$ . This gives  $n_2$  sheets at  $y$ . The value  $z$  is then obtained for  $n_1$  points. Therefore  $n_1$  sheets decompose to  $n_2$  sheets.

### How the structural elements of language can be understood?

One must understand what is behind the notions of subject, object, verb. How tense, case, singular and plural, pronouns, adverbs, etc. are expressed: at the level of genetic code or of conscious experience as contents of imagined sensory experience and motor activity associated with the experience? Are they coded already by the oscillation pattern of the basal ganglia membrane giving rise to imagined experience beside genuine sensory experience? This would be the most elegant option.

The same FoxP2 gene or its analogs could be involved. Consider tense as an example. How the tense would be coded to the oscillations of the ganglia membrane or to the position of these membranes in the brain - to what subself they represent. Who is talking and about what and when!

- "I see" would correspond to a real sensory perception.
- "I saw" corresponds to immediate personal memory: could this be a virtual almost percept produced by a memory and realized at different places as virtual sensory percept. Basal ganglia associated with a level higher than sensory organs responsible for imaginations and inner speech..
- "I will see" would correspond to sensory percept, precognitions in reversed arrow of time.
- "I have done" seems to refer to a remote past: different time scale and perhaps different value of  $h_{eff}$ .
- "I had done" is talk of another self above or parallel me in self hierarchy about me as sub-self as an outsider. Now the basal ganglia would be at some part of the brain containing mental images representing some outsiders, say community as sub-self.

One should also understand what makes the sentence a question or command. In written language formal tools to express whether the sentence represents a question, command or something else have emerged. The many-sheeted structure of space-time should express these aspects of language using fixed words as vocabulary at the basic level. For instance, the building bricks for "Did you do this?" and "Do this!" should have the same "genotype" but different "phenotypes" if the reduction to dark genetic code makes sense. The context represented by a mental image containing the standard mental images representing the words of the sentence would determine "phenotype" allowing to differentiate between the two cases. The geometric representation would be based on flux tubes. Context - the larger flux tube - would be associated with the mental image "I do not know" for "Did you do this?" and "I am the boss" for "Do this!": this context would determine the phenotype just like the environment affects the phenotype in ordinary genetics.

## 11.5 Appendix: Living matter, biochemistry, and consciousness

The model for living matter relies heavily on the notions of MB carrying  $h_{eff} > h$  phases behaving like dark matter and ZEO.

### 11.5.1 ZEO based quantum measurement theory extends to a theory of consciousness

ZEO based quantum measurement theory [L188] leads to a quantum theory of consciousness (see **Fig. 13.10**) by lifting the observer from an outsider to part of physical system. In particular, the theory predicts that the arrow of time changes in "big" (ordinary) state function reductions (BSFRs) as opposed to "small" SFRs (SSFRs) as the counterparts of weak measurements (see **Fig. 13.13**).

This suggests that self-organization in all scales reduces to dissipation with reversed arrow of time. The energies of states increase with  $h_{eff}$  and  $h_{eff}$  tends to be reduced spontaneously. This means that energy feed is needed to preserve the distribution for  $h_{eff}$ : in biology this

corresponds to metabolic energy feed. The energy feed necessary for self-organization would reduce to dissipation of self-organizing system in reversed time direction. Dark matter at MB of the system would serve as a master controlling the ordinary matter serving in the role of slave. Note that there would be master-slave hierarchy of MBs ordered by  $h_{eff}$ .

This would happen at magnetic and have dramatic implications. Time reversed dissipation looks like energy feed from the environment to system. Self-organization involves always energy feed and generation of structures rather than their disappearance in apparent conflict with second law. Self-organization would correspond to dissipation in reversed time direction implied by generalized second law. No specific mechanisms would be required and only metabolic energy storages- systems able to receive the energy dissipated in reversed time direction - are enough. Obviously this provides a totally new vision about energy technology.

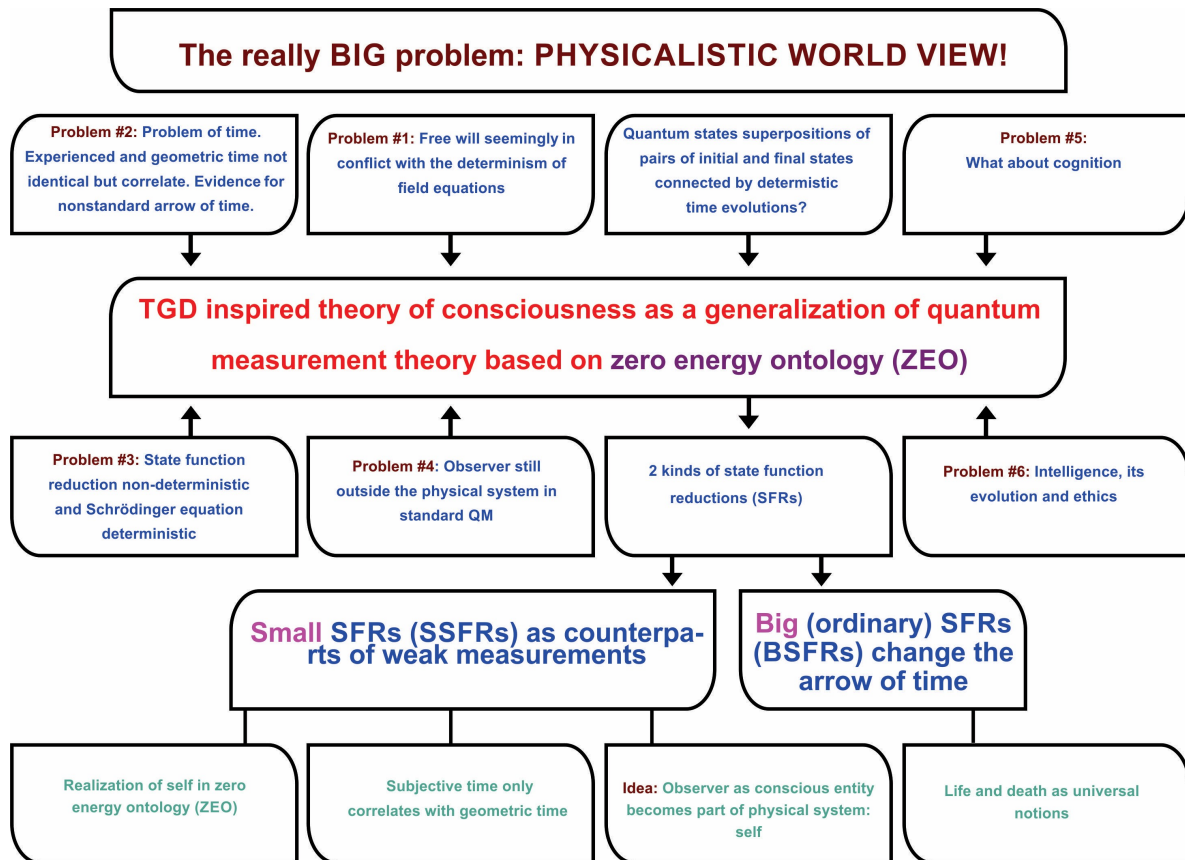
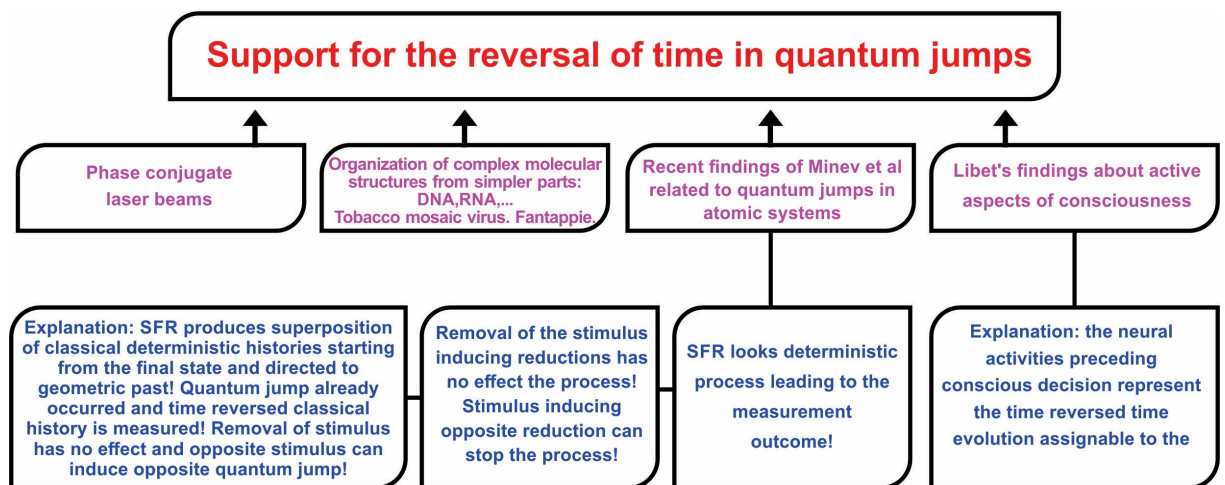


Figure 11.4: Consciousness theory from quantum measurement theory

### 11.5.2 p-Adic physics as a correlate of intention and cognition

One of the earlier ideas about the arrow of subjective time was that it corresponds to a phase transition front representing a transformation of intentions to actions and propagating towards the geometric future quantum jump by quantum jump. The assumption about this front is unnecessary in the recent view inspired by ZEO. Intentions should relate to active aspects of conscious experience. The question is what the quantum physical correlates of intentions are and what happens in the transformation of intention to action.

1. The old proposal is that p-adic-to-real transition could correspond to a realization of intention as action. One can even consider the possibility that the sequence of state function reductions decomposes to pairs real-to-padic and p-adic-to-real transitions. This picture does



**Figure 11.5:** Time reversal occurs in BSFR

not explain why and how intention gradually evolves increasingly stronger, and is finally realized. The identification of p-adic space-time sheets as correlates of cognition is however natural.

2. The newer proposal, which might be called adelic, is that real and p-adic space-time sheets form a larger sensory-cognitive structure: cognitive and sensory aspects would be simultaneously present. Real and p-adic space-time surfaces would form a single coherent whole which could be called adelic space-time. All p-adic manifolds could be present and define kind of chart maps about real preferred extremals so that they would not be independent entities as for the first option. The first objection is that the separate assignment of fermions to every Cartesian factor of the adelic space-time does not make sense. This objection is circumvented if fermions belong to the intersection of realities and p-adicities.

This makes sense if string world sheets carrying the induced spinor fields- define seats of cognitive representations in the intersection of reality and p-adicities. Cognition would be still associated with the p-adic space-time sheets and sensory experience with real ones. What can be sensed and cognized would be represented by the intersection.

Intention would be however something different for the adelic option. The intention to perform quantum jump at the opposite boundary would develop during the sequence of state function reductions at fixed boundary and eventually Negentropy Maximization Principle (NMP) [K61] [L82] (stating that in given state function reduction negentropy gain is in some sense maximized) would force the transformation of intention to action as first state function reduction at opposite boundary. NMP would guarantee that the urge to do something develops so strong that eventually something is done.

Intention involves two aspects: The plan for achieving something which corresponds to cognition and the will to achieve something which corresponds to emotional state. These aspects could correspond to p-adic and real aspects of intentionality.

The recent view relying strongly on  $M^8 - H$  duality lead to ask whether the picture could be made more precise. This picture forces also to challenge the above picture.

1. The basic idea is that p-adic integration constants of the differential equation are pseudo-constants having a vanishing derivative but depending on finite number of binary digits-rational numbers satisfy this condition. In  $M^8$  picture a real polynomial with rational (or possibly algebraic) coefficients determines the space-time surface. The roots of this polynomial as a function of radial light-coordinate  $r$  at light-like boundary of CD determine this polynomial. When pseudo constants are allowed, the coefficients become pseudo constants, which are constants at the interval  $[0; T]$  divided to sub-intervals  $I_1 = [0; t_1]$ ,  $I_2 = [t_1; t_2]$ , ...,  $I_N = [t_{N-1}; t_N]$  by the division  $0 < t_1 < t_2 < \dots < t_N = T$ .
2. Could the division to the intervals be unique by some argument? The roots of  $P$  are identified as moments for which SSFRs occur. Could they correspond to a root of the polynomial  $P_k$  defined in the interval  $I_k$ . Could the "very special moments in the life of self" as roots of a polynomial correspond to introduction of new pseudo constants as a p-adic correlate for the state function reduction? Each interval has its own polynomial  $P_k$  and the allowed roots  $r_{k_i}$  become to the interval  $[t_k; t_{k+1}]$  and their number is usually smaller than the degree  $n$  of the polynomial. Assume that each polynomial restricted to its own range defines a 4-surface inside the same CD. One would have  $m$  separate p-adic space-time surfaces. These surfaces would serve as correlates for intentions or dreams.

How could the real space-time surface as a realized intention relate to these surfaces?

1. Each of the 4-surfaces with genuinely constant coefficients of  $P_k$  has its own cognitive representation as points common to real and all p-adic variants. If the number of points  $t_k$  is finite one indeed has p-adic pseudo-constants for any prime  $p$ .
2. The realization of intention should be a quantum jump, state function reduction, or action of free will. Does this state function reduction have the selection of one of the polynomials  $P_k$  as a real polynomial defining the real space-time surface as a geometric correlate.
3. Could one generalize this to fermionic degrees of freedom. In [L150] it is proposed that one could super-symmetrize TGD and quark spinors as embedding space spinors by replacing embedding space coordinates with super fields with components expressible as hermitian composites of second quantized quark and antiquark oscillator operators. Analogous generalization would be made for the second quantized quark field.

In the  $M^8$  picture the real polynomial would be replaced with a polynomial of super coordinate algebraically continued to super-octonionic coordinate. Solutions of the algebraic equations defining space-time surface would be now super-space-time surfaces which are unions of components assignable with the fermionic super coefficients of the super-polynomial.

The rational coefficients of this polynomial could be replaced with pseudo-constants and the above picture seems to generalize. The spinor super-field would be a restriction of the  $M^8$  spinor super-field to the p-adic branches of the p-adic space-time surface. Could the above picture about intentional act as a choice of the real branch generalize.

The next important step is to understand intentional action at quantum level.

1. The most general vision is that intention corresponds to a superposition of p-adic spacetime surfaces with coefficients of polynomials which are genuine pseudo constants and by number theoretic universality same in all p-adic sectors. These superpositions would represent intentions and dreams. One could also speak of a dreamy CD containing a dreamy quantum Universe. Since cognitive representations are considered, everything would reduce to an extension of rationals, and the quantum dynamics by SSFRs and BSFRs would not formally differ from that for the real space-time surface and one could speak about transition amplitudes between dreams.

2. The realization of an intentional action would correspond to an SFR in which the pseudo constants become genuine constants. The simplest model is that one of the polynomials  $P_k$  is selected and be extended to a polynomial in the entire CD associated with  $P$ . The origin of CD is in a unique role in  $M^8$  picture and  $P(0) = 0$  makes possible hierarchies of extensions and conservation of number theoretical data as roots of  $P$  in the composition of polynomials realized for space-time surfaces.

If  $P_k(0)$  is required also for  $k > 1$ , any  $P_k$  can be selected. One can however challenge the idea that intentional action involves a selection. If  $P_k(0) = 0$  for  $k > 1$  is not assumed,  $P_1$  associated with the interval  $[0, t_1]$  must be chosen and CD corresponds to its size scale. One can talk about a partial realization of the intention in accordance with the intuitive expectations. For instance, imagined sensory percepts and motor actions could correspond to this kind of partial realizations.

3. If motor action corresponds to BSFR, intentional action can be realized only for BSFR. SSFR could not allow a realization of intention if the sequence of SSFRs corresponds to a functional composition of polynomials or even iteration of a single polynomial: I have considered these options for the sequence of SSFRs in [L168].
4. This picture is in accordance with the conservation laws in ZEO and allows the creation of Universes as from nothing. CDs do not pop up from vacuum but dream-CDs transform to real ones.

It is difficult to avoid the question of whether the notion of state function reduction could be reduced to a classical choice selecting one  $P_k$ : quantum jump as choice between dreams to be realized. This option would lead to purely classical probability theory and it would be however very difficult to understand what determines the transition probabilities.

### 11.5.3 The notion of magnetic body

Magnetic body (MB) would carrying dark matter would serve as the boss controlling ordinary matter at flux tubes.

1. MB has as building bricks magnetic flux quanta. Typically flux tubes and flux sheets. It consists of two kinds of flux quanta. Flux can be vanishing, which corresponds to Maxwellian case. The flux can be also non-vanishing and quantized and corresponds to monopole flux. In monopole case magnetic field requires no current to create it. This option is not possible in Maxwellian world. These flux tubes play a key role in TGD Universe in all scales.
2. Also Earth's magnetic field with nominal value  $B_E = .5$  Gauss would have these two parts. Monopole part corresponds to the "endogenous" magnetic field  $B_{end} = .2$  Gauss explaining strange effects of ELF em radiation to the physiology and behavior of vertebrates [J47]. The presence of this part identifiable as monopole flux explains why Earth has magnetic field: this field should have decayed long time ago in Maxwellian world since it requires currents to generate it and they disappear. Magnetic fields of permanent magnets could have a monopole part consisting of flux quanta. Electromagnets would not have it.
3. MB would carry dark matter as  $h_{eff} = n \times h_0$  phases and act as a "boss" controlling ordinary matter [L157]. Communication to and control of biological body (ordinary matter) would be based on dark photons, which can transform to ordinary photons and vice versa. Molecular transitions would be one form of control.
4. Dark photons with large  $h_{eff}$  serve as as communication and control tools. Josephson frequencies would be involved with the communication of sensory data to MB and cyclotron frequencies with control by MB. Dark photons are assumed to transform to biophotons [L29, L28] with energies covering visible and UV associated with the transitions of bio-molecules. The control by MB which layers having size even larger than that of Earth means that remote mental interactions are routine in living matter. EEG would be a particular example of these communications: without MB it is difficult to understand why brain would use such large amounts of energy to send signals to outer space.

5. The experiments of Blackman and others led originally to the notion of  $h_{eff}$  hierarchy. The large effects of radiation at ELF frequencies could be understood in terms of cyclotron transitions in  $B_{end} = .2$  Gauss if the value of  $h$  in  $E = hf$  is replaced with  $h_{eff}$ , which would be rather large and possibly assignable to gravitational flux tubes with  $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ .

MB would control BB by cyclotron radiation - possibly via genome accompanied by dark genome at flux tubes parallel to the DNA strands. Cyclotron Bose-Einstein condensates of bosonic ions, Cooper pairs of fermionic ions, and Cooper pairs of protons and electrons would appear in living matter and  $h_{eff} = h_{gr}$  hypothesis predicts universal energy spectrum in the range of bio-photon energies.

Cell membrane could act as generalized Josephson junction generating dark Josephson radiation with energies given by the sum for ordinary Josephson energy and of the difference of cyclotron energies for flux tubes at the two sides of the membrane. The variation of the membrane potential would induce variation of the Josephson frequency and code the sensory information at cell membrane to a dark photon signal sent to MB.

6. In ZEO field body and MB correspond to 4-D rather than 3-D field patterns. Quantum states are replaced by quantum counterparts of behaviors and biological functions. The basic mechanism used by MB would be generation of conscious holograms by using dark photon reference beams from MB and their reading. In ZEO also the time reversals of these processes are possible and make possible to understand memory as communications with geometric past. Sensory perception and memory recall would be time reversals of each other and correspond to sequences of SSRs. Motor action would correspond to BSRs.

#### 11.5.4 Life is not mere chemistry

The dogma about biology as mere bio-chemistry is given up in TGD framework.

1. Bio-catalysis remains a mystery in bio-chemical approach. MB carrying dark matter could provide the needed mechanisms.

According to TGD view about catalysis, the U-shaped flux tubes associated with the MBs of reactants reconnect to a pair of flux tubes connecting the molecules [L134]. This happens if there is cyclotron resonance for dark cyclotron radiation assignable to massless extremals (MEs) associated with U-shaped flux tubes. This requires that the flux tubes have same strength of magnetic field and therefore same thickness by flux quantization. The same value of  $h_{eff}$  guarantees resonance. The next step is the shortening of the flux tubes by a reduction of  $h_{eff}$  and liberating energy kicking the reactants over the potential wall making the process extremely slow otherwise.

2. Also valence bonds and hydrogen bonds could correspond to magnetic flux tubes characterized by  $h_{eff} = h_{em} = n \times h_0$ , where  $n$  is now rather small number ( $h = 6h_0$ ). This leads to a model for valence bond energies of atom with  $n$  increasing as one moves to right along the row of the periodic table providing insights to the biological roles of various molecules in biology [L105]. For instance, the molecules involving atoms towards right end of the periodic table would be natural carriers of metabolic energy whereas at the left end of row would be naturally involved with biocontrol via cyclotron frequencies.
3. The physics of water is full of anomalies [I84]. TGD suggests an explanation [L108] in terms of flux tubes assignable to hydrogen bonds [L108, L133]. These flux tubes could correspond also to values of  $h_{eff} > h$  so that these flux tube could be long and give rise to long range quantal correlations. Water could be seen as a manyphase system. The MBs assignable to water molecule clusters could mimic the cyclotron frequency spectrum of invader molecules and make possible water memory and primitive immune system based on reconnections of U-shaped flux tubes of water cluster and invader molecule [L177]. In this framework water would represent a primitive life form.

In Pollack effect [I70] exclusion zones (EZs) are induced at the boundary between gel phase and water by energy feed such as IR radiation. The negative charge of EZs is explained as a



formation of flux tubes carrying dark protons having interpretation as dark nuclei. A simple model for linear dark proton triplets predicts their states to be in 1-1 correspondence with DNA, RNA, tRNA, and amino-acids and the numbers of codons coding for given amino-acid are predicted to be same as for vertebrate genetic code [L130, L156]. The model thus predicts deep connections between nuclear physics, condensed matter physics, chemistry, and biology usually thought to be rather disjoint disciplines.

EZs are able to remove impurities from interior in conflict with second law. TGD based explanation of the mystery is change of the arrow of time induced by TGD counterpart of ordinary state function reduction in ZEO) [L188]: self-organization would be dissipation with reversed arrow of time at the magnetic body (MB) of system acting as master and forcing time reversed evolution at the level of ordinary bio-matter serving as a slave.

DNA has one negative charge per nucleotide, microtubules are negatively charged, also cell is negatively charged, ATP carries 3 units of negative charge. This together with ZEO suggests that Pollack effect plays a key role in bio-control and macroscopic SFRs play a key role in living matter.

## Chapter 12

# About TGD based view of neuron

### 12.1 Introduction

The inspiration for looking again at the TGD view about nerve pulse conduction [K86] 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 Hodgkin-Huxley model of nerve pulse conduction (<https://cutt.ly/ATvjVHD>).

J. W. Jacak proposes a model of saltatory conduction [J179] (<https://cutt.ly/cTvjd0db>) according to which action potential could propagate in plasmon-polariton condensate and the myelinated portions of length about  $L = 100 \mu\text{m}$  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 [K86], EEG [K33, K89, K53, L191] 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 induced 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  $\Delta E_c$  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  $1 \mu\text{m}$  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 [L192].

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.

## 12.2 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 [E1] 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 [L111, L191, L200, L198] [K12]. 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 [L196].

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  $f_J = ZeV/\hbar_{gr} = ZeVv_0/(2\pi GMm)$  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 considered and the model of bioharmony suggested that approximately correspond to frequencies of 12-note scale [L31, L140, L170, L192].

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.

### 12.2.1 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 generalized 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 Josephson 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 that 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  $100 \mu\text{m}$ . 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 [J179] (<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) [K74, K10]) associated with them act as wave guides for classical gauge fields. Neurotransmitters at the synaptic contacts would connect pre- and 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  $\tau$ . 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 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  $\Delta f_c$  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.

### 12.2.2 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) [L149] [K129] 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  $A \rightarrow MB \rightarrow B$  rather than directly as  $A \rightarrow B$  and involve BSFR at MB.

The BSFR at the level of MB would be followed by the step  $S \rightarrow MB$  (S denotes sensory organ) inducing a virtual sensory input  $MB \rightarrow S$  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  $MB \rightarrow S$  would be a time reversal for the transformations of the Josephson photon signal to resonance peaks in the step  $S \rightarrow MB$ .

**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  $BB \rightarrow MB \rightarrow MB$  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  $S \rightarrow MB \rightarrow S$ .

One can also consider the possibility  $S_1 \rightarrow MB \rightarrow S_2$  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 Mineev *et al* [L141] and Libet [J31] support this picture [L141]. 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  $S \rightarrow MB \rightarrow S$  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.

### 12.2.3 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 symbols 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 appropriate 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 [L31, L170]. 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 [L192]. Perhaps the simplest tessellation, known as icoso-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 [L222, L223].

#### 12.2.4 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 patterns assignable to the myelinated portions of axon define "sentences"?

The intuitive feeling is that the decomposition of axon to myelinated portions and the Ranvier nodes 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  $T = 1 \mu s$ , 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  $\mu m/s$ . Slow Calcium waves propagate with velocity about  $v \sim 1 \mu/s$  (<https://cutt.ly/tTWTrTrA>). 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 [J179] but with  $h_{eff} \leq h_{gr}$ . 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 [I34] (<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  $6 \times 10^5$  Hz. For an unmyelinated portion of axon of length about  $1 \mu$  m 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  $F_{J,min} = \Delta f_c - f_{J,c}$ .

## 12.3 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 [J141] (<https://cutt.ly/8TvhMej>).

### 12.3.1 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/GTvjjFp>), dendrites (<https://cutt.ly/KTvjo7J>), and myelination (<https://cutt.ly/ZTvjd1>) 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?

### 12.3.2 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 [L222, L223] 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  $\lambda$  assignable to a signal propagating along the dendrite. For an ordinary photon,  $\lambda$  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  $\mu\text{m}$ .

3. Nerve pulses [K86] are induced 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  $\mu\text{m}$ ) and IR wavelengths of order  $14.8 \mu\text{m}$ . Note however that the lengths of myelinated portions are about  $100 \mu\text{m}$ .

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 motoneurons of frog (<https://cutt.ly/HTnmq0i>) 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 " $A \rightarrow B$ "  $\rightarrow$  " $A \rightarrow MB \rightarrow B$ " 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 13

# Does Consciousness Survive Bodily Death?

### 13.1 Introduction

The questions of this essay is “*What is the best possible evidence for the survival of human consciousness after bodily death?*”. It is very difficult to provide water tight evidence for life after death since near-death experiences (NDEs) are subjective and do not offer objective proof.

By re-framing the question as one that addresses consciousness, the situation changes. That is, a theory of consciousness inspired by Topological Geometrophysics (TGD) [L173], which derives from a broader proposal for the unification of fundamental interactions, provides a general theory of consciousness in which consciousness, life and death are universal phenomena. The theory makes testable predictions at all scales and supports the view that consciousness survives death albeit not in the way one might expect.

The following represents a broad overview of the theory. A glossary of terms that may be alien to the lay reader is provided at the end of the essay.

1. Zero Energy Ontology (ZEO) [L188] solves the basic problem of quantum measurement theory and extends quantum measurement theory to a theory of consciousness. The observer is repositioned from an outsider to an intrinsic part of the system - the conscious entity or self. The self is born, lives and dies.

The moments of birth and death correspond to what I describe as “Big” State Function Reductions (BSFRs) as counterparts to the ordinary state function reductions (SFRs). What is new is that in the BSFR the self re-incarnates with an opposite arrow of time (AT). Life corresponds to a sequence of “Small” State Function Reductions (SSFRs) in which AT does not change. SSFRs are analogs of “weak” measurements analogous to classical measurements (<http://tinyurl.com/zt36hpb>).

2. A number theoretic view of cognition generalizes real number based physics to adelic physics [L97, L102] involving not only reals but also p-adic number fields and their extensions. One outcome is the identification of dark matter as phases of ordinary matter labelled by extensions of rationals (EQ). The dimension  $n$  of EQ is identifiable in terms of the effective Planck constant  $\hbar_{eff} = n\hbar_0$  ( $\hbar = 6\hbar_0$  is suggested by the findings of Mills [D7] [L104]).

EQ induces extensions of p-adic number fields serving as correlates of cognition. [L97, L102]. “ $n$ ” measures the algebraic complexity of these extensions and therefore a universal measure for the level of cognition not restricted to human brain or even living matter. “ $n$ ” also serves as a measure for the scale of quantum coherence typically proportional to  $\hbar_{eff}$ . For these reasons, “ $n$ ” serves as a kind of universal “intelligence quotient” (IQ).

Quantum coherence, consciousness, and life are predicted to be possible in arbitrarily long length - and time scales so that the notions of life and death are universal.

3. TGD provides a new view of space-time, classical gauge fields, and gravitational fields. The identification of space-time as a 4-D surface in certain 8-D space-time fixed by the standard

model (SM) symmetries leads to a geometrization of the classical fields and their elimination as primary dynamic variables: once the space-time surface  $X^4$  is known, all classical fields are also known. The many-sheeted space-time of TGD is locally extremely simple but topologically extremely complex whereas the space-time of General Relativity (GRT) is topologically extremely simple but locally complex.

The notions of a field body (FB) and its special case *magnetic body* (MB) are central. In Maxwellian theory, the fields of different objects superpose and in this superposition information is lost. In TGD, the fields of distinct objects in general correspond to separate space-time sheets and the fields do not superpose so that information is not lost. This distinction is crucial to TGD inspired quantum biology. By its higher “IQ” (algebraic complexity measured by  $n = h_{eff}/h_0$ ), MB carrying dark matter in the TGD sense acts as a master which controls the layers of MB with a smaller value of “ $n$ ” and also the ordinary biomatter at the bottom of the hierarchy. This makes life in all its variety possible at all scales.

The following describes this theory in more detail and some of the applications that suggest an affirmative answer to the question posed in this essay contest. In the TGD Universe, fractality replaces length scale reductionism as a foundational concept, and the notions of life and death are universal so that the question can be formulated in a much wider framework.

The plan of the article is as follows:

1. Section 1: TGD as a solution of the energy problem of GRT by replacing the Einsteinian space-time with 4-surface or as a generalization of string models by replacing string world sheets with 4-surfaces; the dual views of TGD reducing physics to geometry or to number theory; examples of applications.
2. Section 2: TGD inspired theory of consciousness as a generalization of quantum measurement theory based on ZEO and negentropy maximization principle (NMP).
3. Section 3: TGD inspired quantum biology relying on the notions of MB and dark matter as a hierarchy of phases with effective Planck constant  $h_{eff}/h_0 = n$ .
4. Section 4: TGD view of the brain.
5. Section 5: Aging and death understood in ZEO as universal phenomena.
6. Section 6: Evidence for life after death in the TGD Universe.
7. Section 7: A model for biological death and near death experiences (NDEs).

#### List of abbreviations:

TGD: Topological Geometrodynamics

QFT: Quantum field theory

GCI: General Coordinate Invariance

SH: Strong form of holography

EP: Equivalence Principle

EQ: Extension of rationals

ZEO: Zero energy ontology

CD: Causal diamond

AB: active boundary of CD PB: passive boundary of CD SFR: State function reduction

BSFR: “Big” (ordinary) SFR

SSFR: “Small” SFR

NMP: Negentropy Maximization Principle

SL: Second Law of thermodynamics

AT: Arrow of time

NE: Negentropic entanglement

FB: Field body

MB: Magnetic body

BB: Biological body



RMS: Rotating magnetic system

NDE: Near-death experience

OBE: Out-of-body experience

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## 13.2 Brief summary of TGD

Topological Geometrophysics is a proposal for a unification of fundamental interactions on which I have worked for the past 43 years. The books “Topological Geometrophysics” (2006) [K121] and “Topological Geometrophysics: Revised Edition” [K5] provide summaries of the theory of TGD. The book “Life and Consciousness: TGD based vision” (2014) [K3] describes a TGD inspired theory of consciousness. The article “Philosophy of adelic physics” (2017) [L97, L102] describes a number theory based vision of TGD and extends real number based physics to p-adic number fields to describe physical correlates of cognition. The most recent mathematical progress concerning the construction of scattering amplitudes in TGD is discussed in the articles [L179, L180, L181].

The article “Summary of Topological Geometrophysics” (2020) [L185] provides the most recent summary of TGD with illustrations. My CV (<https://cutt.ly/3bJ2aSm>) contains a list of published articles, books, and online books about TGD. A list of online articles can be found at <https://cutt.ly/ZbJ2s75>.

### 13.2.1 The basic problem and idea behind TGD

TGD relies on a new view of space-time inspired by the problem of GRT due to the loss classical conservation laws (the “energy problem”). Matter makes the flat Minkowski space  $M^4$  of Special Relativity (SRT) curved so that it loses Poincare transformations as its symmetries. Poincare invariance implies the conservation laws of energy, momentum, and angular momentum via Noether’s theorem so that they are lost in GRT.

The following is a short summary of the solution of this problem provided by TGD (see **Fig. 13.1**).

1. If space-times are 4-surfaces in a space of form  $H = M^4 \times S$ ,  $S$  some compact space with a very small size, space-time isometries (Poincare transformations) are lifted to those of  $H$ . If these isometries act as symmetries of a general coordinate invariant action determining the space-time surface as an orbit of a 3-surface, Poincare symmetries are not lost and Noether’s theorem guarantees the existence of conserved charges and gives explicit expressions for them.

The geometry of  $S = CP_2$  codes for the symmetries of SM: color symmetries correspond to the isometry group  $SU(3)$  and electroweak symmetries to the holonomies of  $CP_2$  being broken by  $CP_2$  geometry.  $CP_2$  does not allow spinor structure in the standard sense [L12] but - as already observed by Hawking and others [A31, A25] - it allows a modified spinor structure obtained by coupling spinors to an odd multiple of the Kähler gauge potential: this coupling is essential to obtain correct electromagnetic charges for fermions. For quarks and leptons the couplings would correspond to  $n = 1$  and  $n = 3$ .

However, the TGD view of color makes it possible to identify leptons as local 3-quark composites [L161, L160, L151, L179, L190] so that only quarks are needed as fundamental fermions. The mystery of matter-antimatter symmetry would thus be solved: leptons correspond to antimatter and baryons to matter.

2. Besides sub-manifold geometry, topology also becomes important (hence the term “**TGD**”) since the many-sheeted space-time of TGD is topologically non-trivial at all scales and the physical objects that we see around us correspond directly to space-time sheets, topologically condensed at ever larger space-time sheet. Length scale hierarchies form.

### 13.2.2 Physics as geometry and physics as number theory

TGD decomposes to two basic threads: physics as geometry [L14, L13, L47, L164] and physics as number theory [L106, L107, L102] (see **Fig. 13.2**).

1. In the geometric approach space-time surfaces  $X^4$  correspond to extremals for both volume action and the so called Kähler action as an analog of Maxwell action. This action is predicted by the twistor lift of TGD [L81] (see **Fig. 13.6**).

The essential distinction between this approach and the standard quantization is that classical physics is an exact part of quantum physics rather than its long length scale limit: quantum states are superpositions of preferred extremals of the action, analogous to Bohr orbits (see **Fig. 13.3**).

2. In the approach based on number theory,  $X^4$  corresponds to an algebraic surface in a complexified 8-dimensional Minkowski space  $M^8$ , having an interpretation as complexified octonions  $O_c$ . This surface is obtained as a “root” for the complexified quaternion-valued “real” part of an octonionic polynomial obtained from a real polynomial with rational coefficients by algebraically continuing it to  $O_c$ . This is done by replacing the real argument with a complexified octonion [L180, L181] (see **Fig. 13.7**).

These approaches are related by the  $M^8 - H$  duality [L180, L181] (see **Fig. 13.7**) for which weak and strong forms can be considered.

1. The identification of  $M^8$  as an analog of 8-D momentum space as cotangent space of  $M^4 \times CP_2$  represents the most recent step in this progress [L180, L181, L193].
2. One can realize both weak and strong forms of  $M^8 - H$  duality in  $M^4$  degrees of freedom by an inversion map  $p^k \in M^4 \rightarrow m^k = \hbar_{eff} p^k / p^2$  [L180]. This conforms with the Uncertainty Principle (UP) but does not however the full UP. An even stronger form of  $M^8 - H$  duality states that momentum  $p^k$  is mapped to a union of points  $m^k + \delta m^k$ , such that  $\delta m^k \cdot p_k = n2\pi$  belong to the interior of causal diamond (CD), and would satisfy full UP [L193].
3. The weak form of  $M^8 - H$  duality relies on the strong form of holography (SH) which makes it possible to deduce  $X^4 \subset H$  from the images of 2-D surfaces  $X^2 \subset X^4 \subset M^8$  (and possibly also of light-like 3-surfaces) under  $M^8 - H$  duality [L158].
4. Recent work strongly suggests that SH may not be necessary: the strong form of  $M^8 - H$  duality maps the *entirety* of space-time surfaces from  $M^8$  to  $H$ . This provides a major simplification [L180, L181].

The identification of  $M^8$  as an analog of momentum space generated a breakthrough but also resulted in an objection. Periodic functions and Fourier analysis characteristic for dynamics are absent at the level of  $M^8$ . Could they emerge at the level of  $H$ ? The conjecture is that the non-locality of the map of the tangent planes of  $X^4 \subset M^8$  to  $CP_2$  points brings in dynamics and implies that  $CP_2$  points are represented as Fourier expansions of  $M^4$  coordinates [L165, L193].

Quantum TGD leads to a generalization of the geometrization of the physics program of Einstein. The entirety of quantum theory is geometrized in terms of the notion of a “world of classical worlds” (WCW) consisting of space-time surfaces identifiable as preferred extremals (PEs) analogous to Bohr orbits (see **Fig. 13.8**). General Coordinate Invariance (GCI) implies 3-D holography and probably also effectively 2-D holography (strong holography (SH)).

The mere existence of WCW Kähler geometry requires a maximal isometry group. This was shown by Freed [A26] to be the case for loop spaces. This leads to the vision that physics is unique from its existence. Indeed, the twistor lift of TGD [L162, L163] works only for  $H = M^4 \times CP_2$  [A32] since only  $M^4$ ,  $E^4$ , and  $CP_2$  have twistor spaces with the Kähler structure required by the existence of the twistor lift based on 6-D Kähler action. At the number theory side, the octonionic  $M_c^8$  is the unique choice.

The number theory based vision is a completely new element and leads to adelic physics [L97, L102] involving both real physics and various p-adic physics (where  $p = 2, 3, \dots$  are primes). p-Adic physics are identified as correlates of cognition and imagination in a universal sense predicted

to be present at all scales (see **Fig. 19**) and not restricted to human brain or even living systems as usually understood.

The polynomials defining the  $X^4 \subset M_c^8$  give rise to an infinite hierarchy of extensions of rationals (EQs) inducing those of p-adic number fields. This predicts an infinite hierarchy of adeles. The adele for a given EQ is defined essentially as the Cartesian product of real numbers and extensions of various p-adic number fields induced by EQ.

This hierarchy is identified as an evolutionary hierarchy (see **Fig. 13.9**). The dimension  $n$  of EQ has an interpretation as an effective Planck constant  $h_{eff} = nh_0$  ( $h = 6h_0$ ). Quantum coherence is predicted to be possible in arbitrarily long scales and the values of “ $n$ ” define a length scale hierarchy as quantum coherence scales. The phases with a non-standard value of  $h_{eff}$  behave like dark matter.

### 13.2.3 About the applications of TGD

TGD has non-trivial applications at all scales.

1. Space-time topology is non-trivial at all scales. “Einsteinian” space-time surfaces have an  $M^4$  projection of dimension  $D_P = 4$ , and look like small deformations of  $M^4$ . Also 4-D space-time surfaces with  $D_P < 4$  are possible and correspond to non-perturbative gravity. In particular, the so-called  $CP_2$  type extremals with  $D_P = 1$  and cosmic strings with  $D_P = 2$ , are possible. These deviations from GRT are crucial for an understanding of elementary particles and galactic dark matter and energy [L159, L155].

All space-time surfaces - including “Einsteinian” ones - have a finite size. In the “Einsteinian” case,  $CP_2$  coordinates can be many-valued functions of  $M^4$  coordinates, and it is convenient to talk about a many-sheeted space-time.

A quantum field theory (QFT) limit for “Einsteinian” space-time surfaces is obtained by replacing the space-time sheets with a single, slightly metrically deformed, region of  $M^4$ . The counterparts of the SM gauge potentials are identified as the sums of induced spinor connections of space-time sheets. The counterpart of the GRT metric corresponds to the sum of the deviations of the induced metric from the flat  $M^4$  metric. Einstein’s equations can be regarded as a remnant of Poincare invariance. Many-sheeted space-time is topologically non-trivial at all scales and this hidden many-sheetedness leads to non-trivial predictions at all scales, in particular, biology.

2. For a given EQ fixed by a polynomial defining space-time surface  $X^4 \subset M^8$  there is a unique discretization of  $X^4$  - cognitive representation - as points, whose coordinates are common to the real and p-adic variants of  $X^4$  and therefore in the EQ. This intersection of reality (i.e. real space-time surfaces) and p-adicities implies a strong correlation between cognition and sensory reality. The p-adic length scale hypothesis that emerged from p-adic thermodynamics as a model for particle massivation [L19] and p-adic fractality are very powerful quantitative tools, which lead to highly non-trivial predictions.

For more detailed representations, one can consult the books [K121, K3, K5], the article [L97] about adelic physics, and the articles [L103, L136]. The latest mathematical progress is described in the articles [L179, L180, L181, L193]. The homepage dedicated to TGD (<http://tgdtheory.fi>) contains online books and articles - also updated versions of published articles.

## 13.3 TGD inspired theory of consciousness

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) [L188]. When I wrote the first version of this chapter, the view about ZEO, in particular about what happens to the causal diamonds (CDs) in state function reductions, involved many uncertainties. In [L215] the recent, much more precise view is represented.

### 13.3.1 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.

### 13.3.2 ZEO based quantum measurement theory extends to a theory of consciousness

ZEO based quantum measurement theory [L188] leads to a quantum theory of consciousness (see **Fig. 13.10**). In particular, the theory predicts that the arrow of time (AT) changes in “Big” (ordinary) SFRs (BSFRs) (see **Fig. 13.13**) 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 [L180, L181]. 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 [L221]. 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 [K67] and  $h_{eff}$  hierarchy [L147]. 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 [L188] is required.

1. The notion of a causal diamond (CD) (see **Fig. 13.11**) 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 [L96]) via the  $M^8 - H$  duality [L158, L180, L181].
2. The quantum formulation based on the notion of fini-dimensional moduli space of CDs forming that backbone of WCW [L215]. This formulation makes it possible to get rid of various uncertainties of the earlier formulations. The sequences of "small" state function reductions (SSFRs), or rather a sequence unitary transformations, which in the moduli space of CDs correspond to dispersion analogous to that associated with Schrödinger equation followed by localizations in the moduli space (SSFR) as position measurements. These are the TGD counterparts of sequences of measurements of the same observables. Present are also "big" SFRs (BSFRs) changing the arrow of time and serving as the TGD counterparts of the ordinary SFRs.
3. 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/y17oIUy>) [L188].

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 [L193] 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  $\hbar_{eff}$  with arbitrarily large values. There is empirical support for BSFRs.

1. The findings of Mineev *et al* [L141] for atomic systems can be explained by the same mechanism [L153]. 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 [J31] 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 [J19] 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 [L154, L137].

In biology, the reversals of AT may occur routinely [J133] 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 [L157, L221]. 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 [L184] 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 [L184]. 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 (see **Fig. 13.11**). 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” [L89, L90, L91, L145, L180, L181]. 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 [L180, L181] 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  $P(o)$  [L145, L180, L181].

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 [J26] 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 [L226] 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 [L178]. 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 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.

### 13.3.3 Negentropy Maximization Principle (NMP) as variational principle of consciousness

Negentropy Maximization Principle (NMP) defines the variational principle of consciousness in TGD [K61] [L195].

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 [L97, L102] 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 [I67] has proposed that SL implies evolution. This statement seems to be in conflict with the standard thermodynamic view of biology [L48].

England’s view that SL implies evolution, is clearly in error. NMP [L195] 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 [K61] [L195].

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 [L48].

p-Adic number fields, combining with real numbers to form an adele, are needed [L97, L102]. 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 [L180, L181]. 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  $h_{eff} > h_0$  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.

## 13.4 TGD and quantum biology

Often, problems have served as starting points for developments in TGD. This also applies to biology. The following list includes some examples. A more detailed discussion is in [L136].

1. How can one understand the coherence of living systems? If bio-chemistry alone explained life, we would be sacks of water with some chemicals added. Sacks of water do not climb in trees or write poems. Could quantum coherence induce ordinary coherence? What entities serve as intentional agents and how could they realize their intentions?
2. Why is metabolism needed? Particles with nonstandard  $h_{eff}/h_0$  have a higher energy as a rule. Is metabolic energy needed to excite particles to dark states and thus to increase their "IQ"? Could evolution be seen as an increase of  $h_{eff}/h_0 = n$  as the dimension of EQ forced by the fact that the number of extensions with a dimension higher than a given integer  $n$  is infinitely larger than the number of extensions with a dimension smaller than  $n$ .
3. Is the genetic code (GC) totally accidental? Could the biochemical realization of the GC mimic a deeper level of the GC?
4. What is morphogenesis? If biology is merely biochemistry, this question remains unresolved. However, if space-time topology is non-trivial at all scales, the situation changes dramatically. All structures - *including bio-molecules, membrane like structures, organelles, organs, etc.* - are 4-D space-time surfaces representing dynamic patterns, and morphogenesis emerges at a classical level in the 4-D sense [L135, L77]. Holography implies that 3-D surfaces are equivalent to corresponding 4-D surfaces as analogs of Bohr orbits. Thus ZEO replaces the ordinary quantum state as a structure with zero energy state as an analog of function, behavior, or program and notions such as 4-D brain emerge. One might even say that structure and function are equivalent.

The model for living matter relies heavily on the notions of MB carrying  $h_{eff} > h$  phases behaving like dark matter and ZEO.

### 13.4.1 MB carrying dark matter as controller of ordinary biomatter

MB contains dark matter identified, as phases of ordinary matter characterized by EQ with a dimension  $n = h_{eff}/h_0$  serving as a measure of the algebraic complexity of a given space-time region [L180, L181], 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 [L157].

#### 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 [L155].

Also the Earth’s magnetic field with nominal value of  $B_E = .5$  Gauss has two parts.

1. The monopole flux part (see **Fig. 13.14**) 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 [J47].

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 [L176]. 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 [L201]. 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  $\Delta E_c$  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 [J47] 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 [K14, K23].

3. For the value  $v_0/c \simeq 2^{-11}$ , suggested by the Nottale's model for planetary orbits [E1], 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 [L200]. The most plausible solution [L200, L191] is  $\beta_0 = v_0/c = 1/2$  for living matter so that gravitational Compton length  $\Lambda_{gr} = GM/\beta_0$  equals to Schwarzschild radius at the surface of Earth. and brings nothing new to the original Nottale hypothesis.

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 [L29, L28] 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 13.3.2).

### Evidence for dark charged particles

The notion of dark matter as a controller of biomatter preceded its justification based on number theory [L96, L97].

1. The values of  $h_{eff} = nh_0$  must be so large that the energies  $E = h_{eff}f$  of dark photons with EEG frequencies are in the biophoton energy range (visible and UV) assignable to molecular transitions [K14, K23].
2. What makes the large values of  $h_{eff}$  possible? Nottale's hypothesis [E1] introduces the notion of the gravitational Planck constant  $\hbar_{gr} = GMm/v_0$ , whose form is fixed by an Equivalence Principle (EP). In the TGD framework,  $h_{eff} = h_{gr}$  is assigned to gravitational flux tubes [L139]. There are non-trivial implications that reflect EP.
  - (a) The cyclotron energy spectrum  $E_c = n\hbar_{gr}eB/m = nGMeB/v_0$  does not depend on the mass  $m$  of the charged particle and is thus universal. The energies involved are proposed to be in the range of biophoton energies (at least) suitable for control of the transitions of the bio-molecule. One cannot exclude lower energies above thermal energy for physiological temperature.
  - (b) The gravitational binding energies of a mass  $m$  for Bohr orbits around  $M$  do not depend on  $M$  at all [L201].

Also relatively small values of  $h_{eff}$  are possible.

1. Electrons can also have dark phases, but now the value of  $h_{eff}$  would be much smaller and satisfy the generalized Nottale hypothesis  $h_{eff} = h_{em}$ , where  $h_{em}$  is the electromagnetic analogue of  $h_{gr}$  assignable to flux tubes accompanying valence bonds. This inspires a model

of valence bonds [L186] (<https://cutt.ly/5f5QrgF>) predicting that the value of  $h_{eff}/h_0 = n = h_{em}$  increases along the rows of the Periodic Table.

This picture can explain why molecules such as proteins containing atoms towards the right end of the rows of the Periodic Table are ideal carriers of metabolic energy. It also explains why ions, such as  $\text{Ca}^{++}$  involved with the control and communications of the cell membrane with the “large” part of MB and having very large  $h_{eff} = h_{gr}$ , are towards the left end of the rows.

2. The energy scale of dark variants of valence electrons is proportional to  $1/h_{eff}^2$  so that the orbital radii are scaled up and the identification as a Rydberg atom provides the only possibility in the standard physics model. Could dark valence electrons be in question? There is empirical evidence, known for decades, for the mysterious disappearance of valence electrons of some rare earth metals in heating. An article by Chatterjee *et al* [L95] discusses this phenomenon for Yb.

The finding [D6] about “misbehaving” Ruthenium atoms also supports the view that covalent bonds involve dark valence electrons. Pairs of Ru atoms were expected to transform to Ru dimers in thermo-dynamic equilibrium but this did not happen. This suggests that valence electrons associated with the valence bond of Ru dimers are dark in the TGD sense and the valence bonded Ru dimer has a higher energy than a pair of free Ru atoms.

TGD based explanation [L105] could be justified by a resonant coupling of dark electron with an ordinary Rydberg state of the valence electron. In the lowest approximation, dark valence electrons have energies in the spectrum of ordinary valence electrons so that a resonant coupling with Rydberg states can be considered. The evidence found by Randell Mill [D7] for atoms with an abnormally large scale of binding energy suggests the formula  $h = 6h_0$  [L104]. Atomic binding energies are proportional to  $1/h_{eff}^2$  and Mills reports that the binding energy scale can be 4 times larger than for ordinary atoms. This would correspond to  $h_{eff} = h/2$ .

### Pollack effect

In the Pollack effect (PE) [I70] negatively charged exclusion zones (EZs) are induced at the boundary between the gel phase and water by an energy feed such as IR radiation. The negative charge of EZ is explained as a formation of flux tubes carrying dark protons, which are interpreted as dark nuclei. Every 4<sup>th</sup> proton should transform to a dark proton transferred to the flux tubes to explain the observations.

A simple model for linear dark proton triplets predicts their states to be in a 1-1 correspondence with DNA, RNA, tRNA, and amino-acids and the numbers of codons coding for given amino-acid are predicted to be the same as for the vertebrate genetic code [L130, L156]. This suggests deep connections between nuclear physics and condensed matter physics, chemistry, and biology, which, in the reductionistic spirit, are considered separate disciplines.

EZs are able to remove impurities from their interior in conflict with the second law of thermodynamics (SL). The TGD based explanation is that the time reversal by BSFR at the level of MB [L188] also induces an effective time reversal in long time scales at the level of ordinary bio-matter.

PE explains the occurrence of a charge separation in living matter. DNA has one negative charge per nucleotide, microtubules are negatively charged, the cell is negatively charged, and ATP carries 3 units of negative charge. Therefore ZEO suggests that PE plays a key role in bio-control and macroscopic SFRs play a key role in living matter.

### Basic differences between organic and in-organic matter

One of the basic differences between organic and in-organic matter would be the presence of dark protons and electrons.

1. The notions of acids and bases would reduce to the presence of dark protons: pH would characterize the fraction of dark protons. Reduction and oxidation (the REDOX reaction) could be understood in terms of a transfer of dark electrons associated with valence bonds [L224] (<https://cutt.ly/5f5QrgF>).

2. In biochemistry the density of dark protons would be much higher in PE [I46, I45, L34, I70, I86]. Dark ions could play a key role in TGD based view of biochemistry as the findings of Blackman and others suggest [J47].

### Biocatalysis and water memory

Bio-catalysis and water memory [I84] remain mysteries in the bio-chemical approach. MB carrying dark matter could provide the needed mechanisms. Reconnection of flux tubes would be the basic mechanism of bio-catalysis and also explain water memory, which in the TGD framework forms the basis of the immune system [K48].

1. According to the TGD view of catalysis, tentacle-like U-shaped flux tubes associated with MBs of reactants reconnect to a pair of flux tubes connecting the molecules [L134]. This happens if there is a cyclotron resonance for dark cyclotron radiation assignable to massless extremals (MEs) associated with these “tentacles”. This requires that the flux tubes have identical magnetic field strengths and - by flux quantization - the same thickness. The same value of  $h_{eff}$  guarantees resonance. The next step is the shortening of the “tentacles” by a reduction of  $h_{eff}$  and the liberation of energy which “kicks” the reactants over the potential wall making an otherwise extremely slow process possible.
2. The physics of water is plagued by anomalies [I84]. TGD suggests an explanation [L108] in terms of flux tubes assignable to hydrogen bonds [L108, L133]. These flux tubes could have  $h_{eff} > h$  so that these flux tube could be long and give rise to long range quantal correlations. Water could be seen as a many-phase system. MBs assignable to water molecule clusters could mimic the cyclotron frequency spectrum of the invader molecule and make possible water memory and a primitive immune system based on reconnections of the “tentacles” of a water cluster and invader molecule [L177]. In this framework water would represent a primitive life form.

### 13.4.2 Adelic physics, cognition, and biology

$M^8 - H$  duality [L158, L180, L181] 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 [L184, L195].
3. Galois confinement [L177] 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 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 [L195, L193] 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)?

### 13.4.3 Genetic code (GC)

The model of bio-harmony [L39, L40, L156, L175, L192] 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 fifths, reduced by an octave equivalence (notes differing by octave are experienced as equivalent) 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 [L130], 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 [L156].
2. Dark proton triplet - dark codon - would be analogous to baryon and Galois confinement [L177] 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 [L192]. 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) [L194].

## 13.5 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 [K54, K53]. 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.

### 13.5.1 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 [J75]. 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 [L178]. 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) [J152]. In [K82, K84] 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 [K16]). 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 [K23, K14].

Dark Josephson radiation would make information transfer to MB possible whereas the control signals from the MB would be as dark cyclotron photons. **Fig. 13.15** illustrates the communication of sensory data to the “big” part of MB as dark 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 [K33].
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 [L191].
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  $\Delta f_J$  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 [K86, K33, K89] 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 [L224]. The model of Galois confinement (GC) based on the notion of bio-harmony [L39, L40, L175, L192] and the notion of GC [L184] 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 [L175, L192]. This picture leads to a model of human language [L222, L223].

### 13.5.2 A new 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 [L131]. 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 [L182, L183] based on three ZEO and the notion of CD (see **Figs. 13.11** and **13.12**) 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 percept 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 [L131] [K86]. 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 [L131]. 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. **Fig. 13.15** illustrates the back and forth communications of sensory data between sensory organ and brain using dark photons.

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 require 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 [K48], 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 [L188, L145].

### 13.5.3 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 (see **Fig. 13.11**) with maximal size located in the middle of the CD. If one accepts  $M^8 - H$  duality [L158] “geometric now” corresponds to a “special moment in the life of self” [L158, L187] 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 (see **Fig. 13.11**), the order of recalled memories is opposite to that of the original experience. There is evidence for this kind of change [J138] (see also the popular article at <http://tinyurl.com/y7hbmug>).

## 13.6 Aging and death from TGD point of view

ZEO based vision is that aging and death are universal phenomena and that death is followed by a reincarnation with a reversed AT.

### 13.6.1 Aging as approach of MB and BB to thermal equilibrium

The book “Lifespan” by Sinclair and LaPlante [I22] proposes that aging corresponds to an approach to epigenetic chaos. The book also proposes that bio-information is not only associated with DNA and GC but also the conformational degrees of DNA and that these are crucial in epigenesis. This vision serves as the starting point of a TGD inspired view of aging written with Reza Rastmanesh [L225].

In adelic physics, NMP [L195] replaces the second law (SL) but implies SL. MB carries dark matter and controls dynamics. Its quantum coherence induces non-quantum coherence of ordinary biomatter. The dissipation of a subsystem with a reversed AT looks like self-organization (SO) from the point of view of the outsider. Also self-organized quantum criticality (SOQC), which is difficult to understand in ordinary thermodynamics, can be explained.

The basic idea is that at birth the temperatures of the MBs of the information molecules are very low but gradually they approach the physiological temperature near the Hagedorn temperature  $T_H$  [B7] defining the maximal temperature of MB.  $T_H$  is determined by string tension as the energy density of the flux tube and much lower than  $T_H$  in superstring theory or in the hadronic string model.

The thermalization leads to epigenetic chaos implying that the flux tubes carrying dark DNA and therefore also ordinary DNA, become looped. The control of methylation and other modifications and their reversals crucial for epigenesis is lost. In particular, demethylation fails and leads to hyper-methylation of the promoter regions of genes. This leads to the failure of the control of genes coding for housekeeping proteins and eventually the system suffers collapse.

### 13.6.2 What death as BSFR looks like to an outsider?

One can enote the moment of geometric time associated with BSFR of a dying and reincarnating system by  $T$ ; the dying system before death as  $S$  and its time-reversed reincarnate after death as  $R$ . Consider an outsider, labelled  $O$ . Refer to the AT of  $O$ , opposite to that of  $R$ , as standard AT. How does  $O$  see the situation before  $T$  and after  $T$ ?

### Death as seen by outsider before moment $T$

$T$  can be larger than the “geometric now” of  $O$  so that the death of  $S$ , which has taken place with respect to the subjective time of  $O$  is located in the geometric future of  $O$ .

The time evolution of  $R$  allows classical signals to propagate in a non-standard time direction. This could explain the reported strange events preceding the death of a close relative or a friend. In neuroscience, the analog for this is what happens in Libet’s experiments involving active aspects of consciousness [J31]. The brain receives a time reversed signal arriving from the geometric future. This signal is interpreted in the standard picture as a readiness potential.

Although BSFR is a discontinuous change with respect to subjective time, ZEO implies that  $O$  sees the outcome of BSFR of  $S$  as an average over continuous and deterministic time evolutions with the standard AT leading to its death. The outcome for a single time evolution is actually the initial state of a time reversed time evolution of  $R$ .

Dissipation with the reversed AT is a conspicuous thermo-dynamic anomaly implied by BSFR. For  $O$ , this looks like SO, which involves generation of gradients. In particular, the extraction of energy from the environment manifests as a cooling of the environment [L221]. It may be possible to test this prediction.

### Death as seen by an outsider after moment $T$

The life of the  $R$  increases its CD in an opposite direction of time (see **Fig. ??**). The CD of  $R$  eventually remains in the geometric past of those still alive. What happens in the region of space-time surface in  $H = M^4 \times CP_2$  in the future of the CD of  $R$ ?

What  $O$  see, is the decaying organism. The interpretation is that the highest layer of the onion-like MB is absent and does not continue its control in the original time direction. The ship has “lost its captain”. The layers of MB corresponding to the lower levels of the hierarchy are also expected to disappear. The decay of the organism continues down to the lowest molecular levels.

Note that death can be seen as a cascade of BSFRs proceeding downwards to shorter scales and destroying quantum coherence since the metabolic energy feed keeping the distribution of the values of  $h_{eff}$  unaffected is not present or usable.

Geometrically the “loss of a captain” means that the CDs in the personal hierarchy of CDs cease to increase in size by SSFRs as they suffer BSFR.

Physically the loss means that dark photon radiation from BB providing metabolic energy to the highest control level of MB is not needed anymore and dark photons leak out as biophotons. The same happens at all levels as death proceeds to smaller scales.

Direct evidence here is the biophoton emission from dying plants, which intensifies and is used to deduce the vegetable age.

## 13.7 Evidence for life after death in universal sense

In any BSFR, the self, - identified as a sequence of SSFRs -, can be said to die and reincarnate with a reversed AT and continue to live as a conscious entity with a reversed AT. Selves thus live back and forth in geometric time. Experience from the previous life cycle would be represented as “silent wisdom” at the passive boundary of CD (PB), and experienced as mental images which need not be directly conscious or are barely conscious.

### 13.7.1 General signatures of life with reversed arrow of time

The time reversal at the level of MB occurs over considerably longer spatio-temporal scales than for ordinary matter with  $h_{eff} = h$  and induces an effective time reversal at the lower levels. This makes it possible to assign well-defined signatures to the presence of time reversed conscious entities. In the TGD Universe life and death are universal phenomena so that these signatures should appear at all scales. This makes it possible to test the theory if these general assumptions are accepted.

1. Time reversal implies that the thermo-dynamic AT for some layers of MB is non-standard. This can induce thermo-dynamic anomalies at the level of ordinary matter. Already Fantap-

pie [J133] proposed that time reversal is common in living matter and introduced the notion of syntropy as time reversed entropy.

To  $O$ , dissipation with a reversed AT looks like a development of various kinds of gradients assignable to temperature, pressure, various chemical concentrations in biochemical systems, and to electric and magnetic fields.

In particular, cooling of the environment of a system, for which some layer of MB has suffered time reversal, is possible. This might explain anecdotal reports of eerie, cool spaces, where ghosts are said to be present.

Ordinary dissipation implies the decay of various structures, such as the decay of biomolecules to simpler building bricks. ATs of these processes can occur and the self-assembly of biomolecules challenging SL in its standard form could, at least in some cases, involve time reversal.

2. SO could be induced, not only by an active energy feed, but by a time reversed dissipation of the ordinary bio-matter induced by MB [L157]. There is evidence that living systems are quantum critical systems [I78]. In TGD, the entire Universe is quantum critical in the sense that the values of the fundamental coupling constant (Kähler coupling strength), are analogous to critical temperatures.

Self-organized criticality (SOC) is a phenomenon difficult to understand in standard physics. Criticality is, by definition, unstable since the critical degrees of freedom act as repellers of dynamics. Even the smallest perturbation can lead far away from the repelling point. If the arrow of time is reversed, the repeller becomes an attractor and the system tends to stay near criticality. This would give rise to self-organized quantum criticality (SOQC) [L221].

### 13.7.2 Examples about BSFR and death in various scales

Some examples about BSFR as the death of a conscious entity in various scales are in order.

#### Pollack effect and time reversal

The generalization of the Pollack effect (PE) [I46, L34, I86, I70] plays a key role in TGD inspired biology.

1. As previously explained, PE occurs in the presence of an energy feed such as IR photons, and means a charge separation in water bounded by gel, forming a negatively charged exclusion zone (EZ).
2. EZ has a strange property of driving out impurities: this is a thermodynamic anomaly (along with charge separation). The interpretation is that AT is changed at MB controlling EZ and induces an effective change of AT at EZ differing from the standard AT of an observer positioned outside.

In the TGD framework, PE also generalizes to other ions than  $H^+$  - at least the positively charged ions inside neuronal (cell) membrane. Negatively charged entities are indeed abundant in biology.

1. DNA nucleotide involves a negatively charged phosphate ion. This suggests that DNA strands are accompanied by parallel magnetic flux tubes which carry dark proton triplets as a representation of genetic codons [L78, L156, L175].
2. The cell interior is negatively charged, which suggests similar charge separation with the positive charge assignable to dark ions at the magnetic flux tubes outside the cell. Bosonic ions such as  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $Fe^{2+}$  and Cooper pairs of fermionic ions such as  $K^+$ ,  $Na^+$ ,... could form Bose-Einstein condensates (BECs). Also negatively charged ions, such as  $Cl^-$ , could form BECs at flux tubes.
3. Microtubules carry a constant negative charge density per unit length realized in terms of GTP molecules suggesting that they are accompanied by parallel flux tubes carrying dark charges, such as dark protons. Microtubules could be partially responsible for the negative charge of the cell and could relate to the control of the membrane potential.

### BSFRs and homeostasis as self-organized quantum criticality

The article “*Homeostasis as self-organized quantum criticality*” [L221] represents an attempt to understand the properties of cold shock and heat shock proteins (CSPs and HSPs). Since these proteins are similar, it may be preferential to talk about stress proteins (SPs) as having two different operational modes.

The problem of understanding the behavior of SPs turns out to be only one particular facet of a more general problem: how is self-organized criticality (SOC) or even a quantum variant of SOC (SOQC) possible? Kauffman represented empirical evidence for quantum criticality at the level of bio-chemistry [I78]. As previously explained, ZEO leads to a theory of SO and of SOQC.

In fact, living systems as a whole may be quantum critical and manage to stay near criticality, which means that SOQC could be interpreted as homeostasis central for life. There would be no life without death: homeostasis would be possible only by the temporary death/sleep/hibernation of subsystems. Homeostasis would not be due to extremely complex biological programs but caused by the dissipation with a reversed AT driving the system towards quantum critical configuration.

### Bio-rhythms as life-death cycles and living clocks

In the TGD Universe, living matter is a population also in 4-D sense. Periodic biological processes would correspond to sequences of CDs associated with sub-selves living back and forth in geometric time.

In the geometric future of a given CD, the decay process occurs and is followed by a generation of the self corresponding to the next CD in the sequence: this self must be distinguished from time-reversed re-incarnate in its geometric past. The first half-period (lower half-cone of CD) would correspond to life and the second half-period (upper half-cone of CD) to a decay process. The next period would correspond to the next CD in the sequence defining a living and conscious biological clock.

EEG rhythms could be associated with these kinds of life forms. There is indeed evidence that the first half of the EEG period is ordered and the second half is chaotic [J79]. The single EEG half period as a counterpart to a living system would represent mental images shifted towards the geometric future, inside the CD, after its birth.

Perhaps most periodic processes identifiable as bio-rhythms are such processes. The most obvious examples are breathing and heartbeat. At longer time scales the annual cycles represent similar examples.

### 13.7.3 Direct subjective evidence

NDEs provide subjective evidence for the continuation of conscious experience after death at the level of human conscious experience. The universality of death as BSFR also suggests other evidence.

#### Sleep, anesthesia, and hibernation as “small” deaths?

Sleep, anesthesia, and hibernation could involve BSFR at some layer of MB. Falling asleep would be a “small” death and waking up a “small” rebirth. No dramatic changes of world view usually occur during sleep. Can one conclude that the layer of MB and the corresponding CD are not changed dramatically in size so that the physical decay processes are avoided? The layer of MB could correspond to a considerably smaller size scale as in the case of biological death: this layer is not the “boss” at the highest level so that ship would still have the captain and the decay processes would not start.

#### After images as re-incarnations in the usual sense

The phenomenon of after images, discussed from the TGD point of view in [K14], suggests that mental images arise and die. The reincarnation of a mental image as an after image is analogous to “ordinary” reincarnation and is distinguished from re-incarnation with a reversed AT. The mental images would shift to the geometric future of the “geometric now” and repeat their karmic cycle and experience BSFR in memory recall.

The process generating after images would be analogous to the proposed process behind bio-rhythms. MB could have loops such that the signals circulating around loops serve as a sensory input and generate sequential after images.

## 13.8 Near-death experiences (NDEs)

The Wikipedia article “Near-death experience” [J11] gives a good overall view of NDE, research on NDE, and theories of NDE.

Raymond Moody, the pioneer of NDE, wrote “Life after Life” (1975) [J155] consisting of interviews with NDErs. Two accounts by medical professionals about personal NDE convinced them that the standard neuroscience view of NDE was wrong. Books by Mary Neal [J143] and by Eben Alexander [J62] conveyed a similar message.

NDE can be studied scientifically. The article by Lichtfield [J109] summarizes the empirical research. Retrospective research relies on interviews of NDErs and its scientific soundness may be questioned: memories many years after NDE are not reliable and a documentation about the state of the NDEr during NDE is missing. However, prospective studies can be made in hospitals so that documentation regarding patient status is contemporaneous. Interviews can be made immediately after NDE. It is even possible to test various claims such as autoscapy (seeing oneself from outside).

A book edited by Janice Miner Holden, Bruce Greyson, and Debbie James (2009) [J119] summarizes the results of 30 years of scientific investigation since Moody’s book.

Books by Pim van Lommel (2010) [J153], by Sam Parnia [J168] (2013) [?]2018), and by Bruce Greyson [J30] are recent important publications.

### 13.8.1 What are NDEs?

The challenge is to understand the structure of NDE and its often deep effect on the life of NDEr.

#### NDE experience

The following aspects of NDEs summarized in the Wikipedia article [J11] seem nearly universal. These basic aspects need not occur in the order listed below.

- Out-of-body experience (OBE) characterized as detachment from the body and seeing one’s own body from outside; awareness of being dead.
- Sensation of darkness, the tunnel experience, and movement toward/or sudden immersion in a powerful light; unconditional love and acceptance; encountering beings of light; reuniting with deceased loved ones.
- Life review.
- Decision by oneself or others to return back and reluctance to return.
- Suddenly finding oneself in one’s own body.

This view is over-simplified.

1. NDE does not always have a positive emotional tone. About 25 % of NDEs involve negative emotions such sensations of anguish and distress.
2. Universality is not complete: the notions used to describe NDE depend on culture, in particular religious background.
3. Charlotte Martial, a neuropsychologist who led a team that investigated 154 NDE cases, concluded that findings challenge the assumption about a fixed sequence of events [J90] (see <https://cutt.ly/ZkPdiBT>).

However, NDE seems to always begin with OBE and end with a return to one’s own body. The most common order of events was OBE; being aware of a tunnel; seeing a bright light;



and finally a feeling of peace. This exact sequence was reported in 22 percent of the 27 experiences that had all these 4 basic elements.

The order of basic elements of NDE may be important if the goal is to build a concrete model for NDE. Neuroscientific models may well identify components of NDE that occur in a “disturbed bodily multisensory integration” but do not provide a holistic view.

### After effects of NDE

NDE has often profound after effects. Physiological effects include heightened sensitivity to light at some frequencies, sound, and certain chemicals. Anecdotally, NDErs can also have a strange influence on electrical equipment.

Other effects include changes in behavior and social attitudes. Documented changes include

a greater appreciation for life, higher self-esteem, greater compassion for others, less concern for acquiring material wealth, a heightened sense of purpose and self-understanding, desire to learn, elevated spirituality, greater ecological sensitivity and planetary concern, and a feeling of being more intuitive.

### Physiological correlates of NDE

The following is a list of basic physiological correlates of NDE.

1. EEG is absent during the experience. There is no pulse and breathing has stopped. Oxygen based metabolism is reduced leading to hypoxia or even anoxia. It is highly questionable whether the neural activity can receive the needed energy from oxygen based metabolism.
2. Experiments with rats suggest that NDE follows an intense gamma peak in EEG (around 40 Hz) 30 seconds after death (meditative states begin with a gamma peak followed by an alpha peak). The states involving NDE can last for hours. It is difficult to understand how a clinically dead brain could give rise to NDEs at all. It is not clear how long NDEs can be.
3. Pupils are fixated and dilated so that visual experiences seem impossible. How could visual percepts be produced? It has been proposed that biophotons could produce the visual perceptions during NDE [J40] in the visual cortex. The intensity of biophotons might indeed increase in biological death (decaying vegetables emit biophotons [I51]). Visual sensations of this kind are, however, simple dots or light, phosphenes: how could they integrate to form visual perceptions?
4. Meditators can produce NDEs at will and can even control them. Also psychedelics, in particular DMT produced by the body, and present in mammalian pineal gland (PG) [J158] can predictably produce NDE-like experiences. The concentration of DMT in the hippocampus of rats having heart arrest increases.

Could the function of DMT (<https://cutt.ly/Izq2mEz>) and PG be the creation of a third person perspective (always present at cognitive level) and various aspects of NDEs and altered states of consciousness in general?

### 13.8.2 Explanations of NDE

The explanations of NDE [J11] can be classified as transcendental/religious, psychological, and physiological.

Many transcendental and religious beliefs about the after-life include descriptions similar to NDEs. According to the dualistic interpretations of NDE, the soul leaves the body temporarily during NDE.

Both dualistic, materialistic, and idealistic theories of consciousness can be criticized. Materialism has problem with free will. By requiring that conscious experiences correlate with the physical reality, it is difficult to avoid the reduction of dualism to materialism [J53]. The problems of idealistic theories are mirror images of the problems of materialistic theories.

For instance, Susan Blackmore [J163, J164, J162] is materialist and an advocate of physiological explanations. She sees consciousness as an illusion. One wonders what the identification of consciousness as one particular phenomenon of consciousness really means.

According to the neuroscientific hypothesis, NDE is a subjective phenomenon due to a “disturbed bodily multisensory integration” that occurs during life-threatening events. The experience would not reflect reality but the disturbed state of the brain. What “disturbed bodily multisensory integration” means and how it is produced, remains unclear.

There are several objections against the neuroscientific hypothesis.

1. Advanced meditators can generate NDE at will; NDE is universal - even children can have NDEs; NDE is well-organized rather than a bundle of chaotic sensations; the empirical justification of the hypothesis is missing.
2. How could a clinically dead brain produce such complex and structured perceptions and even simulate a sensory third person perspective at the level of sensory experience? We do not even understand how a living brain can produce ordinary perceptions in the first person perspective.

Concerning the explanation of NDEs there are several philosophical guidelines.

1. A cognitive third person perspective is part of the conscious experience, yet it is not easy to understand. A sensory third person perspective is even more difficult to understand from a neuroscience perspective. It is difficult to identify a physical correlate or physiological explanation for the “third person” in the physicalistic approach.
2. Eastern philosophies based on an introspective study of conscious experience emphasize that the identification of the experiencer with the physical body is illusory. Is even the notion of an experiencer only a convenient auxiliary notion? Are experiences alone fundamental as idealists argue?

It is hard to see how NDEs could be understood within a framework of materialistic, idealistic or dualistic theories of consciousness. Something new is mandated.

### 13.8.3 Psychological and physiological explanations of NDE

The summary of psychological and physiological explanations of NDE follows the Wikipedia article [J11].

#### Psychological explanations

The depersonalization model, expectation model, dissociation model, and birth model represent the basic psychological explanations.

##### 1. *Depersonalization model*

According to this model, “persons who face their impending death become detached from the surroundings and their own bodies, and no longer feel emotions, and experience time distortions”.

The Wikipedia article mentions the following objections against the model. The model does not explain NDEs for subjects who do not experience OBE; unlike NDEs, the depersonalization experiences are dreamlike, unpleasant and characterized by “anxiety, panic and emptiness”. Also, during NDEs subjects remain very lucid about their identity; their sense of identity does not change.

##### 2. *Expectancy model*

The expectancy model states that although NDEs appear very real, they are actually mental constructions in response to the stress of an encounter with death, and do not correspond to real events.

Wikipedia mentions the following objections. Subjects’ accounts often differ from their own religious and personal expectations regarding death whereas imagined scenarios would rely on their cultural and personal background. The NDEs of meditators do not conform with this proposal.

### 3. *Dissociation model*

The dissociation model proposes that NDE is a form of withdrawal to protect an individual from a stressful event. Under extreme circumstances, some people may detach from certain unwanted feelings in order to avoid the associated suffering. Detachment from one's immediate surroundings occurs.

The model explains the OBE aspect of NDE but does not say much about other aspects.

### 4. *Birth model*

The birth model suggests that near-death experiences could be reliving the trauma of birth. Since a baby travels from the darkness of the womb to light and is greeted by the love and warmth of the nursing and medical staff, the dying brain could be recreating the passage through a tunnel to light, warmth and affection.

The basic objection is that newborns do not possess “the visual acuity, spatial stability of their visual images, mental alertness, and cortical coding capacity to register memories of the birth experience”.

## Physiological explanations

A wide range of physiological explanations of NDE have been proposed and can be classified according to whether the disturbance is neuroanatomical (say abnormal activity in the temporal lobes), due to the imbalance of involved molecules, such as neural blood gas models (cerebral hypoxia, anoxia, and hypercapnia) or due to an imbalance associated with information molecules (endorphins and other neurotransmitters). Multifactorial models for NDE include an interplay of endorphins, neurotransmitters of the limbic system, the temporal lobe and other parts of the brain.

### 1. *Neuroanatomical models*

Olaf Blanke and Sebastian Dieguez [J39] suggest a neuroanatomical model assigning NDEs with a malfunction of temporal-parietal junction:

“Type 1 NDEs are due to bilateral frontal and occipital, but predominantly right hemispheric, brain damage affecting the right temporal-parietal junction and characterized by OBEs, an altered sense of time, lightness vection (sensation of bodily motion) and flying.”.

Type 2 NDEs are due to bilateral frontal and occipital, but predominantly left hemispheric brain damage affecting the left temporal parietal junction and characterized by the feeling of a presence, meeting and communication with spirits, seeing glowing bodies, as well as hearing voices, sounds, and music without vection..

According to French [J41] “ the temporal lobe is almost certainly involved in NDEs, given that both damage to and direct cortical stimulation of this area is known to produce a number of experiences corresponding to those of NDE, including OBEs, hallucinations, and memory flashbacks”.

According to Greyson [J29]

Multiple neuroanatomical models have been proposed in which NDEs have been hypothesized to originate from different anatomical areas of the brain, namely: the limbic system, the hippocampus, the left temporal lobe, Reissen's fiber in the central canal of the spinal cord, the prefrontal cortex, the right temporal lobe. Although some of the neuroanatomical models proposed may help to explain NDEs, they remain speculative at this stage since they have not been tested in empirical studies..

### 2. *Neurochemical models*

These models suggest imbalances of various neurotransmitters (such as glutamate, noradrenaline, dopamine, endogenous opioids, serotonin). There are indeed similarities between NDEs and the effects of hallucinogens.

According to Parnia [J166, J167], neurochemical models are not based on actual data. Parnia writes that no data has been collected via thorough and careful experimentation to back “a possible causal relationship or even an association” between neurochemical agents and NDE experiences.

### 3. Altered blood gas levels models

Low oxygen levels characterize life-threatening situations. Anoxia or hypercarbia (abnormally high level of  $\text{CO}_2$  in blood) are hypothesized to produce phenomena such as seeing brilliant lights, reliving past memories and OBE.

The visual cortex dysinhibition that accompanies anoxia (severe hypoxia) has been suggested as an interpretation of tunnel-like perception during NDEs.

## 13.8.4 TGD based view of biological death

This section represents a possible TGD based view of biological death. The model is of course only one particular interpretation, but is defensible by a rationale that it is based on a general vision of consciousness, biology and neuroscience, is internally consistent, and does not have any obvious conflicts with empirical facts.

### Biological death as process

The first challenge is to build a model for biological death.

1. Upon death, breathing and heartbeat cease which leads to a loss of oxygen based metabolism. EEG signals also disappear after gamma peak (at least in the case of rats). Pupils are fixated and dilated.
2. Sleep as a “small death”, is in many respects, similar to death and could represent an example of a life cycle in an opposite time direction. Falling asleep involves a shift of the EEG frequency scale below the alpha band (around 10 Hz). There are four stages of sleep and the lowest frequency scale is around 3 Hz. Since EEG wavelengths naturally correspond to the size scales of MBs, the size scale of MBs receiving sensory input would increase in the process. Gradually the sizes of MBs receiving information from BB would increase. At least four size scales for MBs corresponding to EEG bands during sleep would be involved [K102, K33, K89, L191].

This is also expected to happen in biological death. The disappearance of EEG readings could mean a shift of EEG to frequencies so low that EEG effectively disappears.

3. This would suggest that death proceeds from short to long scales in the hierarchy of MBs and CDs as the feed of metabolic energy from lower to higher levels ceases and the values of  $h_{eff}$  are reduced. Since the size scale  $L$  of CD is expected to be  $L = (h_{eff}/h)L(h)$ , its size is reduced if  $L(h)$  is not changed. This would allow the reincarnated self to experience “childhood”.

$h_{eff} = h$  need not be reduced if  $L(h)$  is reduced. One however expects that ontogenesis involves the emergence of levels with an increasing value of  $h_{eff}$  in the hierarchy of MBs/CDs.

One can see the process possibly leading to death as an attempt of higher levels  $\text{MB}_n$  of MB to resuscitate BB by dying and in this manner providing metabolic energy to the lower level. If  $\text{MB}_n$  fails,  $\text{MB}_{n+1}$  tries. If all levels fail, death is inevitable.

1. First the level  $\text{MB}_{n+1}$  immediately above level  $\text{MB}_n$  performs BSFR (i.e. it dies in order to save  $\text{MB}_n$ ). AT changes and the energy of the 3-D state initiating time reversed evolution increases since dark photons at level  $n+1$  transform to those at level  $n$  (just like dark photons can transform to bio-photons giving rise to an energy release as a plant dies). Thus  $\text{MB}_n$  receives metabolic energy. NMP forces BSFR of  $\text{MB}_n$  if the negentropy gain is larger for BSFR than for SSFR, and  $\text{MB}_n$  “wakes up” as the original AT is established.

$\text{MB}_n$  in turn performs the same operation for  $\text{MB}_{n-1}$ . If this process manages to proceed to the level of BB, revival occurs. Breathing, heartbeat, metabolism, EEG and other basic rhythms are re-established and the person experience the return to one’s own body.

2. BSFR for  $\text{MB}_{n+1}$  need not necessarily generate enough metabolic energy by time reversed dissipation to induce the revival of  $\text{MB}_n$ . In this case,  $\text{MB}_{n+2}$  tries the same. If all these attempts fail, death is inevitable.

This proposal brings to mind the story of Jesus who died to save mankind. There are also variants of the story where Jesus lived another life before resurrecting: is this time reversed life? Myths may tell us something that our present day science cannot express.

### What could the peak in EEG gamma band mean?

The death process begins with a peak of EEG activity (at least in the case of rats) over the entire brain lasting about half a minute.

Consider a summary of the findings concerning the EEG of rats suffering cardiac arrest, as given by Bokkon *et al* [J40]. They proposed a model for the visual sensations of NDE in terms of bio-photons.

1. Borjigin *et al.* (2013) [J73] recorded EEG signals over the frontal, parietal, and occipital cortices bilaterally in rats during wakefulness, anesthesia, and cardiac arrest. Within 30 s after the rats' hearts stopped beating, cardiac arrest produced a transient and global surge of synchronized gamma oscillations of brain activity that exceeded the waking state.
2. High levels of global alpha-gamma coupling were also found. This suggests that the visual cortex can be highly activated in cardiac arrest. Previous studies indicate that alpha-gamma coupling is especially important for visual perception [J102]. In particular increased gamma intensity in an area of the brain that is right on top of the visual cortex is detected. The speculation was that the activation level is high and gives rise to visual aspects of NDE.
3. Could a gamma peak occur for humans? The proposal of Bokkon *et al* [J40] is that a gamma peak is accompanied by biophotons assumed to be created by radicals related to oxygen based metabolism and these give rise to NDE. There is evidence that light induces phosphene like sensations in the brain but it is difficult to understand how this could lead to a highly organized sensory perception. Also the assumption that biophotons originate from molecular transitions is questionable since there is no discrete spectrum characterizing molecular transitions.

What could be the exact function of the EEG peak in the gamma band?

1. The EEG peak could mean communications between BB and MB and control by MB. Gamma peak correlates with vision and gamma activity couples to alpha activity: gamma peak and its coupling to alpha is known to occur in the transition to a meditative state and NDE has basic aspects of the meditative state.
2. Could the gamma peak correspond to dark photons with energies of visible light? Could the gamma peak relate to the first stage of NDE involving the tunnel experience and darkness, which is also a visual experience, rather than a lack of visual consciousness, and theorized to be based on a narrowing of the visual field caused by anoxia?
3. How could the gamma peak relate to the experience of seeing light and light beings? These perceptions are not congruent with the effects of hypoxia or anoxia. Where does the light come from and where is it received? Does the light arrive from personal MB? Retinas cannot serve as receptors since during NDE they are not functional. Hence the proposal that NDE could correspond to virtual sensory input from MB to the eyes is not plausible.
4. Could MB utilize PG - the "third eye" - as a sensory receptor to which dark light would be transferred from MB via visual cortex. This may also provide an understanding of auditory experiences during NDE if dark photons are also the mediators of auditory information, perhaps transferred to ears.

### Pineal gland as "third eye" in NDE?

The pineal gland (PG) - colloquially referred to as the "third eye" and the principal seat of the soul by Descartes - carries pigments like the retina in the eye and indeed serves as an eye for some animals. What about us? Could visual imagination utilize PG as an eye? Could PG take the role

of the eye during NDEs during which virtual sensory input to the eyes (as in case of REM sleep) is not plausible?

A feedback loop between MB and PG could, in principle, make building of the sensory perceptions by a feedback loop possible. Also auditory inputs from the right and left combine to form a single perception. PG has the unique property that it has no division into left and right parts. Could it act as a central unit integrating both the right and left visual and auditory perceptions?

The presence of DMT in PGs of mammalian brain is documented [J77] (<https://cutt.ly/8k5eQSS>). According to the researchers, the discovery of PG as a source of DMT reinforces the idea of the role of this enigmatic gland in unusual states of consciousness. DMT has been linked to the generation of images in dreams, with the states of consciousness that generate NDEs and various mystical experiences. In rats suffering heart arrest the concentration of DMT in PG increases.

Rick Strassman in his aptly named book “DMT: The Spirit Molecule” has studied the effects of DMT on volunteers [J158]. DMT consistently produced NDEs and mystical experiences. Many reported convincing encounters with intelligent nonhuman presences, aliens, angels, and spirits. Nearly all felt that the sessions were among the most profound experiences of their lives.

A curious finding is that PG becomes visible in the human fetus at 49 days, which in the Tibetan traditions (see Bardo Thodol - the Tibetan Book of the Dead) is the number of days in which a soul takes to reincarnate. These coincidences led Strassman to theorize that the soul incarnates in the body at the seventh week of pregnancy.

Could one establish a connection to MB? Could the third person aspect of consciousness emerge before the first person aspect? Interestingly, small children often talk about themselves in the third person perspective.

These findings compel the question: Could PG act as a third eye - and maybe also third ear - during NDE?

1. In the TGD based model for the brain, neural transmitters and various information molecules serve as relays inducing flux tube connections. The binding to receptors would connect the magnetic flux tubes assignable to pre- and post-synaptic neurons to longer flux tubes, which act as wave guides for dark photons and mediate sensory information from sensory organs to brain, and from brain to MB (see **Fig. 13.15**).

The EEG frequencies associated with these flux tubes are inversely proportional to their length and EEG wavelengths could correspond to the flux tube lengths. Could an EEG burst also build flux tube connections for frequencies below EEG range so that communications to large layers of MB are present although not visible in EEG.

2. Various information molecules, in particular DMT which induces altered states of consciousness and is endogenous, could connect the flux tubes at the neuronal level to long flux tubes and build connections to the distant layers of MB.
3. Could DMT serve as a relay to build the flux tube connections to higher layers of MB with size scales assignable to the Earth's magnetosphere [?] and communicate its third person sensory input to PG as dark photons? The gamma peak suggests that DMT acts as a relay to build flux tube connections to the visual cortex which in turn has pre-existing flux tube connections to MB. Specifically how the “Spirit Molecule” connects to dark photons and flux tubes calls for further laboratory investigations.

In TGD framework sensory organs are carriers of sensory qualia and sensory perception requires feedback from MB and brain as a virtual sensory input as dark photons to sensory organs to build standardized mental images [L131]. In the case of NDEs virtual sensory input to eyes and ears is also absent in TGD unless REM dream periods and their possible auditory counterparts occur. A feedback loop between MB and PG could, in principle, make the construction of organized sensory percepts and pattern completion possible.

If PG serves as a kind of organizing center, not only the visual but also the auditory input during the entire NDE including OBE, tunnel experience and darkness would be amplified using PG as a sensory organ. Gamma peak would not give rise to NDE but make NDE

possible. This would be analogous to the gamma peak coupled to the alpha peak that precedes the transition to the meditative state.

4. More generally, psychedelics could act as relays inducing these kinds of connections and psychedelic experiences and NDE indeed have some common features. This leads to ask whether the anecdotal reports given by psychedelic experiencers and involving meetings with members of advanced civilizations could be real in the sense that remote sensory experience is involved [L49, L79, L80]. Note that if these experiences are based on sending light signals reflecting back with an opposite AT (BSFR for the flux tube carrying the signal), finite light velocity is not a problem.

### Could pineal gland also act as a third ear?

There are indications that PG could also act as a third ear.

1. An article by Baconnier et [J69]) tells about a discovery of calcite microcrystals in PG of the human brain. These studies were carried out using electron diffraction and Raman spectroscopy to view cubic and hexagonal morphologies. The only other known deposits of crystal in the human body occur in the otoconia structure of the inner ear. The suggestion is that this rare crystallographic symmetry has links to piezo-electric properties. Investigations continue to explore the bio-electromagnetic crystalline connection between PG and inner ear.

If calcites are also present in the ear, they could transform the incoming sound signal to dark photon signals propagating to the brain and MB and also facilitate the receipt of the virtual auditory input as dark photons transformed into acoustic oscillations. Oto-acoustic sounds are sometimes heard even by an outsider. An interesting question is whether REM sleep has an analog at the level of the ears.

In [L131] it is proposed that PG could serve as a relay station at which the dark photon radiation from MB could generate imagined visual and auditory sensations as almost-sensory experiences or send signals to the sensory organs. NDEs suggest that the sensations could already be created in PG so that in some circumstances it could act as a third ear. At the ears, the calcite crystals would transform sound to dark Josephson radiation transferred to MB, where they would generate a sequence of resonance peaks communicated back to the brain and induce a nerve pulse sequence as a cognitive representation of the sensory input.

2. The action of PG as a third ear could explain several strange subjective experiences, including my own. For instance, when I wake-up partially so that my body continues to sleep, I can hear my own snoring as an outsider and it takes time to realize that it is actually me. The intensity of the sensation is considerably stronger than usual. Does my personal MB directly listen to my breathing and perhaps also pick up sounds from the environment - at least those created signalling the presence of living entities - and communicate the sensory data to my PG to wake me up if needed? In this way MB could act as a “guardian angel”.
3. Crystals are not present only in the brain. Bones - and also PG - contain hydroxyapatite, a mineral form of calcium apatite  $Ca_{10}(PO_4)_6(OH)_2$ . Hydroxyapatite contains Posner molecules  $Ca_9(PO_4)_6$  proposed to play crucial role in quantum biology by Mathew Fisher [J145] (<http://tinyurl.com/hd3t6sr>): Posner molecules are discussed from the TGD point view in [L53] and it is proposed that the 6 phosphorus atoms could define the 6 bits of genetic codon playing a fundamental role in the dark photon communications using the GC realized as bio-harmony [L39, L40, L175, L192].

Could bones also act as transmitters/receivers of sound and dark photon signals to MB and back? Could they make the third person aspect of sensory consciousness possible and perhaps be active during sleep? Note that shivers up the spine - possibly related to quantum coherence - are induced by experiences with a strong negative or positive emotional color, in particular good music.

### 13.8.5 TGD based model for NDE

Existing data provide the groundwork for experimental tests and help to develop a more detailed picture of what happens in death and NDE.

#### What happens in OBE?

Consider first a sketch for what might happen in OBE.

1. The experience starts with OBE. The roles of the environment and observer effectively change: the perceiver becomes the perceived one. The third person aspect of experience is actually always present but not at the level of sensory input.

The following analogy may provide a further clarity. Consider a video stream of a room to a TV monitor watched by a person. The disappearance of the video stream from the monitor serves as an analog for OBE. The video stream having the monitor screen as a blind spot would be analogous to the ordinary sensory input, and the direct visual perception of the room including TV screen would correspond to the third person sensory input.

2. EEG would be flat and would not communicate sensory data about the environment via BB to MB unless it has shifted to frequencies below EEG spectrum. MB acting as the “third person” must receive sensory information about BB as seen from the outside. The sensory information could be communicated as dark photons emitted by the dying BB produced as Josephson radiation from cell membranes and as dark cyclotron BE condensates decay in the absence of a metabolic energy feed.

Eventually darkness enters: this does not however mean an absence of visual consciousness. The interpretation is that the burst of dark photons resulting from the reduction of the values of  $h_{eff}$  is over and MB cannot see BB anymore unless a secondary burst occurs.

3. An interesting challenge to this model are descriptions of NDEs involving memories of the conversations of the hospital personnel performing resuscitation. Could the sound waves in the environment generate the signals sent to MB directly?

Could the oscillations of flux tubes of MB analogous to Alfven waves and those of vibrating string provide fundamental representation of sound and the correlates for the auditory qualia: this would mean that auditory qualia are realized at the fundamental level as some eastern philosophies propose.

The proposal that GC is realized for dark photons [L175, L192] inspires the question whether dark phonons (i.e. quanta of sound) also realize GC and whether musical experiences rely on dark phonons and dark phonon triplets as basic chords coding for harmony?

#### Tunnel experience, immersion into light

Recall that a physiological explanation of the tunnel experience is as a reduced visual perception due to the metabolic restrictions caused by hypoxia or even anoxia. This model generalizes to the TGD framework.

1. In TGD framework the sudden emergence of light might be interpreted as the start of visual input from MB as sensory input to PG.
2. This does not explain the movement along the tunnel. What is moving and where it is moving? The reconnection of U-shaped flux tubes for two systems creating a pair of flux tubes connecting the systems is a necessary prerequisite for dark photon communications by resonance. Could the motion of the U-shaped flux tube (functioning as a tentacle) reaching out from the brain and eventually meeting the U-shaped flux tube from MB create the sensation of motion along a tunnel and the emergence of light? This would initiate the sensory input from MB.

One can also ask whether tunnel experience and immersion into light could be understood as sensory memories about birth as the psychological explanation of NDE proposes? Sensory memories indeed accompany NDEs.



1. The basic objection is that the memories about this period are not linguistic: the immersion to light instead of having a detailed visual view would conform with this since the infant does not cognize and cannot decompose the visual input into objects (similarly, if congenitally blind people get vision back, they see only diffuse light).
2. Note that if the child entangles with mother negentropically, he/she could share its mother's sensory mental images to perceive and perhaps even interpret the world. The experience of unconditional love and peace during this period of NDE could correspond to a memory about maximum entanglement with the mother before the moment of birth. NEDrs also report meeting light beings, relatives, friends, and beloved ones. Do they correspond to a later part of life review or does the negentropic entanglement with mother make this kind of experience also possible immediately after birth?
3. Memories would be represented essentially as sensory mental images - conscious entities living in the geometric future of the deceased self and inside its CD, which is inside the larger CD of MB. Memory mental images should radiate dark photons with positive energy located in MB and form a representation of memories.

### Life review and the decision to return

Life review at death is both an abstraction and a summary. Life review consists of experiences of the reincarnate R during NDE, when the entire brain could be dead. The survivor S remembers them. How can one understand this?

1. Sleep is "small death" and corresponds at some level of MB to a conscious state with non-standard AT. Life review is analogous to remembering conscious experiences during the sleep state. We remember from the sleeping period only our dreams.

The TGD proposal is that MB for some part of the brain (say the visual cortex) is awake during dreams. This makes communication of memory mental images possible since the signals have the AT of the awake person.

2. Could this also be true for memories in the life review experience associated with NDE. Could the dead brain have regions whose MBs are awake and make possible the communication of life review? Could the MB of PG, which would act as a guardian angel and soul, be the higher level self which communicates the life review?

What does the decision to return to life mean? Return could mean a second BSFR re-establishing the original AT leading to a revival. NMP forces BSFR [L195] so that the effective decision maker would be an abstract principle rather than a conscious entity.

### 13.8.6 After effects of NDE

The psychological after effects of NDEs could be understood in terms of the two BSFRs which can profoundly affect the "silent wisdom" associated with PB. Also the actual memories located in the half-cone representing the active half of CD are changed.

NDErs are sensitive to light at some wavelengths and their presence has anecdotally been associated with strange effects on electronics.

1. The sensitivity to light at some wavelengths should relate to dark photons having an energy spectrum in the visible and UV range. Flux tubes of MB have cyclotron frequencies (very low) but due to the large value of  $h_{eff} = h_{gr}$  the energies are in the biophoton range. The educated guess here is that the connections to some parts of MB (with cyclotron frequencies to certain wavelengths) are strengthened in NDE.
2. The emission of this light changing partially to ordinary photons (biophotons) might also cause effects on electronics. The electronvolt is the natural energy unit for charged particles accelerating along flux tubes in electronic systems. Therefore these dark photons could have effects on MB of electronic systems. Could the poorly understood  $1/f$  noise in electronic

systems be assigned to MB as an analog for biophotons resulting from dark photons? If this were the case, the distribution of flux tube lengths would be scale invariant and behave like  $1/\text{length}$  in accordance with fractality.

## 13.9 Conclusions

Let us summarize the basic vision of life after death proposed in this essay.

1. The TGD inspired theory of consciousness relies on adelic physics [L96, L97], which fuses the physics of sensory experience, based on reals, with the physics of cognition based on p-adic number fields. Entanglement negentropy is always non-positive in ordinary physics but in adelic physics it contains an additional cognitive contribution and can be positive for EQs. NMP was originally proposed as the basic variational principle of consciousness generalizing SL and implying it for ordinary matter. The net increase of negentropy is by NMP however non-vanishing. It however turned out that there is no need to postulate NMP separately. NMP is mathematically analogous to the second law and follows from the fact that the dimension of extension of rationals characterizing algebraic complexity of space-time region and therefore evolutionary level is bound to increase in statistical sense. Furthermore, NMP implies the second law.
2. According to ZEO based quantum measurement theory, consciousness, life and death are universal phenomena. This can be tested in all length scales, varying from sub-atomic to astrophysical scales, by identifying signatures of time reversal. For an observer with standard AT, dissipation with a reversed AT manifests as thermo-dynamic anomalies conflicting SL. Generation of gradients and structures, SO and also SOQC giving rise to homeostasis are the basic signatures.
3. The biological applications include models of quantum biology and of a quantum brain relying on the notion of MB and  $h_{eff} = n \times h_0$  hierarchy defining a master-slave hierarchy. The basic prediction is the quantum coherence of layers of MB with arbitrarily long size scales. MB induces the coherence of ordinary biomatter at the bottom of the hierarchy. This vision inspires a model of aging and biological death. Aging would be due to the approach of MB to a thermal equilibrium with BB. The temperature of MB increases and approaches the Hagedorn temperature [B7] of flux tubes which would be near physiological temperatures. By its large heat capacity, MB could also serve as a metabolic energy storage unit. For instance, MBs of stress proteins would serve this function [L221].
4. The TGD based model of the brain differs from the standard neuroscience view in several respects. MB controls BB and brain and uses them as sensory receptors and motor organs in a general sense. Quantum coherence makes possible the identification of sensory organs as seats of fundamental qualia - also basal ganglia inside the brain could also play this role. In particular, PG could serve as a sensory organ during NDEs.
5. A model for what happens in biological death is developed using NDEs as input. The proposal is that MB performs a hierarchical resuscitation operation: BSFR at a given level “ $n$ ” of this hierarchy induces BSFR. This however provides metabolic energy to the level “ $n - 1$ ” possibly inducing a revival so that temporary death at level “ $n$ ” gives to the possibility of rebirth as a second BSFR at level “ $n$ ”. If not, the level “ $n + 1$ ” tries the same. An analogy with the Christian resurrection story is one comparative example. The model explains the basic aspects of NDE such as OBE experience, tunnel experiences and immersion into light, meeting light beings dead beloved ones, life review, and a decision to return. OBE would correspond to a third person sensory perspective with MB in the role of perceiver. The sensory input could be sent by MB to the brain and amplified at PG taking the role of eyes and ears as a central sensory receptor.

As I wrote the first version of this chapter there were uncertainties related to the details of what precisely happens in BSFRs: for instance, could the size of CD decrease or is there a steady increase of the size. The recent purely quantal formulation of time evolution [L215] is

in terms of the finite-dimensional space of CDs with maximal isometries forming the backbone of WCW. The time evolution defined by SFRs and the counterparts of unitary time evolutions preceding them would be essentially dispersion plus localizations in the space of CDs. Much like for Schrödinger equation.

## 13.10 Appendix

### 13.10.1 Appendix A: Brief glossary of the basic concepts of TGD

The following glossary explains some basic concepts of TGD and TGD inspired biology.

- **Space-time as surface.** Space-times can be regarded as 4-D surfaces in an 8-D space  $M^4 \times CP_2$  obtained from empty Minkowski space ( $M^4$ ) by adding four small dimensions ( $CP_2$ ). The study of field equations characterizing space-time surfaces as “orbits” of 3-surfaces (3-D generalization of strings) forces the conclusion that the topology of space-time is non-trivial in all length scales.

- **Geometrization of classical fields.** Both weak, electromagnetic, gluonic, and gravitational fields are known once the space-time surface in  $H$  as a solution of field equations is known.

**Many-sheeted space-time** (see **Fig. 13.4**) consists of space-time sheets with various length scales with smaller sheets being glued to larger ones by **wormhole contacts** (see **Fig. ??**) identified as the building bricks of elementary particles. The sizes of wormhole contacts vary but are at least of  $CP_2$  size (about  $10^4$  Planck lengths) and thus extremely small.

Many-sheeted space-time replaces reductionism with **fractality**. The existence of scaled variants of physics of strong and weak interactions in various length scales is implied, and biology is especially interesting in this respect.

- **Topological field quantization (TFQ)**. TFQ replaces classical fields with space-time quanta. For instance, magnetic fields decompose into space-time surfaces of finite size representing flux tubes or -sheets. Field configurations are like Bohr orbits carrying “archetypal” classical field patterns. Radiation fields correspond to topological light rays or massless extremals (MEs), magnetic fields to magnetic flux quanta (flux tubes and sheets) having as primordial representatives “cosmic strings”, electric fields correspond to electric flux quanta (e.g. cell membrane), and fundamental particles to  $CP_2$  type vacuum extremals.

- **Field body (FB) and magnetic body (MB).** Any physical system has field identity - FB or MB - in the sense that a given topological field quantum corresponds to a particular source (or several of them - e.g. in the case of the flux tube connecting two systems).

Maxwellian electrodynamics cannot have this kind of identification since the fields created by different sources superpose. Superposition is replaced with a set theoretic union: only the *effects* of the fields assignable to different sources on test particle superpose. This makes it possible to define the QFT limit of TGD.

- **p-Adic physics** [K67] as a physics of cognition and intention and the fusion of p-adic physics with real number based physics are new elements.
- **Adelic physics** [L97, L102] is a fusion of real physics of sensory experience and various p-adic physics of cognition.
- **p-Adic length scale hypothesis** states that preferred p-adic length scales correspond to primes  $p$  near powers of two:  $p \simeq 2^k$ ,  $k$  positive integer.
- A **Dark matter hierarchy** realized in terms of a hierarchy of values of effective Planck constant  $h_{eff} = nh_0$  as integers using  $h_0 = h/6$  as a unit. Large value of  $h_{eff}$  makes possible macroscopic quantum coherence which is crucial in living matter.

- ***MB as an intentional agent using biological body (BB) as a sensory receptor and motor instrument*** . The personal MB associated with the living body - as opposed to larger MBs assignable with collective levels of consciousness - has a hierarchical onion-like layered structure and several MBs can use the same BB making possible remote mental interactions such as hypnosis [L27].
- ***Magnetic flux tubes and sheets*** serve as “body parts” of MB (analogous to body parts of BB), and one can speak about magnetic motor actions. Besides concrete motion of flux quanta analogous to ordinary motor activity, basic motor motor actions include the contraction of magnetic flux tubes by a phase transition reducing Planck constant, and the change in thickness of the magnetic flux tube, thus changing the value of the magnetic field, and in turn the cyclotron frequency. Reconnections of the flux tubes allow two MBs to get in contact and temporal variations of magnetic fields inducing motor actions of MBs favor the formation of reconnections. Flux tube connections at the molecular level bring a new element to biochemistry making it possible to understand bio-catalysis. Flux tube connections serve as a space-time correlates for attention in the TGD inspired theory of consciousness.
- ***Cyclotron Bose-Einstein condensates (BECs)*** of various charged particles can accompany MBs. Cyclotron energy  $E_c = \hbar ZeB/m$  is much below thermal energy at physiological temperatures for magnetic fields possible in living matter. In the transition  $\hbar \rightarrow \hbar_{eff}$   $E_c$  is scaled up by a factor  $\hbar_{eff}/\hbar = n$ . For sufficiently high value of  $\hbar_{eff}$  cyclotron energy is above thermal energy  $E = \hbar_{eff} ZeB/m$ . Cyclotron Bose-Einstein condensates at MBs of basic biomolecules and of cell membrane proteins - play a key role in TGD based biology.
- ***Josephson junctions*** exist between two superconductors. In TGD framework, ***generalized Josephson junctions*** accompany membrane proteins such as ion channels and pumps. A voltage between the two super-conductors implies a ***Josephson current***. For a constant voltage the current is oscillating with the ***Josephson frequency*** . The Josephson current emits ***Josephson radiation***. The energies come as multiples of ***Josephson energy***.

In TGD generalized Josephson radiation consisting of dark photons makes communication of sensory input to MB possible. The signal is coded to the modulation of Josephson frequency depending on the membrane voltage. The cyclotron BEC at MB receives the radiation producing a sequence of resonance peaks.

- ***Negentropy Maximization Principle (NMP)***. NMP [K61] [L195] is the variational principle of consciousness and generalizes SL. NMP states that the negentropy gain in SFR is non-negative and maximal. NMP implies SL for ordinary matter.
- ***Negentropic entanglement (NE)***. NE is possible in adelic physics and NMP does not allow its reduction. NMP implies a connection between NE, the dark matter hierarchy, p-adic physics, and quantum criticality. NE is a prerequisite for an experience defining abstraction as a rule having as instances the state pairs appearing in the entangled state.
- ***Zero energy ontology (ZEO)*** In ZEO physical states are pairs of positive and negative energy parts having opposite net quantum numbers and identifiable as counterparts of initial and final states of a physical event in the ordinary ontology. Positive and negative energy parts of the zero energy state are at the opposite boundaries of a ***causal diamond*** (CD, see Fig. 13.11)) defined as a double-pyramid-like intersection of future and past directed light-cones of Minkowski space.

CD defines the “spot-light of consciousness”: the contents of conscious experience associated with a given CD is determined by the space-time sheets in the embedding space region spanned by CD.

## 13.10.2 Appendix B: Figures

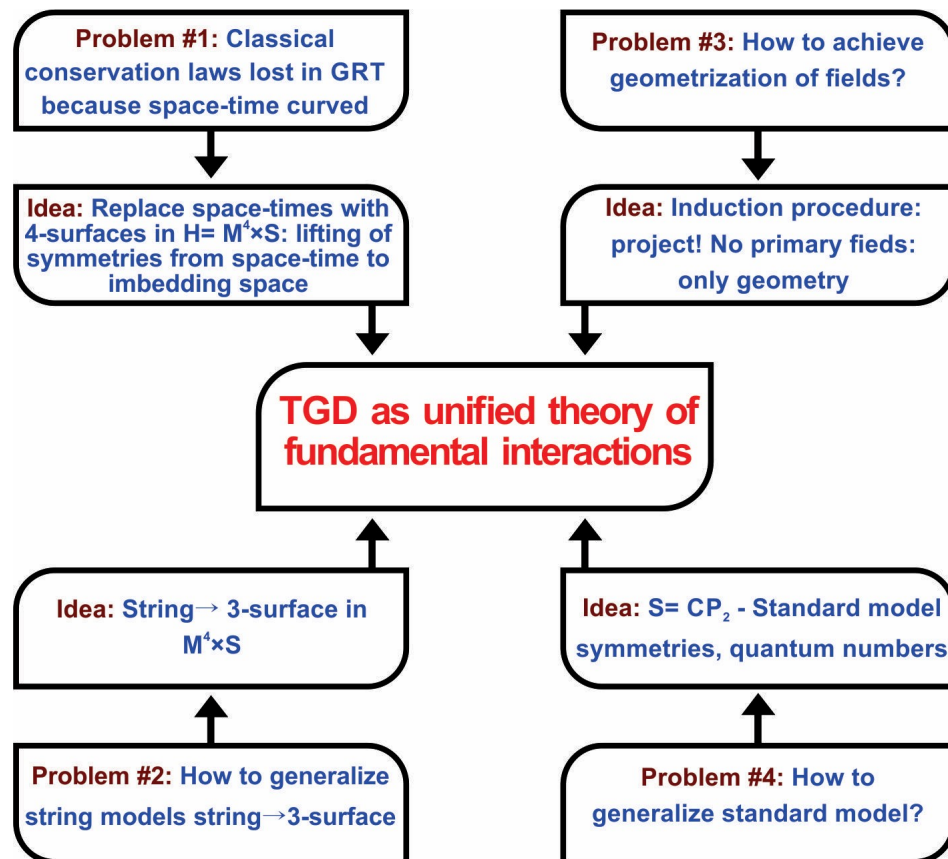
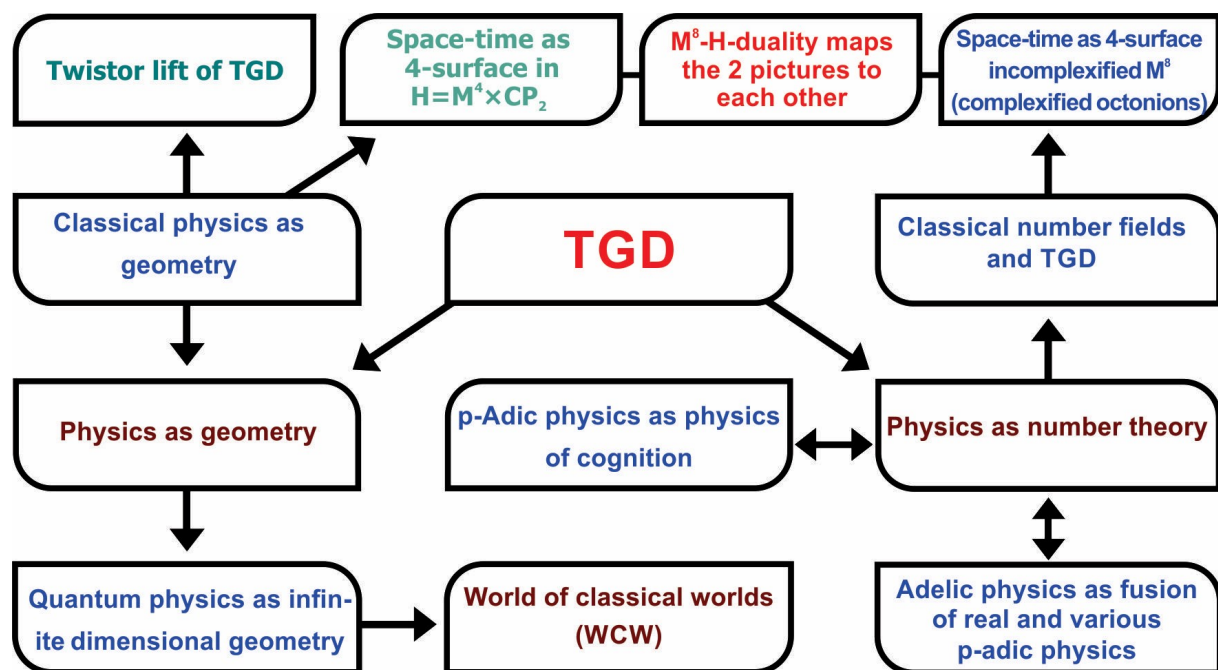


Figure 13.1: The problems leading to TGD as their solution.



**Figure 13.2:** TGD is based on two complementary visions: physics as geometry and physics as number theory.

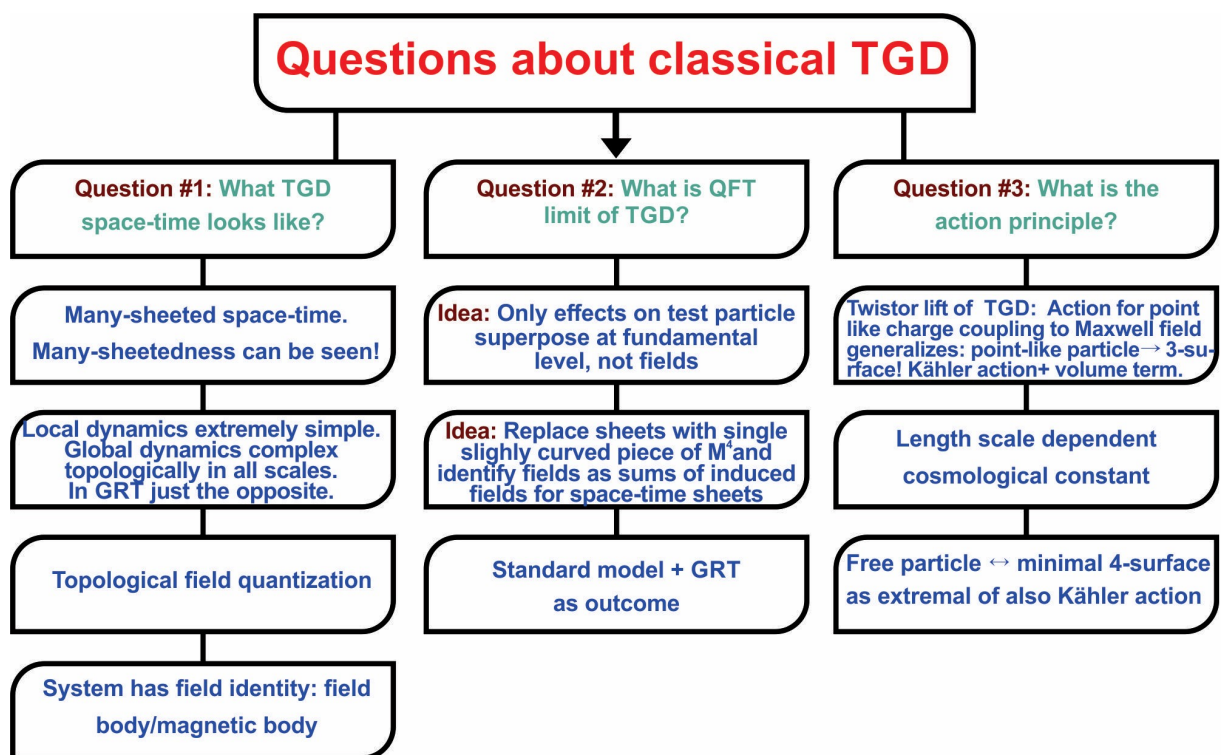


Figure 13.3: Questions about classical TGD.

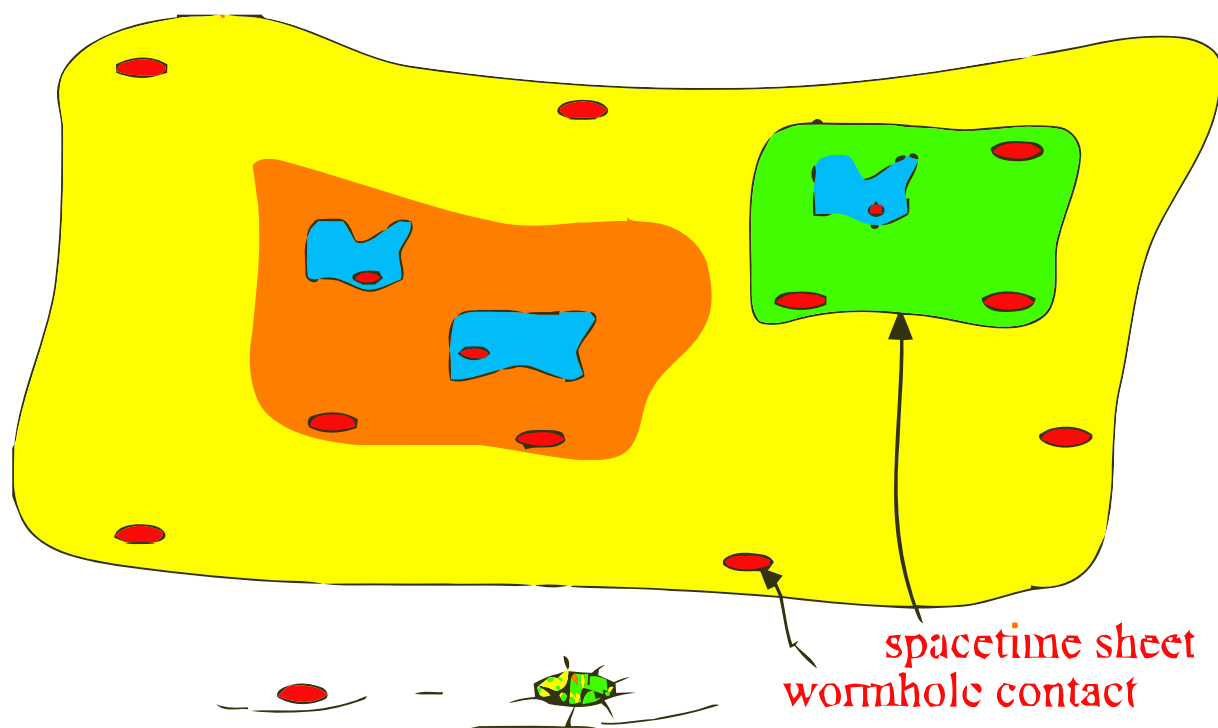
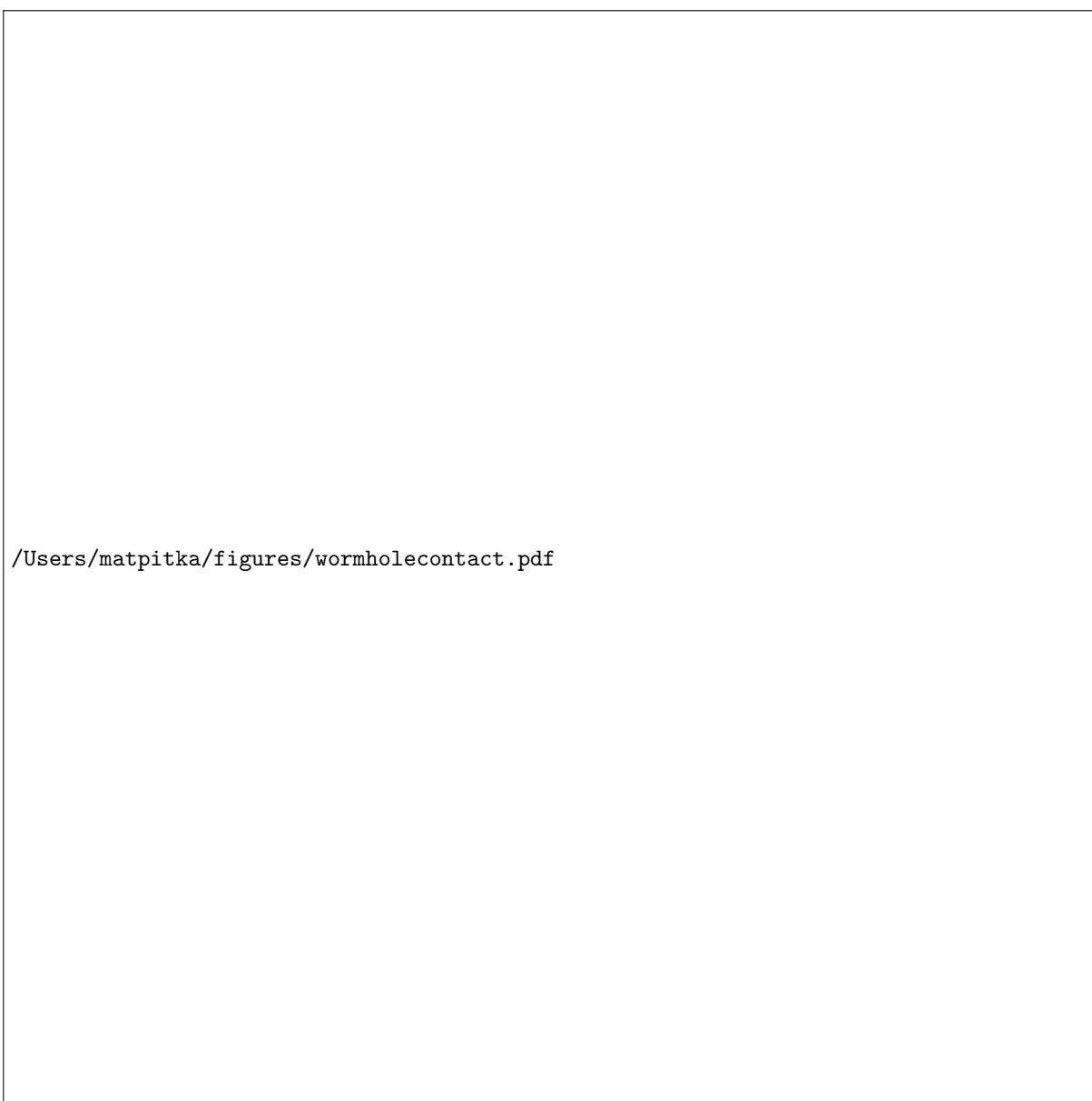


Figure 13.4: Many-sheeted space-time





**Figure 13.5:** Wormhole contact.

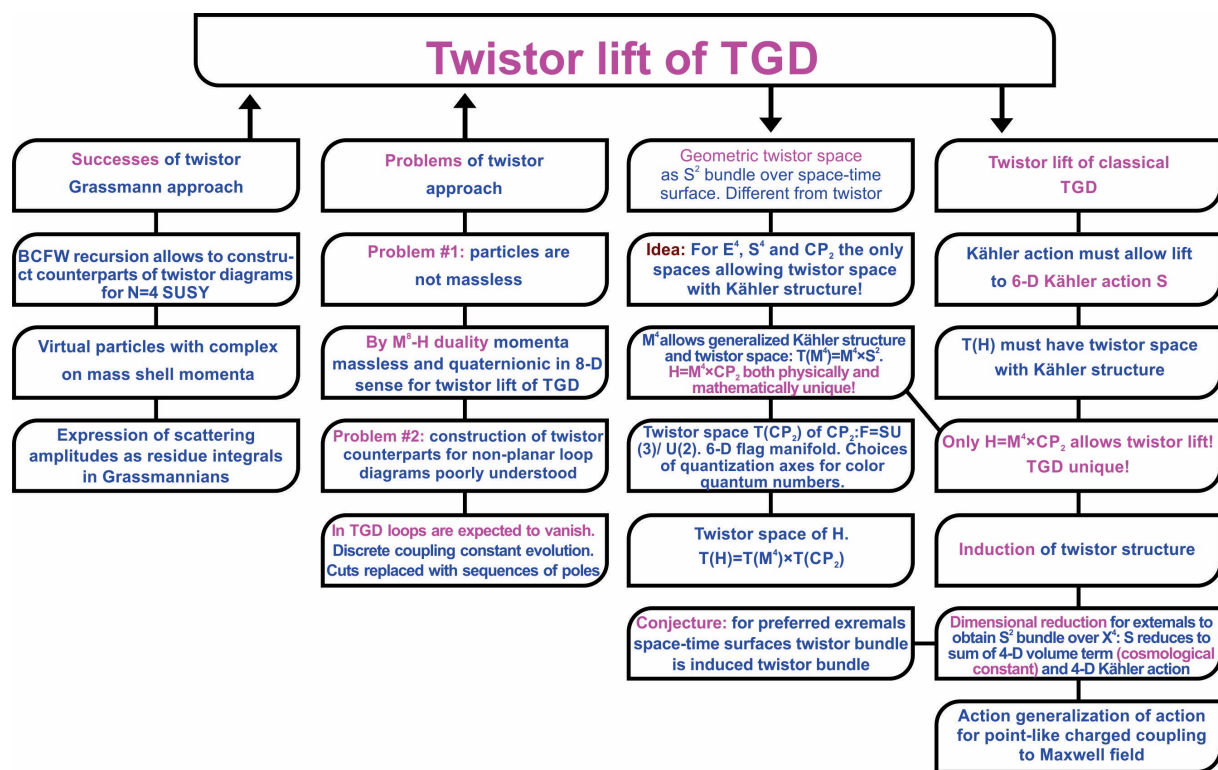
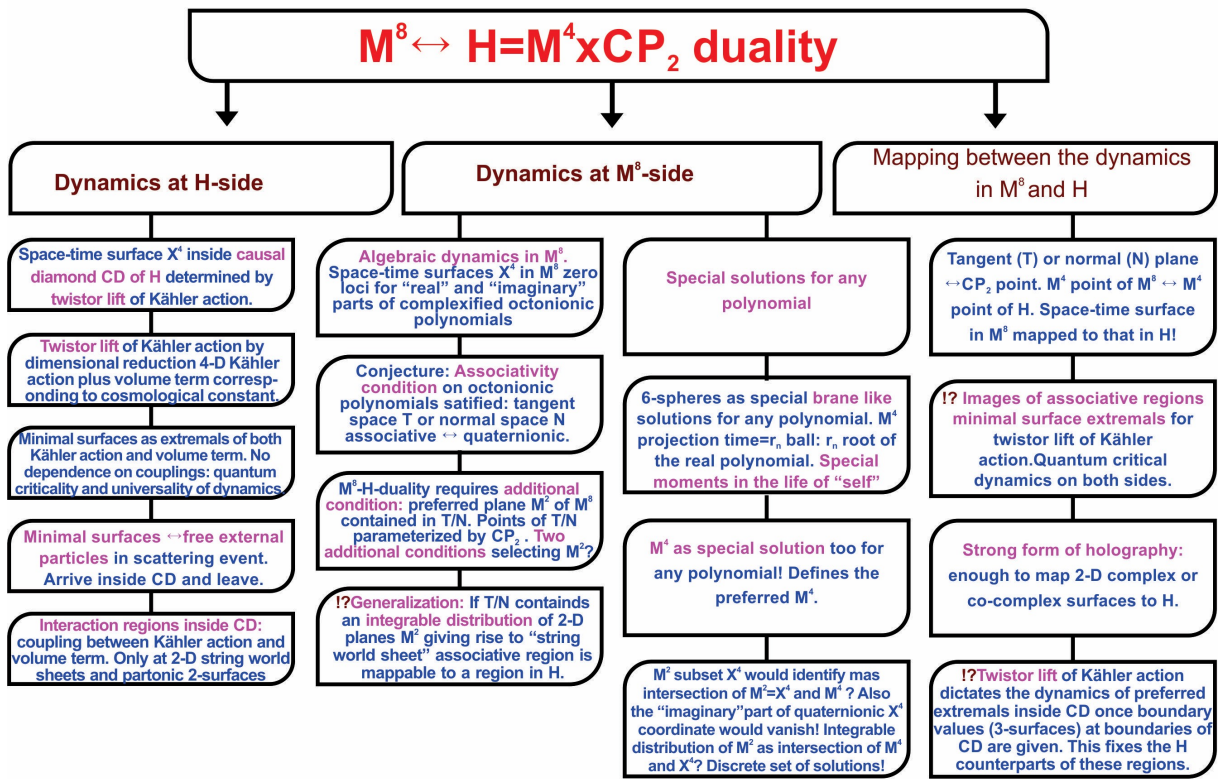
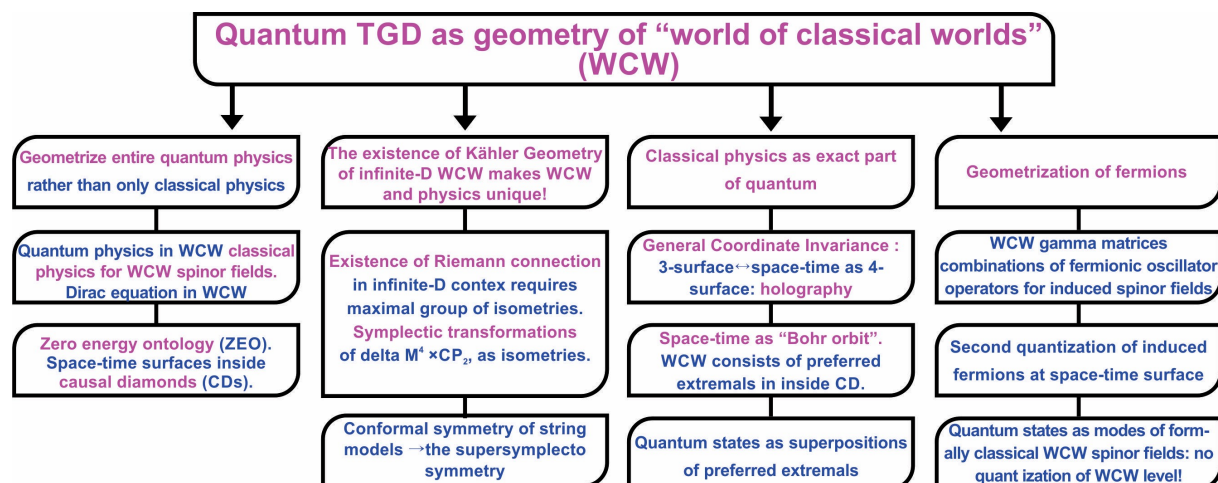


Figure 13.6: Twistor lift

Figure 13.7:  $M^8 - H$  duality



**Figure 13.8:** Geometrization of quantum physics in terms of WCW

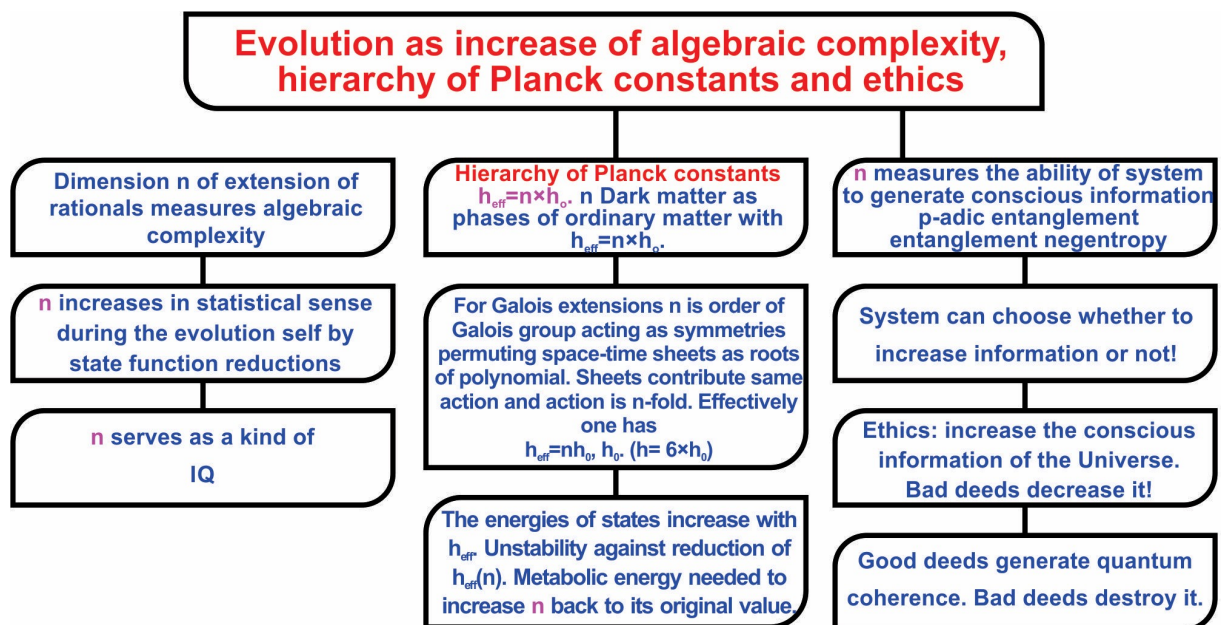


Figure 13.9: Number theoretic view of evolution

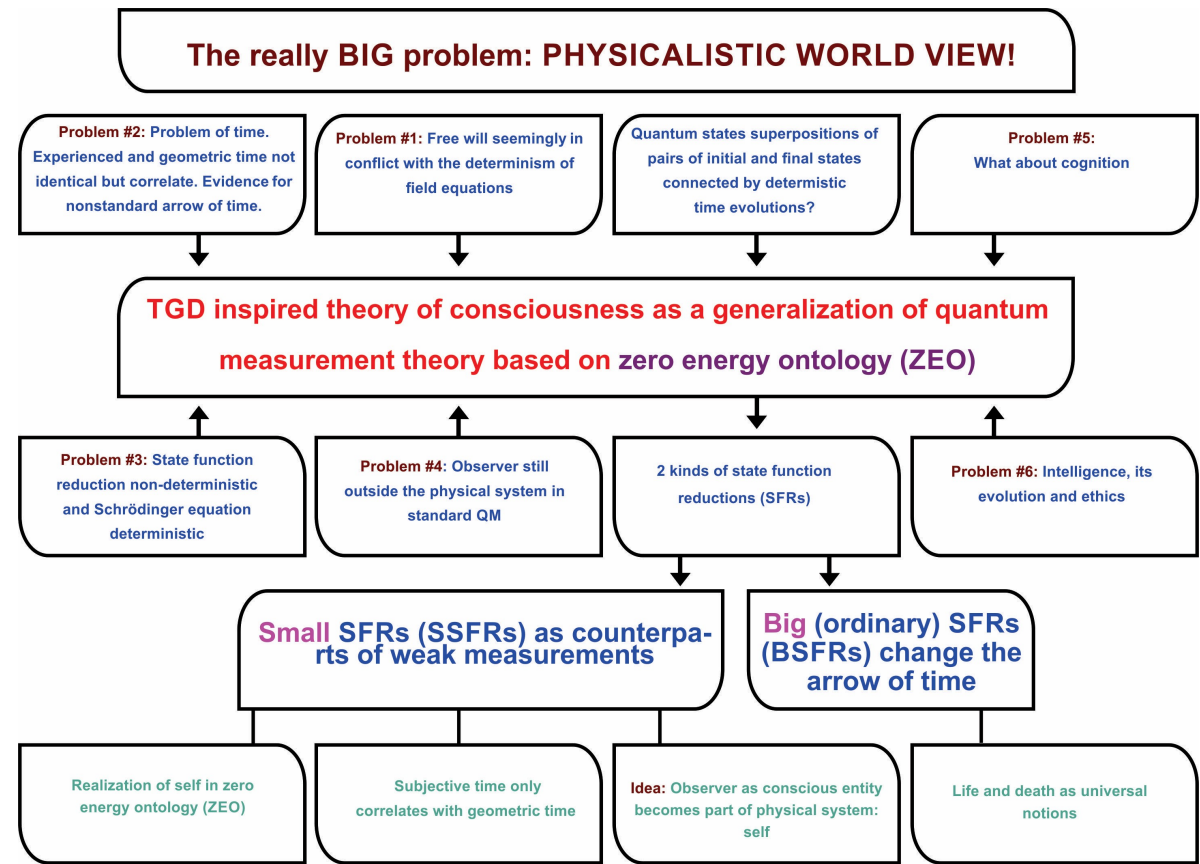
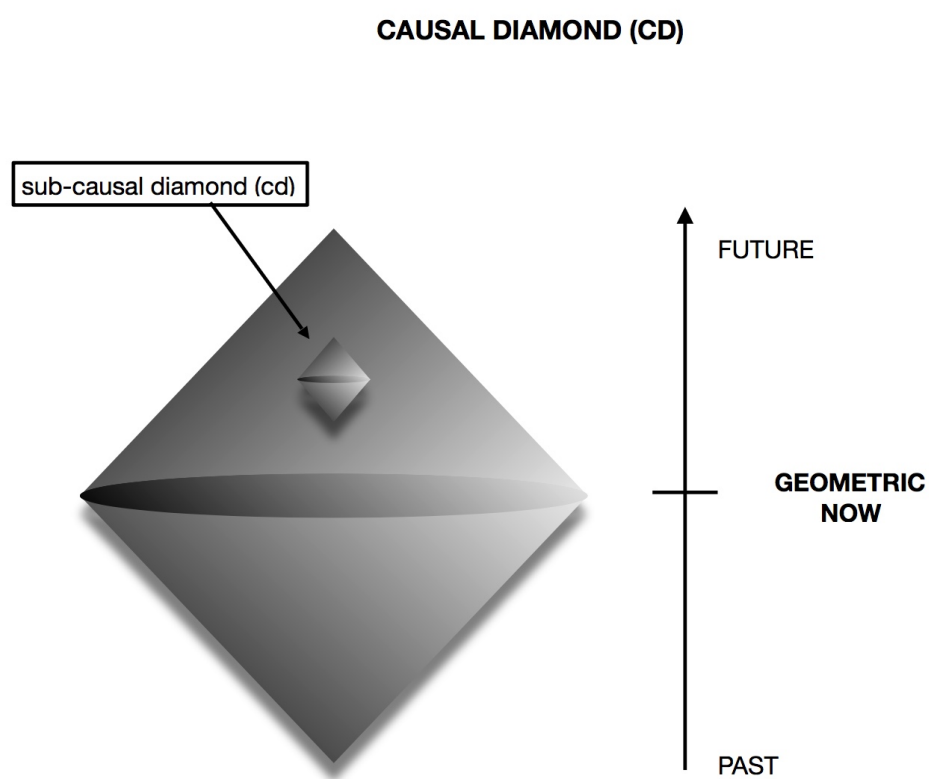
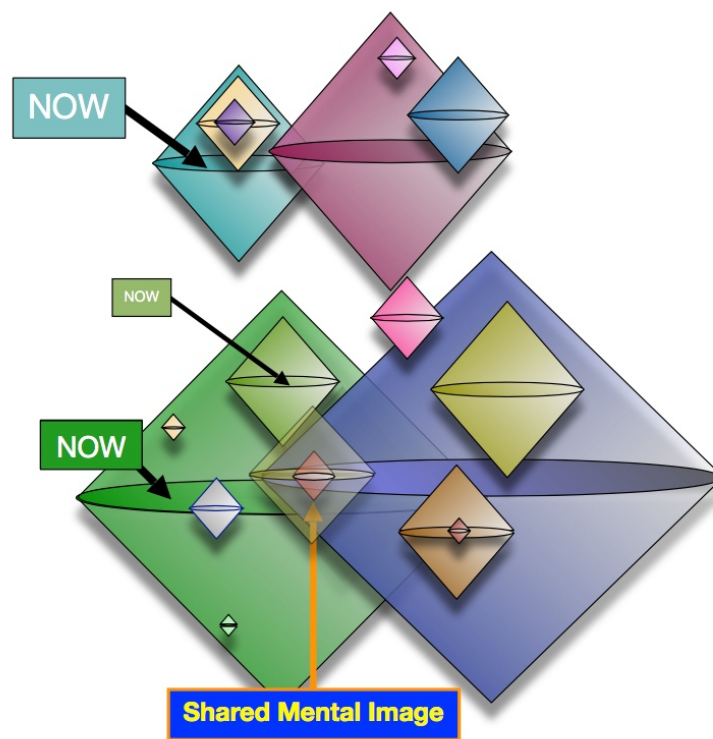


Figure 13.10: Consciousness theory from quantum measurement theory

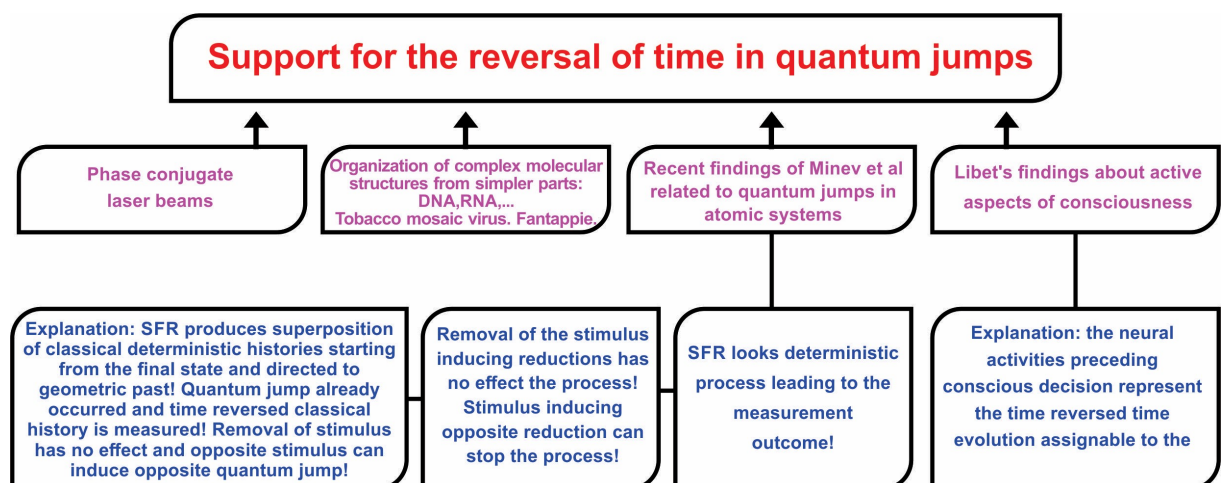


**Figure 13.11:** Causal diamond

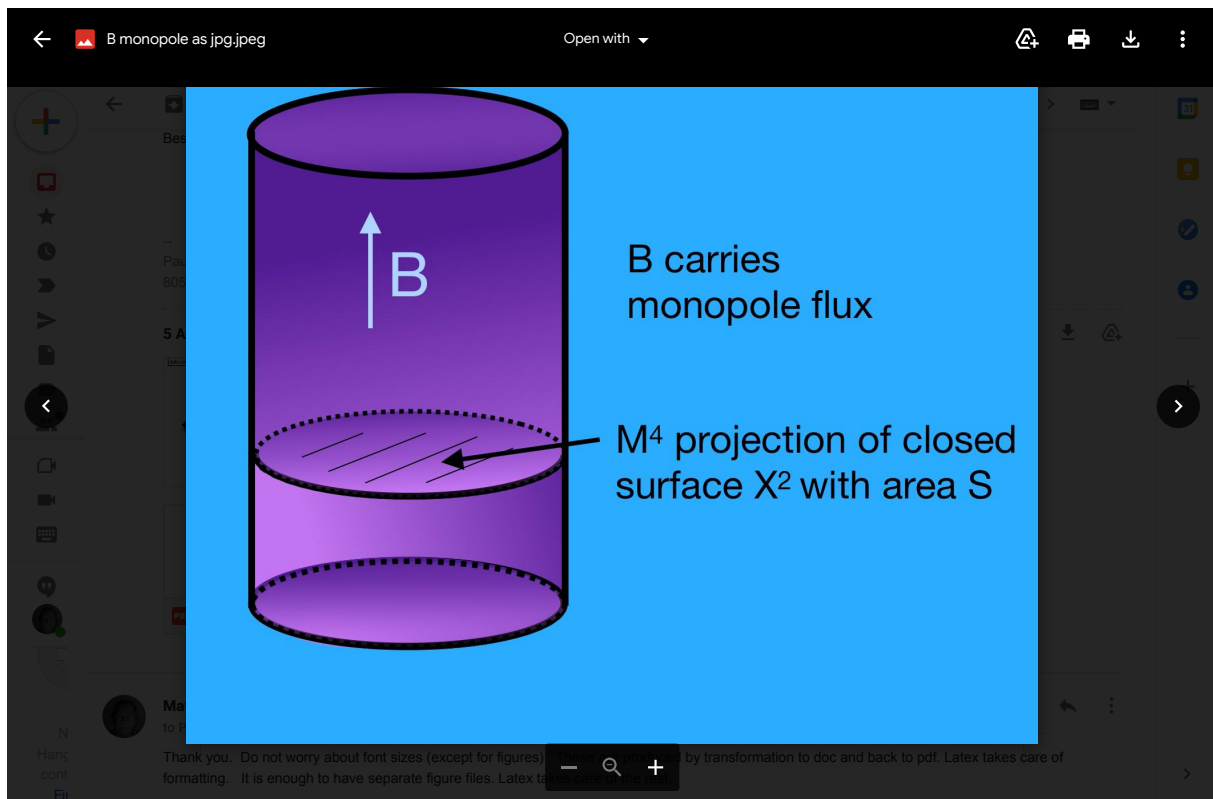


**Figure 13.12:** CDs define a fractal “conscious atlas”

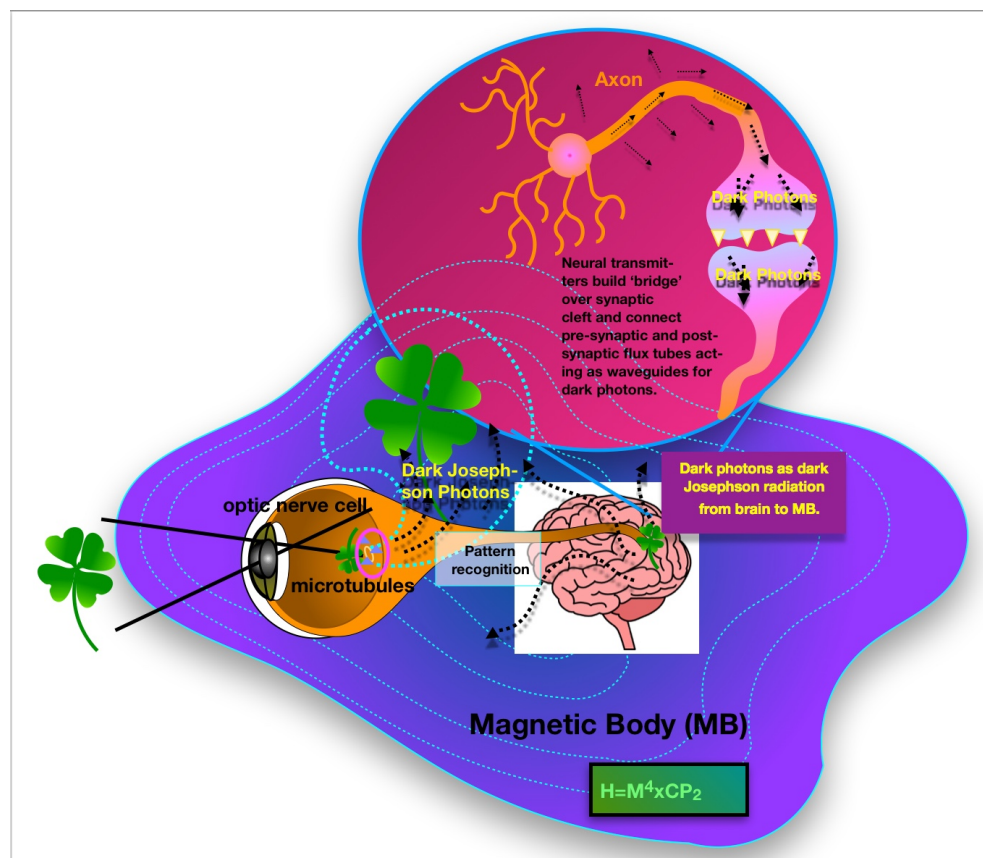




**Figure 13.13:** Time reversal occurs in BSFR



**Figure 13.14:** The  $M^4$  projection of a closed surface  $X^2$  with area  $S$  defining the cross section for monopole flux tube. Flux quantization  $e \oint B \cdot dS = eBS = kh$  at single sheet of  $n$ -sheeted flux tube gives for cyclotron frequency  $f_c = ZeB/2\pi m = khZ/2\pi mS$ . The variation of  $S$  implies frequency modulation.



**Figure 13.15:** Dark Josephson photons communicate sensory data to the “big” part of MB. Also the back and forth communications between sensory organ and brain use dark photons.

## Part II

# REMOTE MENTAL INTERACTIONS



## Chapter 14

# TGD inspired view about remote mental interactions and paranormal

### 14.1 Introduction

The latest TGD inspired articles related to quantum biology, quantum mind, and remote mental interactions were published in JNLRMI around 2003. Several new ideas related to basic TGD, TGD inspired quantum biology and theory of consciousness have emerged during the subsequent 8 years. The article *Evolution of TGD* [L21] provides a short summary about the development of idea. The general vision is that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal are predicted to share the same basic mechanisms, and that the proposed vision provides basic concepts and the language allowing to speculate and build simple models. One cannot of course take the proposed models too seriously at the level of details.

My original intention was to write just single article trying to give a summary about the progress of quantum TGD first and after that I will discuss the implications for quantum TGD based view about biology, consciousness and remote mental interactions and related mysteries. It however turned out that book would provide a more concise a more appropriate way to represent the overall view. One cannot of course take the proposed models too seriously at the level of details.

This is the first part of an article devoted to remote mental interactions. In the first part of the article I will summarize the new ideas that have emerged since 2003, the basic problems and basic ideas, and what parapsychological phenomena are at general level. There is also a more detailed representation at my homepage [K113] as a chapter of a book.

In the second part of the article I will discuss some applications of the basic vision. The notion of conscious hologram is discussed from the point of view of remote mental interactions. The notion of magnetic body is in decisive role as it is also in the understanding of quantum biology in TGD framework.

TGD inspired model for OBEs relying on the notion of magnetic body is summarized. The idea is that OBEs could correspond to sensory experiences assignable to magnetic body rather than real body. Also the connections with the work of other researchers, such as Shnoll, Persinger, and Tiller are discussed briefly. The challenge of testing the vision is also considered.

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> [L30].

## 14.2 Brief Summary Of The Basic Vision Around 2003 Compared With The Recent Situation

To get perspective it is perhaps good to briefly summarize the basic vision about TGD inspired model for biology and consciousness as it was around 2003 according to the articles published in JNL RMI (see <http://tinyurl.com/me77ur>). The recent view about TGD inspired theory of consciousness is described in the chapter *Matter, Mind, Quantum* of the book “TGD Inspired Theory of Consciousness” [K59]. The general vision was that both biology, consciousness, and remote mental interactions and related phenomena labelled as paranormal are predicted to share the same basic mechanisms, and that the proposed vision provides basic concepts and the language allowing to speculate and build simple models. One cannot of course take the proposed models too seriously at the level of details.

Several new ideas and concepts have emerged since 2003.

The most important ones are following.

1. ZEO giving justification for notions like negative energy photons propagating to the geometric past and the notion of causal diamond (CD) providing embedding space correlate for the notion of self and predicting a hierarchy of fundamental time scales and predicting a connection between biology and elementary particle physics.
2. Hierarchy of Planck constants (see <http://tinyurl.com/y7c8e6x8>) [K37] giving rise to phases behaving as dark matter and suggesting the identification of living matter as ordinary matter controlled by dark matter in this sense.
3. The identification of ATP as a correlate of negentropic entanglement (see <http://tinyurl.com/yd7j9f5j>) and information theoretic interpretation of metabolism [K51].

### 14.2.1 TGD Inspired Theory Of Consciousness

The article *TGD inspired theory of consciousness and biosystems as macroscopic quantum system* (see <http://tinyurl.com/yaxe23ce>) [L4] describes the basic assumptions and ideas TGD inspired theory of consciousness and of quantum biology. The basic vision is essentially now although some simplification has taken place and the picture has become more detailed.

1. TGD inspired theory of consciousness can be regarded as an extension of quantum measurement theory by raising the observer from a status of something external to the Universe able to only induce state function reductions (in von Neumann’s view) to something described by quantum physics. The crucial almost paradox like problem is the conflict between the determinism of Schrödinger equation and non-determinism of state function reduction. Similar closely related problems relate to the relationship between experienced time and the geometric time of physicist. Whatever the theory of consciousness is, it must solve these problems.
2. Quantum jump as a moment consciousness, self as sequence of quantum jumps somehow integrating to a flow of consciousness, self hierarchy, and the identification of sub-selves as mental images of self, represent the basic identifications. It seems possible to reduce self hierarchy to a hierarchy of quantum jumps: higher levels of self hierarchy would be analogous to bound states of elementary particles and self hierarchy would relate closely to the corresponding hierarchy at the level of physics.
3. Quantum classical correspondence requires space-time correlates for selves. Space-time sheets are natural correlates of selves at space-time level. At embedding space level so called causal diamonds (CDs) introduced after 2003 in the context of zero energy ontology define this correlates. At the level of “world of classical worlds” (WCW) the correlate is sub-WCW assignable to the CD.

The notion of many-sheeted space-time forces to modify the notion of sub-system. Flux tubes connecting space-time sheets are natural correlates for entanglement. It is possible for space-time sheets without flux tube connections to contain topologically condensed space-time

sheets which are connected by flux tubes although space-time sheets. This would correspond to a situation in which two selves are un-entangled but possess sub-selves which are entangled. The notion of finite length scale resolution is essential for this definition to make sense. This leads to the idea about sharing of mental images by quantum entanglement producing what might be called stereo consciousness.

4. The possibility of quantum jumps and state function reductions occurring in quantum parallel manner is also something new and also relates to the many-sheeted space-time: see the article *Biosystems as macroscopic quantum systems* (see <http://tinyurl.com/y7m9g4n6>) [L1]. The quantum jumps taking place at the scales of sub-selves and their sub-selves could give rise to the experience of a flow of subjective time. One must be however very cautious with this concept: it is not possible to be conscious about not being conscious so that continuous flow of subjective time might be an illusion perhaps created by the model of self as a continuous narrative. At the fundamental level there might not be continuous narrative. Already dreams represent states of consciousness in which this narrative is only piecewise continuous.
5. The identification of quantum jump as relating entire deterministic *quantum histories* as analogs of solutions of Schrödinger equation solves the problems related to the conflict of non-determinism of state function reduction and determinism of Schrödinger equation and classical field equations which in TGD framework define an exact part of quantum theory. Quantum measurement theory involves also the notion of classical variables. These can be identified as zero modes which by definition do not contribute to the metric of WCW and are therefore not quantum fluctuating variables. The entanglement between zero modes and quantum fluctuating degrees of freedom must be fundamental element of state function reduction and also sensory perception and conscious choice.
6. p-Adic physics as physics of cognition [K69] is a central element of this picture and forces a generalization of number concept. Reals and p-adic numbers characterized by prime  $p = 2, 3, 5, \dots$  are completions of rationals and one can glue reals and p-adic numbers and their extensions along rationals and common algebraics to form a book like structure. The notion of adèle (see <http://tinyurl.com/yc6zy7sf>) - well-known to mathematicians - seems to catch quite well this vision [K73].
7. *Negentropy Maximization Principle* (NMP) [K61] defines the basic variational principle of TGD inspired theory of consciousness and states that the gain of conscious information in quantum jump is maximal. There are variants of NMP depending on what one means with quantum theory.
  - (a) For the ordinary definition of entanglement entropy this means that the two systems involved become un-entangled. Interpreting the density matrix as fundamental observable this gives standard quantum measurement theory.
  - (b) The introduction of hyper-finite factors of type  $II_1$  strongly suggested by the fact that WCW spinors correspond to this kind of von Neumann algebras leads to a further modification of measurement theory since state function reduction to a one-dimensional ray of Hilbert space is not possible in general but always happens to an infinite-dimensional sub-space (in the ordinary sense of the word). The state spaces can of course contain factors of type I for which ordinary measurement theory applies.
  - (c) For rational or even algebraic entanglement coefficients the entanglement entropy can be defined using p-adic norm for some p-adic prime  $p$  and can be negative and always is for certain primes  $p$ . Entanglement would carry genuine information and is expected to be stable under NMP. This leads to the vision about negentropic entanglement as a basic characteristic of living systems.

At space-time level one can also say that the - in general discrete- intersections of real and p-adic partonic 2-surfaces consisting of rational (or more generally, points in some extension of rationals) defined cognitive representations in the intersection of cognition and matter. This discretization would directly correspond to the fact that all cognitive representations have finite resolution and are necessarily discrete: computation represents a basic example of this. At more abstract level the partonic 2-surfaces represented



by algebraic equations making sense both in real and p-adic sense can be said to belong to the intersection of matter and cognition and represent living systems. Quite surprisingly, the art of algebraic geometry which typically involves counting the numbers of rational points of algebraic surfaces would directly relate to fundamental biology!

The basic implication of this vision is the necessity to re-consider the existing views about the relationship between subject and geometric time. I summarized the ideas about time as they were around 2003 in the article *Time, space-time, and consciousness* (see <http://tinyurl.com/yavkn2q7>) [L5]. There were several poorly understood issues and some of these issues are still far from well understood.

1. What is the precise relationship between geometric time and experienced time? How the experience about continuous flow of time emerges? (Is it an illusion: one cannot be conscious about being not conscious, dark moments of visual perception). What induces the arrow of psychological time inducing the apparent arrow of geometric time? Why the contents of sensory experience are restricted to so narrow a time interval whereas the contents of memory come from much larger space-time region. Note that the interpretation of the correlate of self as 4-D space-time regions provides a new vision about memory.
2. In the article *TGD inspired theory of consciousness* (see <http://tinyurl.com/y9bne6cc>) time-like entanglement and signals proceeding in the reversed direction of time was suggested to provide the basic mechanism of memory, intentional action, and (remote) metabolism. Libet's paradoxical findings about strange time delays of consciousness provide the basic support for this vision. The challenge is to give a more precise mathematical content for the notion of negative energy signal propagating backwards in time. Phase conjugate laser wave was proposed as its physical analog. The basic question is to understand how the arrow of geometric time emerges so that one can use these terms.

In TGD framework the notion of many-sheeted space-time challenges the notion of subsystem. One must also give a more precise mathematical content to the notions of U-process, state function reduction, and state preparation.

1. Quantum jump should consist of unitary process characterized by a unitary matrix  $U$  followed by a state function reduction in turn followed by state preparation. State function reduction should be a cascade like process proceeding from top to bottom as a splitting of systems to pairs of unentangled subsystems until negentropic or bound state character of entanglement does not allow splitting anymore [K61]. The identification of the unitary process  $U$  and  $U$ -matrix remained however open questions at that time. ZEO leads to a rather detailed minimal vision about what happens in quantum jump [K9].
2. What happens in quantum measurement? Non-quantum fluctuating zero modes of "world of classical worlds" (WCW) correspond to classical degrees of freedom in TGD and are excellent candidates for classical variables of quantum measurement - such as direction of the point of some "meter". With these zero modes quantum fluctuating degrees of freedom must entangle before state function reduction and measurement must induce state function reduction eliminating entanglement unless it is negentropic. Does state function reduction follow from macroscopic character of zero modes in the sense that there would be analogy with spontaneous magnetization which also selects single direction of magnetization rather than their quantum superposition.

And what is the role of cognition interpreted in terms of p-adic space-time sheets? Is p-adic-real algebraic entanglement carrying negentropy involved? At what level the state function reduction inducing a sequence of state function reductions in the sequence of entangled systems does take place: does the primary reduction take place at the level of cognition?

Ther answers to these questions are still more or less guess work.

### 14.2.2 TGD Inspired Quantum Biology

Many ideas about basic mechanisms of quantum biology already existed around 2003. Mention only the notion of magnetic body and the hypothesis that living matter resides in the intersection

of real and p-adic worlds implying that negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) is a fundamental characteristic of living matter.

The assumption that living matter is ordinary matter controlled by dark matter - identified as a hierarchy of macroscopic quantum phases labeled by the value of Planck constant coming as integer multiples of ordinary Planck constant - has allowed to find a more detailed formulation for these intuitive ideas. The alert reader has perhaps noticed that the hierarchy of Planck constants and negentropic entanglement seem to provide two different ways to realize macroscopic quantum coherence. Are these two realizations independent of each other and if not, how do they relate to each other? This remains an open question to high extent.

1. High  $T_c$  super-conductivity was assumed to play a key role in living matter but the precise mechanism of super-conductivity was poorly understood. For the views at that time see the articles *Biosystems as macroscopic quantum systems* (see <http://tinyurl.com/y7m9g4n6>) [L1] and *Quantum model for sensory receptor* (see <http://tinyurl.com/y7opejka>) [L3].

A detailed model for high  $T_c$  bio-super-conductivity was however lacking. The hierarchy of Planck constants allows to construct this kind of model [K19, K20] applying also in the case of ordinary condensed matter systems. Rather remarkably, dark electrons at magnetic flux tubes play a key role in this model. Also negentropic entanglement could stabilize Cooper pairs.

Another new element not present at the time of writing of these articles is the new physics model of cell membrane (see <http://tinyurl.com/y7vahkzg>) as almost vacuum extremal of Kähler action [K44] motivated by quantum criticality and the expectation that large values of Planck constant correspond to almost vacuum extremals if one accepts the TGD based explanation for the hierarchy of Planck constants as a result of dynamics rather than something fundamental. It must be emphasized that the existing high precision determinations of Planck constant do not exclude the hierarchy since they do not detect dark matter. This leads to a picture about cell membrane as an analog of computer monitor with lipids representing pixels to which one can attach various qualia. These qualia need not however correspond ours which are assigned to sensory receptors.

2. In the article *Manysheeted DNA* (see <http://tinyurl.com/ycz88ss>) [L2] several ideas related to DNA were discussed.
  - (a) Homeostasis in many-sheeted space-time roughly states that supra currents at super-conducting space-time sheets determine the dynamical equilibria also at the space-time sheets containing ordinary matter. The strange findings about the behavior of cell membrane ionic currents support this hypothesis (they are quantal and flow even in absence of metabolic energy feed suggesting that Josephson currents are in question).
  - (b) Quantum spin glass degeneracy generalizing ordinary 3-D spin glass degeneracy to 4-D one meaning that strict determinism breaks down to piecewise one. Hence not only quantum states but also quantum jump sequences and therefore conscious experiences should have space-time correlates. These correlates would relate to conscious experience like written text to conscious thoughts and would provide a kind of feedback essential for symbolic memory. 4-D spin glass degeneracy provides also a justification for the hierarchy of Planck constants.
  - (c) A further key idea was healing by time reversal. The idea is that the reversal of the arrow of geometric time implies that second law holds in opposite direction of geometric time so that basically entropic process looks like negentropic one. Also the notion of magnetic mirror, topological self-referentiality, the identification of information molecules as quantum links in quantum web, the idea about molecular recognition mechanisms, the connection between metabolism and generation of quantum coherent states, scaling law of homeopathy were further ideas discussed in the article.

The developments since 2003 have enriched this picture with several new ideas.

- (a) ZEO and the notion of CD allow to assign the arrow of geometric time directly to the zero energy states rather than their dynamics. Dark matter as a hierarchy of phases with large value of Planck constant can be identified as controller of ordinary matter in living systems, and negentropic entanglement assumed to have ATP as a correlate allow to a more detailed articulation of these ideas.
  - (b) The idea about DNA as topological quantum computer [K4] with braids realized as magnetic flux tubes connecting DNA nucleotides with lipids of cell membrane is another key idea and means that DNA becomes the hardware of quantum computations with software represented by the braidings of flux tubes.
3. The article *Macrotemporal quantum coherence, quantum spin glass degeneracy, and number theoretic information concept* (see <http://tinyurl.com/y7wlrzmo>) [L8] described the vision about living matter as a macroscopic quantum system. The notion of negentropic entanglement and the idea about life as islands of rationality in the oceans of real and p-adic continua was described already in this article.
  4. The article *Biosystems as conscious holograms* (see <http://tinyurl.com/yb79md6j>) [L7] develops the idea about living matter as conscious hologram. One of the key mechanisms was time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of this book) finding a justification in ZEO. A model of remote mental interactions and an model inspired by the findings of William Tiller was proposed with key role played by the notion of magnetic body able to receive information from and control even in-animate matter. ZEO provides first principle justification for the time mirror mechanism.
- The vision was applied to develop a model of bio-photons. The (see <http://tinyurl.com/y7vahkzg>) model of cell membrane (see <http://tinyurl.com/y7vahkzg>) as almost vacuum extremal, which emerged later, led to a radical proposal: bio-photons are nothing but large  $\hbar$  EEG photons which have suffered an energy conserving phase transition reducing the value of Planck constant to ordinary one.
5. The article *Quantum model for nerve pulse, EEG, and ZEG* (see <http://tinyurl.com/y842gm3w>) [L6] describes a TGD inspired view about nerve pulse and EEG. I would not speak about *ZEG* in the title now since the status of  $Z^0$  radiation fields is still uncertain (classical  $Z^0$  fields are however in an essential role in the model of cell membrane and sensory receptor).

Electronic super-conductivity and possibly super-conducting states assignable to biologically important ions are key elements of the model but the model of electronic super-conductivity was not convincing: it was assumed that super-conducting space-time sheets are at very low temperature. The model of electronic super-conductivity was not too convincing at that time and considerable progress has taken place with the advent of the hierarchy of Planck constants [K19, K20].

In case of biologically important ions it had already become clear that “TGD inspired nuclear physics” [K65] allows fermionic nuclei with given charge to have bosonic companions with the same charge and therefore same chemistry. This would make possible to assign Bose-Einstein condensates and super-conductivity even to atoms which are chemically equivalent with fermionic atoms.

EEG and its possible variants were identified as communications and control tools mediating sensory information to the magnetic body and allowing magnetic body to quantum control biological body. This means the presence of a completely new level in biological information processing. Again the hierarchy of Planck constants plays a key role in making possible for ELF photons with extremely small energy to have energies which are above thermal energy and thus have biological effects and carry information [K33, K89].

The aim of this chapter is to describe in some detail the recent view about remote mental interactions. Also connections with the work of other researchers are summarized.

## 14.3 Basic Questions And Basic Ideas

The basic ideas of TGD inspired model for remote mental interactions and related phenomena such as OBEs and near death experiences are summarized in the chapters *Quantum model for paranormal phenomena* (see <http://tinyurl.com/y8fc7zn4>) [K87] and *TGD based model for OBEs* (see <http://tinyurl.com/y797h78x>) [K108] of the book “TGD Inspired Theory of Consciousness”. Also the chapter “Bio-systems as conscious holograms” [K17] (see <http://tinyurl.com/ydx4fuk5>) contains a summary of a model for how conscious hologram might allow to understand remote mental interactions, and TGD based view about the work of Willian Tiller related to intentional imprinting. The chapter contains also a section about bio-photons: there could be a connection with remote mental interactions since bio-photons could result from the transformation of large  $\hbar$  dark photons by a phase transition reducing the value of Planck constant, which in turn would be essential for communications between biological body and magnetic body.

I have not worked with this topic during last years, and I apologize for my very restricted views. The most important new ideas relate to the notion of magnetic body, ZEO, negentropic entanglement, and dark matter hierarchy. It would be interesting to deduce explicitly the implications of new ideas that have emerged since 2003 but the following discussion is just a commentary.

### 14.3.1 Basic Questions

The general idea is that remote mental interactions are by no means paranormal in the sense that they would be in conflict with well-established laws of physics, as skeptics want to see them. Our personal magnetic bodies apply remote mental interactions to receive communications from biological body and to control it routine. Remote mental interactions having living matter as a target would correspond to a situation in which the personal magnetic body of operator is able to receive information from the biological body of target or control it. Becoming possessed would be one manner to say this. Hypnosis would represent the basic example of this. The target could be also water perhaps containing some organic matter as in Tiller’s experiments. Also psychokinesis acting on inanimate targets such as computers can be considered but in this case the mechanisms of remote mental interaction cannot be quite same as in the case of biological targets.

The basic question is why the remote mental interactions having living target are so rare if they apply same mechanisms as living matter in general. A possible reason is that living matter has developed an immune system preventing the situation in which the organism becomes possessed. This would be very similar to what has taken place in the evolution of computers. The restriction of communication windows to narrow frequency ranges depending on species and even individual, and the counterparts of passwords realized as temporal field patterns could make this kind of immune system possible. Cyclotron frequencies would be central here and hierarchy of Planck constant would allow arbitrary low frequencies with energies below thermal energies at physiological temperature range. The first guess is that passwords using genetic code so that communications restricted to those occurring between the members of the same species become possible. The challenge is to invent plausible physical realizations for the passwords. One possible proposal inspired by the experiments of Gariaev and collaborators would realize the values of bit as two orthogonal photon polarization directions. Another realization would be in terms of a collection of frequencies interacting resonantly with the target DNA and inducing gene expression: no explicit knowledge of address of the target would be needed.

Second basis problem in many remote mental interactions such as the intentional effect on random number generator is “Who knows how?”. How the mere intent can be transformed to action without any knowledge about the details of the action? The attempt to understand how neuro-feedback affect the behavior of single neuron leads to the same question.

1. Magnetic mirrors make possible also feedback and this feedback could make possible learning. For instance, in psychokinesis (especially so in micro PK), this learning would be crucial and analogous to that what occurs when we learn to drive a car. In healing this kind of feedback might help to find the healing frequency by trial and error.
2. It is quite possible that also multi-brained and -bodied higher level collective selves actively participate in the process as a third party such that the remote mental interactions would act as a relay states. I have suggested similar explanation for Sheldrake’s findings about

learning at the level of species and Tiller's findings about the "transfer of intent". This could make possible coherent amplification effects (TEM, prayer groups) and could make available information resources of all brains involved with the group. This could for instance explain the ability of a remote viewer to see an object on basis of data which need not have any meaning for her.

3. A fast amplitude modulation of alpha waves introducing higher harmonics to the carrier wave is a good candidate for mediating communication between brains and higher level multi-brained selves. Mesoscopic "features" in brain involve precisely this kind of amplitude modulation and might represent just this kind of messages. Interestingly, also speech is produced by a fast amplitude modulation of 10 Hz basic vibration frequency of speech organs (assignable to electron CD as a fundamental frequency) and kHz (quarks) frequency is a special frequency from the point of view of hearing.

Third key question relates to the metabolic aspects of remote mental interactions. One expects that negentropic entanglement between operator and target is involved. The hypothesis about the presence of ATP molecule at the magnetic flux tube connecting operator and target as a prerequisite for negentropic entanglement would reduce the energetics of remote mental interactions to basic metabolism. This allows to make quite strong conclusions about the character of these interactions. Here one must however remember that earlier model assumed much more general mechanism of metabolism involving transfer of particles to larger space-time sheets liberating or using zero point kinetic energy in this manner. It could be part of  $ATP \leftrightarrow ADP$  mechanism or completely independent mechanism utilized by the prebiotic metabolism. It could be also involved with the remote mental interactions for which targets are in-animate.

Fourth question relates to mechanisms and here time mirror mechanism involving sending of negative energy photons to geometric past is the natural candidate for both intentional action, remote metabolism, and memory. Also its counterpart involving sending of positive energy signals to future can be considered. It must be emphasized that the reflection need not always occur. The negative energy photon could be just absorbed without any signal generated and this leads to ask what happens in the case of memory.

### 14.3.2 Key Ideas Of The TGD Inspired Model Of Remote Mental Interactions

During years a rather concrete TGD inspired model of remote mental interactions has developed.

1. The basic notions of the TGD inspired model are magnetic body as an intentional agent controlling biological body and receiving data from living body or even "dead" matter system with massless extremals (MEs) mediating these communications, zero energy ontology and the related notion of causal diamond (CD) serving as an embedding space correlate of self and assigning to elementary particles fundamental macroscopic time and length scales as those of CD, the hierarchy of Planck constants making possible macroscopic quantum phases and zoom-ups of quantum systems, and the vision about living matter as something residing in the intersection of real and p-adic worlds and the closely related notion of negentropic entanglement crucial for the functioning of living matter and conscious intelligence in TGD Universe. Note that this means that life corresponds to number theoretical quantum criticality in a well-defined sense.
2. Zero energy ontology means a radical departure from standard physics. The creation of zero energy states from vacuum is possible and means that in principle (just in principle!) the claims of parapsychologists about ectoplasm and of yogis about the possibility to create of matter from nothing are consistent with the basic conservation laws of physics. In TGD inspired biology this process could take place routinely. Causal diamond is the embedding space correlate for the zero energy state. Positive and negative energy parts of the state reside at its boundaries. p-Adic length scale hypothesis and number theoretical vision suggest that the proper time distance between the tips of CD comes as powers of two. For electron and quarks playing key role in the model of DNA as topological quantum computer this

temporal distance would correspond 1 seconds and 1 millisecond respectively suggesting a direct connection between elementary particle physics and basic bio-rhythms.

The translates and Lorentz transforms of CDs are also CDs and one can assign to CDs a moduli space further expanded by the introduction of the hierarchy of Planck constants. One expects that this moduli space is crucial for understanding of the geometric qualia [K88]. The communications between sub-selves would be naturally based on resonance. CDs are characterized by resonance frequencies which in the rest system of CD come as harmonics of the fundamental frequency determined by the proper time distance. This would allow a universal coding of geometric data using frequencies. Both MEs and CDs could be regarded as being analogous to music instruments and this in fact explains basic facts about music experience. These resonance frequencies should play a key role in biology and also in remote mental interactions- even those in which target consists of “dead” matter since fundamental biorhythms characterize also elementary particles in TGD Universe.

3. p-Adic physics as physics of cognition is an essential element of approach. Intentions are represented as p-adic space-time sheets. In the intersection of real and p-adic worlds these space-time sheets have a mathematical representation making sense also in real context so that one can say that these surfaces are in the intersection of real and p-adic worlds and the phase transitions transforming surfaces belonging to different number fields are possible. This makes possible transformation of intentions to actions and their reversals possible in the intersection of real and p-adic worlds.  $U$ -matrix indeed makes sense also for transformation representing the transformation of say p-adic space-time surface to a real one and is coded only by data assignable to the rational and common algebraic points of real and p-adic variants of partonic 2-surface [K61]. Note that zero energy ontology makes possible also the transformation of intentions to actions as p-adic-to-real phase transitions without breaking of the conservation laws.
4. Negentropic entanglement, which can be both space-like and time-like in zero energy ontology, makes possible quantum superposition of macroscopically different configurations of the target system correlated with the states of operator system. The operator should be able to achieve the negentropic entanglement and intentionally increase the amplitude of the desired outcome in this superposition. Negentropic entanglement need not involve binding energy and I have proposed this as a deeper level explanation for the nebulous notion of high energy phosphate bond crucial for metabolism in living matter. Quite generally, negentropic entanglement would make possible for the operator to transfer metabolic energy and momentum to the target. Remote healing involves often positive emotions like compassion and love suggesting that negentropic entanglement accompanies healing process. The hierarchy of values of Planck constant would make possible this process in long time and length scales.
5. Addressing of the target is key problem in remote mental interactions. Here password consisting of a collection of frequencies interacting resonantly with the DNA of living target and inducing remote gene expression dictated by the frequencies is one possibility. Gariaev's findings that scattering of red laser beam from DNA generates broad band of frequencies, which are biologically active, could be interpreted in this model. The photons would correspond to the same energy but wide range of frequencies corresponding to different values of Planck constant. These frequencies would define the address of the target, eventually some part of DNA inducing gene expression. The interaction would be by the superposition of the electric field of incoming radiation with the electric field of flux tube inducing the analog of Becker's healing current in turn loading metabolic resources and generating negentropic entanglement and also gene expression.
6. The notion of hologram is often used as a useful metaphor: Gariaev talks about DNA hologram and I have talked about conscious hologram. This notion obviously requires more detailed definition to be testable. What hologram does is that scattering of laser beam from it is effectively scattering from target. Magnetic flux tubes make TGD Universe an Indra's net: could it be that the scattering from object behaving like bio-hologram could actually take place from the target which it represents! Photons would travel from object to the target along flux tubes, scatter, and arrive along flux tubes and leave the object. The object,

which actually acts as a relay station, would define pseudo-hologram. Also frequency coding of the address could be combined with this picture if the lengths of flux tubes are multiples of wavelength (proportional for Planck constant).

### 14.3.3 Some Examples Of Remote Mental Interactions Interpreted In TGD Framework

Some examples about remote mental interactions with living target are in order.

1. In telepathy the communications from biological body of target would be based on EEG and its scaled analogs. Also ECG could be involved. In TGD Universe even electromagnetic field might be replaced with electroweak and color field below some scale in scale hierarchy defined by Planck constants.
2. In hypnosis magnetic body of operator would control the biological body of the target, which would be “possessed” and behave like a part of the biological body of operator.
3. It would be also possible to share sensory percepts and memories of the living target. The mechanism would be time mirror mechanism applying also to ordinary memory and sensory perception.

In the case of in-animate targets the modelling is not so straightforward. One could however assume that also now negentropic entanglement is involved and that the ATP of the operator is used. Note however the possibility of the more general mechanism at the end of the target.

1. In psychokinesis with inanimate target negentropic entanglement would be mediated by flux tubes containing ATP assignable to the operator. The metabolic energy of ATP of operator is transferred to the target. The increase in the rate of metabolism could therefore serve as a signature.
2. In the remote mental interaction with computer the intention is to affect the pattern of random numbers and the mere transfer of metabolic energy is not enough since the effect must also have a correct sign. The net effect is the change of the distribution of random numbers from expected and Tiller observes strange periodicities in the distribution. It seems that remote mental interaction must be able to affect the probabilities of the outcome so that they are not identical as randomness would require. What could be the mechanism? Direct entanglement with the representation of bits is not plausible. While writing this article it occurred to me that there might be a connection with the model for Shnoll effect [K8] which I developed for a couple of years ago and based on a deformation of probability distributions based on p-adic mathematics and quantum groups. What is remarkable is that the parameters characterizing statistical distributions vary slowly with periodicities assignable to the gravitational fields in solar system. Could it be that also the statistical effects of intentional action could be characterized by the same mathematics leading to purely number theoretical predictions? This will be discussed in more detail below.
3. In the intentional imprinting of Tiller creation of flux tubes connecting the magnetic body of operator and non-living target would take place. Intentional action induces changes such as change of pH and this could rely energetically on the use of ATP. Magnetic fields should be important and cyclotron frequencies might be important. When a sequence of random bits is used, periodicities with cyclotron frequencies are suggestive supporting the hypothesis involving magnetic flux tubes and Shnoll effect.
4. What could be the mechanism in the case of remote viewing? Magnetic body should receive from the target extrasensory input generating sensory percepts or more abstract cognitive mental images such abstract shape. Could the signal arrive from the target to the magnetic body of operator and therefrom to the biological body - maybe brain - of the operator to create genuine sensory percept? To have a genuine sensory percept back-projection to sensory organs is necessary and in TGD based model for sensory qualia the back projections to sensory organs are in a central role: the virtual world sensory input from brain and possibly from

magnetic body to sensory organs used to build standardized mental images. Or is there any creation of sensory percept?

5. In the case of precognition the situation is not at all clear. In ZEO based vision the simplest view is that the “upper” light-like boundary of CD corresponds to the seat of sensory percepts realized as mental images. Memories would correspond to information arriving from the geometric past inside CD. Precognition would mean receiving information from the geometric future of CD. Is this possible? How this would be realized. The vision about generalized Feynman diagrams suggests that given CD surrounds a vertex of generalized Feynman diagram in certain scale and that larger CDs are present and precognition would involve time reversed signals at the level of next CD. There presence of larger CD and longer time scale would mean that prophets are indeed “messengers of Gods”.

Why we do not remember the geometric future. Is the reason that the contents of conscious experience is about the boundary of CD which performs the state function reduction.

## 14.4 Parapsychological Phenomena

In this section various parapsychological phenomena are discussed in the general framework introduced in the previous section.

### 14.4.1 Extrasensory Perception, Precognition, And Other Parapsychic Effects

The general model for paranormal effects relies on same basic ideas as the model of quantum biology.

1. The transformation of p-adic [K69] space-time sheets makes possible the transformation of intentions to actions. Since p-adic space-time sheets have literally infinite size in real sense, distance does not matter. The set of points in the intersection of p-adic and corresponding real space-time sheet obeying same algebraic equations consists of rational and possibly also algebraic points common to real and p-adic variants of embedding space.

Parapsychological phenomena involve the transfer of information and negentropic entanglement makes possible genuine information at quantum level as also breaking of the second law of thermodynamics in the time scale of CD in question. Hence remote mental interactions should involve the generation of negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) irrespective of whether the target is living system or consists of “dead” matter.

2. The idea about field body serving effectively as an intentional agent is second element of the model. The topological light rays representing negative energy signals propagating into geometric past created by a transformation of p-adic space-time sheet to a real one might be said to represent the “desire” inducing neural activities in the brain of geometric past. This mechanism provides not only a model for how magnetic body uses biological body as a motor instrument but also for PK.

MEs acting as bridges between different organisms would mediate em oscillations allow a directed transmission of smaller MEs behaving effectively as particles moving with light velocity. These MEs could be both real and p-adic and -using the terminology of Qigong practice- would represent qi (action) and yi (intention) respectively. An essential element would be resonance: sender and receiver in should be accompanied by MEs characterized by the same fundamental frequency: only these MEs could resonantly connect healer and healee. Healer must have ability to continuously vary the healing frequency.

MEs would naturally correspond to pairs of positive and negative energy space-time sheets. They would be attached to magnetic flux tubes and magnetic mirrors consisting of two flux sheets would make possible sensory-motor loop.



3. Zero energy ontology justifies the notion of negative energy signals and brings in also CDs as correlates of selves and natural fundamental targets of remote mental interactions. Zero energy ontology and the new view about time allows to assume that sensory qualia are at the level of sensory organ (objections such as phantom leg phenomenon can be circumvented) and that symbolic representations of objects of perceptive field and their attributes reside in brain.

Sensory input generates sensory representations based on real space-time sheets possibly accompanied by p-adic cognitive space-time sheets. Field body can share these mental images by quantum entanglement and also receive sensory information as classical signals involving using frequency coding and coding by temporal patterns. These latter representations would correspond to cognitive and emotional aspects associated with the sensory input. One could even say that higher level sensory representations are somatosensory experiences of field body. The intersection points of real and p-adic space-time sheet would determine the physical cognitive representation and would be always discrete. The analogy with the discreteness of numerics should be noticed. Since this model would apply also to extrasensory perception, the attribute “extrasensory” becomes somewhat misleading attribute.

4. Extrasensory perception could also result from the direct electromagnetic perturbation of the sensory magnetic canvas outside the body and the sounds generated by auroras and meteors might be genuine “extrasensory” perceptions of this kind [K89]. The frequency spectrum for the sounds produced by meteors and detected both sensorily and electronically in the range 37 – 44 Hz [F3], which is the range of thalamocortical resonance frequencies associated with sensory representations in magnetic sensory canvas model. The sounds are several orders of magnitude more intense than they should be unless em perturbations propagate to Earth in a channelled manner. Only few meteors generate these sounds. These observations suggest that a resonant amplification of the em perturbations by magnetic mirrors of the sensory canvas channelling the em field to the surface of Earth are in question.
5. One might argue that if memes are not universal, remote cognition is not very useful. If memetic and genetic codes are realized in terms of CDs of quarks and leptons, one would have universality. If DNA double strand provides the relay station through which sensory input and motor output of the magnetic body flows, one would achieve universality of communication and control mechanisms at the level of living matter. An interesting question is whether memes are really species-specific as the morphic fields are in Sheldrake’s theory. The ability of shamans to transform at the level of conscious experience to animals suggests that this might not be the case. There is also a famous real life story about a student who spend several days in the experiential world of dog. Various identification phenomena would very probably involve also magnetic mirrors acting as bridges between say shaman and animal (or possibly multibody collective self defining “species self” ) and making possible to share the experience of animal. Same mechanism as in the case of long term memories would be in question but with personal memories being replaced with the experiences of another species.

The fact that p-adic space-time sheets have literally infinite size suggests that cognition and intentionality are cosmic phenomena and that there might be cosmic pool of shared cognitive mental images. Hence memes could be completely universal.

#### 14.4.2 Psychokinesis

One can classify psychokinesis to various types depending on whether the target is living or “dead” and whether the effect on target is a mere transfer of energy and momentum or control action involving information transfer.

Below I briefly discuss an early TGD inspired model of PK, a general model of PK assuming time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig. ??** in the appendix of this book) of ordinary intentional action but applied by the magnetic body of the operator to a system different from the biological body, and a more specific model for machine-human interactions. Also concrete examples of various kinds of PK effects are discussed.

### A possible model for psychokinesis with non-machine targets

In [K128] a mechanism of psychokinesis based on the generation of wormhole magnetic field configurations making possible levitation was proposed. Although this mechanism was yet general it deserves a discussion and reader is recommended to see [K128] for details. Basic mechanism is the levitation of diamagnetic substances in an external magnetic field: the force results when the diamagnetic substance repels external magnetic field from its interior. The force is essentially the gradient of the net magnetic energy inside the volume defined by the object.

The mechanism is purely TGD based and relies on the generation of a pair of space-time sheets having opposite time orientations, and carrying opposite magnetic fields and opposite energy densities, and the subsequent interaction of the second space-time sheet with the object moved in the psychokinesis. Exactly the same mechanism applies in case of MEs (massless extremals) and could be used to generate coherent locomotion of organism resulting as a recoil effect when the second ME is absorbed by the body part. MEs provide a candidate for the mechanism of psychokinesis.

### TGD based general view about PK

A general TGD based explanation psychokinesis relies on the same fundamental mechanism as ordinary intentional action, long term memory, and remote metabolism. The model applies more or less as such also to telepathy and could also allow to understand the notion of water memory explaining homeopathic effects.

1. The basic mechanism of PK and retro PK relies on quantum jumps transforming the p-adic space-time sheets representing intentions to real space-time sheets representing desires represented as negative energy signals to the geometric past. These signals modify the output of say random number generator to a non-random one. Magnetic flux quanta would realize the bridges along with the negative energy signals would propagate. The mechanism would favor retro PK if the operator is in active role. Genuine PK is also possible but in this case target would be active sucking metabolic energy provided by the operator.
2. Negative energy signals could consists of dark phase conjugate photons or even massless  $W$  bosons since TGD allows scaled up variants of electro-weak gauge bosons with large Planck constant and arbitrarily small mass scales. Dark  $W$  bosons are especially interesting since they can induce charged entanglement and purely non-local charge transfer mechanism and have been proposed to play a key role in the generation of the nerve pulse.
3. Magnetic flux quanta are the bridges making possible (presumably) unconscious feedback so that the operator can unconsciously learn how to affect the machine. How intentions can have effect on system whose functioning is unknown to the operator is actually the basic mystery of, not only psychokinesis, but of remote healing and remote mental interaction in general, as also of the phenomena labelled as instrumental transcommunications (ITC). The learning by feedback, much analogous to that happens when we learn to drive bicycle, would solve this mystery. The effects of group activity could be understood if groups tend to form collective selves so that coherent amplification of the effect occurs.
4. The ability of the PK able person to imagine the desired effect is important and could correspond to the ability to generate p-adic space-time sheets representing the intention. The desire about the action represented by the corresponding real space-time sheet should induce the effect optimally. In personal discussions with a PK-able psychic I indeed learned that he always tried to imagine in every possible detail how he moved the physical object (say a box of matches). The role of imagination is important also in remote healing [J134]. Perhaps the p-adic pseudo constants made possible by the non-determinism of p-adic differential equations should be in a good approximation genuine constants.
5. The optimal targets are initial value sensitive- or more generally-critical.
  - (a) Quantum criticality is the basic characteristic of TGD Universe and the prediction is the existence of a hierarchy of criticalities. Number theoretical criticality would in turn characterize living matter and might be a characteristic of optimal targets.

- (b) Also quantum criticality in the sense that several values of Planck constant are possible with large values of  $\hbar$  assignable to negative energy signals mediating the desire of the PK-able person. PK requires energy and this favors systems, which can utilize standardized metabolic energy quanta liberated in the dropping of particles to larger space-time sheets.

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

- (c) Water would be an optimal system from the point of PK and retro PK. Homeopathy might indeed involve PK like aspects. Benveniste’s experiments [I25, I26] gave support for the notion of water memory but could not be replicated when the experimenters did not know in which bottles the treated water was. The preservation of water memories represented in terms of many-sheeted lasers for with  $1/0$  corresponds to a population inverted state/ground state, requires metabolic energy feed and the system might suck this metabolic energy from the biological body of the experimenter [K48].

6. As noticed, the proposed model is extremely general and seems to apply to almost any paranormal phenomena. For instance, the claimed re-incarnation experiences could be understood in terms of the general mechanism for long term memory. The person who remembers having lived in past could share mental images of a person in the geometric past by time like entanglement (episodal memory), or could be able to communicate with negative energy signals to the brain of a person on geometric past memory recall and thus receive declarative memories. It is quite possible that survival of fittest in our culture has led to an evolution of an immune system preventing sharing of mental images and communications with other brains.

### Machine-mind interactions

Machine-mind interactions represent a modern branch of parapsychological research and nowadays methodologically highly advanced. These interactions are studied several groups and individuals: mention only the Princeton Engineering Anomalies Research (PEAR), which is a group directed by Prof. Jahn, the Anomalous Cognition Project of Dick Bierman, and the retrospsychokinesis work of Helmut Schmidt. In the sequel some aspects of this work are discussed.

The generation of negentropic time like entanglement between operator and target leading to a superposition of pre-existing and desired zero energy states and a subsequent increase of the amplitude of the desired outcome could be the general mechanism of machine mind interactions. “Who known how?” is a highly relevant question in the case experiments involving the attempt of operator to affect the function of a machine like computer whose detailed functioning is not known for the operator. This question could have two answers. Either the operator learns to who to affect the outcome by the simple sensory-motor loop provided by MEs or there is third party who knows and corresponds to a higher collective level of consciousness.

#### *1. Retro psychokinesis with random number generators*

The analysis of experiments [J35, J36, J31] discussed in the [K120] suggests that the geometric past can change in the time scale of a fraction of second. Both the work done at PEAR [J61] and the work of Helmut Schmidt with retro psychokinesis [J115] provide support for the change of the geometric past in much longer time scales. PEAR experiments demonstrate the anomalous effect also in the direction of future. For instance, the experiments of Schmidt done 1992 discussed in New Scientist [J122] demonstrate that martial art students were able to affect the visual display determined by pre-recorded random numbers. The probability for this kind of deviations from non-randomness was about  $1/1000$ . Henry Stapp proposed an explanation for this in his paper published in Phys. Rev. A [J116] based on nonlinear quantum mechanics.

The change of also geometric past in the quantum jump between quantum histories implies the notion of a four-dimensional physical reality and forces to regard three-dimensionality of reality as illusion created by the 3-dimensionality of our sensory experience (recall the notion of the association sequence). This implies that our geometric past is changing all the subjective time and that communications to the geometric past and future are possible and are consistent with the weak causality violation hypothesis of Schmidt [J115]. What this hypothesis implies that in the newest quantum history generated by RPK all separate records contain the pre-recorded random numbers are altered in the same manner in RPK. Schmidt has tested weak causality hypothesis by using two separate cassette tapes containing the pre-recorded random numbers, one used in the PK experiment and another one kept locked in a safe. The records were indeed found to be identical after the experiment.

The results of Schmidt suggest also classical signalling to the direction of the geometric past. Real space-time sheets with negative time orientation could serve as the geometric correlates for these signals.

### *2. The work of Princeton Engineering Anomalies Research group*

The study of anomalies in human-machine anomalies provide a highly sophisticated and controlled manner to study psychokinesis in its various forms. For instance, in the experiments carried out in PEAR group (Princeton Engineering Anomalies Research) [J61] operators try to affect various kinds of electronic, mechanical, acoustical, optical and fluid devices. In unattended calibrations these devices yield random output whereas in the experimental situation operator tries intentionally to affect the output so that non-randomness results. Each input that operator tries to affect consists of 200 bits formed from a random physical signal and operator can have either the intention to increase the number of 1: s (high), the number of 0: s (low) or have no intention at all (baseline). Operators can exert their efforts from a distance of thousands of miles, before or after the the actual operation of the devices. Over the laboratory's 20-year history, thousands of such experiments, involving about 100 millions of trials, have been performed by several hundred operators.

The observed effects can be summarized as the average for the sum of bits which is 100.026 for high and 99.984 for low. The effect is by a factor 3.6 higher than the expected margin of error. Effects are thus quite small, of the order of a few parts in ten thousand on average, but they are statistically repeatable and compound to highly significant deviations from chance expectations. Effects are highly operator specific and there are significant disparities between male and female performances. The random devices respond also to the group activities of large numbers of people and are especially sensitive to the effect of small intimate groups, group rituals, sacred rites, musical and theatrical performances, and charismatic events.

Time mirror mechanism suggests the following model for the machine-human interactions encountered in say PEAR experiments.

1. The effect of intention could be on the generator of random noise, on bit sequence represented in the computer memory, or even on the recorded value of the sum of bits. A possible mechanism in the latter two cases is the reversal of electromagnetically represented bit.
2. The general mechanism of intentional action involves negative energy signals inducing a change in the charge distribution determining the value of bit. Negative energy photon could induce a dropping of ions to a larger space-time sheet. Also the emission of negative energy dark  $W$  bosons (appearing in TGD based model of nerve pulse) could induce a change in the net charge. In both cases the sign of charge would correlate with the character of intention and for the first mechanism there would be asymmetry between "high" and "low" (proton, electron).

### *3. The work of William Tiller*

[J180] [J180, J171, J172, J173] has performed experiments involving intentional imprinting of targets such as water. The model for the findings of Tiller is discussed in [K17]. The imprinting manifested itself as temporal and spatial oscillations of pH and temperature. The surprising finding was conditioning: also the air around intentionally imprinted device exhibited these oscillations. Also computer could be conditioned. The Fourier transform of the correlation function for bit

sequences of random number generator demonstrated peaks at harmonics of  $f = 1/T$ ,  $T = 113.778$  min.  $2^n$ -multiple of .1 seconds for  $n = 16$  would correspond to  $k = 143$  and  $T = 109.23$  minutes which is by about 4 per cent too small. The proposed assignment of cyclotron photons with motor action leads to ask whether large  $\hbar$  dark cyclotron photons with these frequencies could induce a periodic perturbation of the random bit sequence?

#### Could Shnoll effect and statistical effects of psychokinesis have common mathematical description?

In the remote mental interaction with computer the intention is to affect the pattern of random numbers and the mere transfer of metabolic energy is not enough since the effect must also have a correct sign. The net effect is the change of the distribution of random numbers from expected and Tiller observes strange periodicities in the distribution. It seems that remote mental interaction must be able to affect the probabilities of the outcome so that they are not identical as randomness would require. What could be the mechanism? Direct entanglement with the representation of bits is not plausible.

1. This brings in mind Shnoll effect [K8] in which probability distribution  $p(n)$  for an integer valued observable transforms from expected smooth distribution - say Poisson distribution - to a many-peaked distribution. The distribution could relate to microscopic observable but the modification of distribution seems to depend on gravitational field created by solar system so that astrophysical and microscopic dynamics couple at the level of probability distributions. I have proposed a mathematical model involving p-adic numbers and their quantum counterparts as a model for the effect but have not been able to understand this astro-micro correlation. Could it be that Shnoll effect allows to describe also statistical psychokinesis. This would lead to precise number theoretic predictions and the model would be testable.

There is an interesting analogy with quantum computation in TGD framework. Individual bits or bit sequences correspond to outcomes of quantum computations inside CD and their distribution determines the outcome of the computation. Intentional variant Shnoll effect would mean that intentional action can affect this distribution. One could localize this intentional action to a CD containing the CDs defining bits.

It is however far from clear whether this model can be formulated as a modification for the probability for a given value of bit. It might well be that the effect is global rather than local and on the distribution of number of bits with a given value. Indeed, in TGD framework reality is 4-D and the sequence of bits produced by random number generator is what corresponds to the event rather than single bit!

2. One can of course consider also a local model. A negentropic entanglement with the macroscopic quantum states of random number generator affecting the environment of system responsible for the random event could be in question and change the situation in such a way that second value of bit becomes more probable. Could the magnetic fields associated with the flux tubes mediating the negentropic entanglement with RNG and interacting with the target make second bit energetically slightly more favored? Could the negentropic entanglement prevent the normal state function reduction producing the random number and produce the random number as ATP is transformed to ADP so that operator would perform some fraction of state function reductions? How it is possible to have an effect with a correct sign without any precise knowledge about the functioning of RG?

#### Telekinesis and electrostatics

In the book "Mind at Large" edited by Tart, Puthoff, and Targ there is an article "An Investigation of Soviet Psychical Research" by Wortz *et al* reporting among other things the research related to the electrostatic aspects of telekinesis. The article mentions the work done by Vasiliev and associates with Nina Kulagina and the work of Adamenko with Alla Vinogradova, another highly gifted person in telekinesis. Kulagina and Vinogradova are said to have been able to move objects of .1 kg along table. Interestingly, according to the article PK able persons tend to be women. Adamenko has tried to understand the phenomenon theoretically and has proposed that the static charges of objects and electrostatic forces generated by the subject might explain the effects.

### Adamenko's work

The objects moved by subject persons were located at a table which was a di-electric cube with of side length of.5 meters in Adamenko's experiments.

1. Vinogradova was able to induce an electric charge in cube and then move objects located at the cube. With biofeedback training also other subjects were able to replicate Vinogradova's feat.
2. To move the object the static friction (friction coefficient between.1 and.3) must be overcome. Adamenko theorizes that there is kind of buoyancy force caused by the flow of air molecules involved and that the electric field somehow induces this force.
3. The reported electric field was 10 kV/cm and corresponds to the voltage at which a di-electric breakdown occurs in a dry air. The reported movement of the air could correspond to a corona wind resulting at strong electric fields.
4. Adamenko assumes that the objects had either static charge or that they were polarizable and developed a dipole moment in the external electric field. The electrostatic interaction with the electric field induced by Vinogradova would have been the cause of the movement.

### TGD based model

TGD based model for phenomena is based on the general mechanism of mind-matter interactions allowed by the many-sheeted space-time concept. There are three questions to be answered: How the table and possibly also object were charged?; How the motion of the object was caused?; How the object was lifted from table to circumvent friction force? *How the table and object were charged?* The charging of the table is certainly crucial for the PK effect. Vinogradova could have emitted "topological lightrays" (MEs), as a matter fact high frequency (microwave) MEs propagating like particles within low frequency (ELF) MEs. Negative energy ELF MEs could have served as correlates for entanglement. Entanglement is however not necessary in this case since conscious telepathy is not involved. Microwave MEs would have induced bridges between the atomic space-time sheets of the object and super-conducting magnetic flux tubes of Earth. The bridges would have made possible ionic and electronic currents between these space-time sheets and led to the charging of the table and possibly of also object. A suitable intentional targeting of MEs would allow to control the charge distributions of the table and object and therefore the pattern of the induced electrostatic fields.

*What could have produced the motion of the object?*

The interaction of the object with the electrostatic field of the table is a possible explanation for the PK effect. The distribution of the charges of the table and object would allow to control the field pattern and thus the direction of the electrostatic force. This is however not the only mechanism. Ionic currents from the magnetic flux tubes to the atomic space-time sheets of the object produce recoil effect (momentum is conserved only in many-sheeted space-time, not for single space-time sheet), and this could have been the fundamental mechanism of motion (essentially the mechanism of rocket motion). In both cases the subject would have produced only the ME bridges taking care of the control of motion but would not have provided the energy and momentum.

The experiments of Modanese and Podkletnov [H3] provide support for the mechanism. Modanese and Podkletnov studied capacitor at a rather low temperature and at a voltage near the di-electric breakdown voltage. The second electrode was a super-conducting disk. The resulting discharge was large and coherent and accompanied by radiation pulses of unknown type. The pulses induced the motion of the air and kicked test penduli. The force was proportional to the mass of the penduli. The effect caused by the pulses did not weaken with distance. This supports the view that the pulses were TGD counterparts of the Tesla's scalar waves realized as pairs of massless extremals with three momenta in different directions [K35] and induced temporary bridges between test penduli and magnetic flux tubes inducing the flow of ions and the recoil effect. The same mechanism should be at work as a microscopic and incoherent version in the case of lifters.

*How to circumvent the friction?: a connection with the physics of lifters*

Lifters exhibit the called Biefeld-Brown effect [K116]. Lifters are asymmetric capacitors consisting typically of a wire electrode and planar electrode, are in a voltage slightly above the voltage causing di-electric breakdown. Lifters move in the direction of the smaller electrode. Also the flow of air from the small electrode to the large one is involved. On basis of the experimentation and guide the findings of Juha Hartikka, I ended up with a simple model of lifters. What would happen is that there is an electric discharge in the form of small plasmoids (discharge sparks would be analogous to ball lightnings), whose emission from the small electrode causes the recoil effect. The emission of the scalar wave pulses could induce the motion of the air by Modanese-Podletnov recoil mechanism. Since the table is charged, there should be a strong electric field also in the narrow space between the object and table. Therefore electronic discharges from the object could occur, and lead to a small scale lifter effect lifting the object slightly above the table. This does not require the object to carry a net charge.

#### **Could the remote EEG sensor of Sergeyev be based on the same mechanism as PK?**

In the same article also the remote EEG sensor invented by the mathematician Sergeyev claimed to remote sense EEG from a distance of 5 meters is described. Unfortunately, the information related to the invention of Sergeyev is classified. What is however known from the existing literature is that the sensor is surprisingly simple, consisting of a metal disk suspended into water and coated with a semiconductor. The immersion in water is reported to double the effectiveness of the sensor. According to the report, the ordinary EEG sensors can detect EEG only up to a distance of few centimeters since the noise of the environment masks the (Maxwellian) EEG at larger distances. Furthermore, the amplifying effect of water is not consistent with the high value of the di-electric constant of water if ordinary Maxwellian electrodynamics is behind the sensor.

Sergeyev's explanation for the functioning of the sensor utilizes bio-plasma hypothesis. The use of the term bio-plasma is remarkable since professional physicists know that plasma state at the temperatures and densities of living matter is not possible in standard physics universe. In TGD framework super-conducting ions leaking from the magnetic flux tubes of the Earth's magnetic field can give rise to what might be called bio-plasma, and Sergeyev's sensor is indeed said to produce bio-plasmagram. Also maser (microwave laser) effect in bio-matter producing ions and electrons flowing into air is mentioned.

All this suggests that EEG MEs containing microwave MEs inducing a leakage of the ions from magnetic flux tubes to the atomic space-time sheets of the metal disk and in this manner generate plasma. The strength of the resulting electric signal would be modulated by the intensity of the net flux of EEG MEs so that information about EEG would indeed result. EEG MEs would not topologically condense at atomic space-time sheets but propagate as bridges connecting the boundaries of the magnetic flux tubes and atomic  $k = 151$  (cell membrane thickness) space-time sheets. This would explain the dissipation free propagation. For positive energy MEs the effective phase velocity would be of the same order as the alpha wave phase velocity since these MEs would tend to "stuck" (in quantum sense). The basic sensing mechanism would be very much the same as explaining the generation of nerve pulse. Also  $Z^0$  MEs could be involved and would usually have a very weak interaction with the environment. The ability of water to act as a many-sheeted maser, presumably crucial for the functioning of living matter, could explain why the water amplifies the effectiveness of the sensor.

Also the remote sensing of the pulsating magnetic fields produced by Nina Kalugina and having strength nearly equal to that of the Earth's magnetic field are mentioned in the article. The possible significance of the pulsating magnetic fields for PK is still poorly understood in the TGD framework: the problem is that solutions of field equations representing this kind of field configurations are not known. One might however think that the pulsating magnetic fields carry also supra-currents, and that their presence intensifies the leakage of charged particles to the atomic space-time sheets of the remote sensor device.

#### **14.4.3 Healing As Rejuvenation?**

The article of Lian Sidorov [J134] and its references give a thorough view about remote healing and viewing. One particular healing method goes under name Qigong [J48]. Qigong is a general term for a large variety of traditional Chinese energy exercises and therapies. Qigong is generally

considered as a self-training method or process through Qi (vital energy) and Yi (consciousness or intention) cultivation to achieve the optimal state of both body and mind. The traditional Chinese medicine postulates the existence of Qi, which could be regarded as a kind of subtle energy circulating around the physical body.

The physiological, chemical and electromagnetic effects of both internal and external Qigong have been studied ([J134] contains large number of related references). Also the effects of Qigong healing on cancer has been studied [J48].

### Negentropic entanglement as Qi?

In TGD framework the energy associated with MEs and supercurrents flowing along magnetic circuitry could be a natural counterpart of Qi. The positive metabolic energy assignable to negentropic entanglement or negentropic entanglement could be an alternative identification for Qi. If entanglement is entropic it corresponds to bound state entanglement and this entanglement of its negative metabolic energy could be seen as the counterpart of “sick Qi”.

Yi could in turn would translate to p-adic cognitive representations representing also intentions, perhaps p-adic variants of MEs or even magnetic mirrors. Internal Qigong refers to self healing whereas external Qigong means directing Qi energy or intention to help others by opening Qi blockages or inducing the sick Qi to get out of body, or helping to achieve Qi balance. The transfer of metabolic energy by ATP-ADP process [?] would be basically a transfer of negentropic entanglement in TGD framework and Qi blockage could be interpreted as a blockage preventing transfer of this entanglement (of metabolic energy in standard framework) would be basically a transfer of negentropic entanglement in TGD framework and Qi blockage could be interpreted as a blockage preventing transfer of this entanglement (of metabolic energy in standard framework).

Zero energy ontology in principle makes possible the creation of matter from vacuum as zero energy states. This process involves a generation of a new CD serving as a correlate for self carrying positive and negative energy parts of the zero energy state at its future and past boundaries. The standard physics interpretation would be as a quantum fluctuation in a space-time volume dictated by CD. At space-time level space-time sheets within CD would be the correlate. Also the transformation of p-adic space-time sheets to real ones and vice versa in the intersection of real and p-adic worlds becomes possible.

### Healing as regeneration of negentropic resources?

De-differentiation of cells taking place in the healing of cancer cells resembles rejuvenation. But what does rejuvenation mean? The first guess is that it corresponds to time reversal and running of biological programs backwards so that the stage before the emergence of disorder is reached. This interpretation is attractive but during the preparation of this article I realized that it does not conform with the most recent view about what the arrow of geometric time is [K9].

To begin with, one must understand how the arrow of psychological time is induced from quantum arrow. This question is not completely understood in TGD framework. There are several arrows of time: quantum arrow of time, arrow of the geometric time of 8-D embedding space, and the arrow of the geometric time of 4-D space-time sheet of subsystem identifiable psychological time.

1. Quantum arrow of time has a nice explanation: for zero energy states either positive or negative energy states (but not both) can be chosen to have well defined single particle quantum numbers - they are prepared. The simplest manner to identify quantum jump and unitary process  $U$  would be as state function reduction taking place alternatively for positive or negative energy part of the state. One would have time-flip flop at embedding space level: the arrow of 8-D embedding space geometric time would alternate. This of course sounds weird unless one makes a sharp distinction between different times.
2. What about the arrow of the time at 4-D space-time level? What is clear that observer of space-time as Flatlander does not observe the change of the arrow of embedding space time but experiences constant arrow of time reflecting itself as second law. In fact, entropy defines natural time coordinate for Flatlander. This can be understood if quantum average 4-D space-time surfaces associated with subsequent zero energy states effectively combine to



form a multiply folded towel like structure. In quantum jump 4-D space-time surface can be said to turn downwards at the upper end of CD, return back to turn upwards at the lower end of CD, and so on. Flatlander would experience the flow of 4-D time as a continual increase of entropy manifesting itself as properties of the space-time sheet with which Flatlander identifies herself. The 4-D arrow of time would not change. Only by observing space-time sheets in different time scales would make possible for the Flatlander to discover that the 8-D embedding space arrow of time alternates. Phase conjugate laser beams and self assembly in biological systems would represent examples of processes allowing to overcome the restrictions of being Flatlander. During last decades we have been indeed able to overcome these restrictions as the discovery of phase conjugate laser beams demonstrates [D3]. In TGD framework massless extremals (MEs, topological light rays) provide a representation for the phase conjugate laser beams. Also the discovery of Italian physicist Fantappie that living systems are characterized by both entropic and syntropic processes demonstrates the presence of both directions for the arrow of time at embedding space level [J133, J23].

In this framework healing corresponds to rejuvenation if the age of cell is as entropy defining also a measure for the amount of differentiation that has occurred. By second law ageing would be reduction of negentropy resources and healing as rejuvenation would mean the increase of negentropy of the system. This is possible if the notion of negentropic entanglement is accepted. The healing as increase of the negentropy of the system implying rejuvenation should take place in state function reductions and NMP [K61] would make them possible if the notion of number theoretic entanglement entropy is accepted.

#### How topological light rays and magnetic flux tubes relate to healing?

Massless extremals are excellent candidates for the space-time correlates of communication and control signals and depending on the sign of the energy can propagate in both time directions. Real bosons correspond to wormhole contacts connecting positive (negative) energy MEs whereas virtual bosons are identified the wormhole contacts connecting positive and negative energy MEs. In zero energy ontology it makes sense to speak about quantum jumps transforming p-adic MEs to real ones and about reflection of MEs in time direction so that positive energy ME transforms to negative energy ME or vice versa. Also MEs analogous to virtual particles are possible. They correspond to pairs of MEs with opposite time orientations so that the wormhole throats carry opposite signs of energy. In this case the classical momentum is not anymore light-like and although wormhole throats are massless the boson itself can be interpreted as a virtual off-mass-shell particle.

In quantum optics time reversal is known as a phase conjugation [D3] and is one of the basic notions of holography. MEs act as both quantum holograms and receiving and sending quantum antennae of [K74] ). MEs can generate reference waves of coherent photons interacting with other MEs and activating dynamical holograms of coherent light. If the reference wave is phase conjugated, the resulting hologram is time reversed.

What makes this so interesting is that MEs and magnetic flux tubes are the tools of of quantum control in the TGD based view about biosystem as a symbiosis in which MEs control superconducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via the many-sheeted ionic flow equilibrium. The coherent light pattern emitted by ME resulting from the interaction of ME with the reference wave (its phase conjugate) could act as a control command (time reversed control command) inducing process (time reversed process).

How topological light rays and magnetic flux tubes relate to healing?

1. In the original vision about healing as time reversal for biological programs phase conjugate reference waves would provide a simple and general mechanism of healing by time reversal allowing the living matter to fight against second law. This picture is however inconsistent with the recent view about the arrow of time.
2. In the recent view about the arrow of time topological light rays generate non-local single particle excitations at the flux tubes carrying cyclotron Bose-Einstein condensates and the resulting negentropic entanglement induces healing.

#### 14.4.4 Near Death Experiences

Near death experiences are rather commonly experienced, say by the victims of various accidents. These experiences are known for centuries but it was the best-selling book “Life after Life” of Raymond Moody which brought these experiences known to the general public [J156].

##### 1. *What NDEs are?*

NDEs seem to possess invariantly the same characteristic features. There are feelings of peace and joy, time speeded up, heightened sense, lost awareness of body, seeing bright light, entering another world, encountering a mystical being or deceased relatives and coming to a point of no return. The experiences seem to proceed in quite universal manner. First comes a loud buzzing or ringing noise and a long dark tunnel. Patient sees his own body from outside and does not feel any pain or agony anymore. Patient meets others and a being of light who shows his life in its entirety as a kind of playback to evaluate. Then comes the point of no return, and although patient feels peace, joy, and love, the patient has to return to continue his life. Often these experiences induce very profound changes in the subsequent life of the patient. The claims of Moody have been supported by subsequent research and hardly anyone, even the most foolhardy skeptic, denies the reality of these experiences.

The latest twist in the development emerged when University of Southampton research team announced the result of a one-year study of NDEs of victims of a heart attack supporting the view that consciousness and mind exist after the brain has ceased to function and the body is clinically dead. The resuscitated patients were various times clinically dead, with no pulse, no respiration and fixed dilated pupils. Independent EEG studies have confirmed that brain’s electric activity, and hence brain function (according to standard dogmas of neuro science) ceases in this kind of situation. 11 per cent of patients who survived the heart arrest however recalled emotions and visions during this state. This announcement has created considerable excitement in various consciousness related discussion groups and the question whether some of the basic dogmas of neuroscience are badly wrong has been raised by the neuroscientists themselves.

##### 2. *TGD based view about life after death very concisely*

It is good to summarize the latest TGD based view about consciousness after physical death before comparison with other theories and detailed analysis of NDEs. The view, which is certainly not the only possible one can imagine, is supported by the improved view about psychological time.

The basic notion is that of 4-D body involving both the physical body and the magnetic mirror structures associated with it. 4-D body is gradually carved like an artwork via state function reduction sequences which can correspond to both directions of geometric time in zero energy ontology. Self interprets these sequences for sub-selves as sensory perceptions and motor actions which would be thus time reversals of sensory percepts. This fractal trial-and-error construction of the 4-D body occurs in various time and length scales. Gradually increasingly stable 4-D body results.

Since magnetic mirror structures are fundamental for the field realization of the genetic code, one can quite well consider the possibility that this process induces also the self-organization of the ordinary living matter around the magnetic mirror structures. This would have interpretation as a reincarnation. Buddhas able to resist the temptation to reincarnate would continue their life at the field level. Interestingly, the development of physics from Newtonian physics of the material bodies to Maxwellian physics of fields would mirror the evolution of consciousness from concrete biological life to life at the field level.

##### 3. *Astral plane theories for NDEs*

There are several theories of NDEs. A theory enjoying popularity in New Age circles is based on the notions of the astral projection and next world stating that we have another body that is vehicle of our consciousness which leaves the body at the moment of death. Although completely respectable as such, this kind of theory is not based on existing or even postulated physics, and is therefore hard to test. The notions of “higher vibrational level” and “astral plane” are simply devoid of a physical meaning.

In TGD framework the idea about “vibrational levels” generalizes in an astonishing con-

creteness to an entire hierarchy of electromagnetic life forms and electromagnetic bodies whose sizes vary to astronomical length scales [K44, K89]. In this framework the idea about brain as a seat of consciousness is an illusion resulting from the fact that sensory data is mostly about the immediate region around body. Of course, even the idea that consciousness (as opposed to its information contents) can be localized to some part of space-time, is basically wrong in TGD approach.

A possible test for the astral projection theories is a weighing of the body after death to deduce the weight of the astral body (assuming of course that astral planes obey ordinary physics!). If “astral planes” correspond to the p-adic space-time sheets, this test of course does not make sense. Magnetic mirror structures are obvious candidates for astral body and are real but their separation from body is impossible so that this kind of measurements do not make sense. The notion of 4-D body also suggests that the physical body remain in the geometric past in the physical death wherefrom it can communicate with the living ones via the magnetic mirrors of magnetic body.

Extrasensory perception via astral bodies is a second possible test. This test might make sense if extrasensory perception can be generated by patterns of ELF em fields as supposed in the TGD inspired model of qualia. Magnetic mirrors connecting organisms to each other and also to “nonliving” matter make possible ESPs. Also direct electromagnetic perturbations of the magnetic sensory canvas can give rise to ESPs: in [K55] the possibility that the strange sounds produced by meteors [F3] could correspond to ESPs is discussed.

#### 4. *Tunnel experience*

The theory of Grof and Halifax [J112] is based on the observation that NDE involves elements which might be assigned to the moment of birth. Perhaps NDE is reliving the moment of birth. The counter argument is that the newly born baby does not see anything unless she is able to perceive extrasensorily. “Nothing but hallucinations” theories are of course no explanations at all and belong to the same category as “consciousness as mere illusion” theories. In neuroscience framework also the wake-up reality is seen basically as a hallucination produced by brain and coupled with sensory input to guarantee correspondence with what is out there.

The tunnel is experienced also during epilepsy and migraine, during meditation and relaxed state of mind, and with certain drugs like LSD, phencyclidine and mescaline. It has been suggested that the physiology of brain could explain the properties of near death experiences [J127]. The theory of Cowan [J127] states that the tunnel results from a failure of the inhibition leading to brain induced activity yielding visual experiences. What is however questionable is why person would feel falling into the tunnel, to say nothing about meeting deceased relatives. Blackmore and Troschlenko have proposed a theory in which also the motion along tunnel could be understood as a visual illusion [J37].

TGD based explanation for tunnel experience might be simply as a direct visual experience about magnetic flux tube structures resulting from the perturbation of the magnetic sensory canvas outside body. Thus a genuine ESP would be in question. Magnetic field obeys indeed same basic equation as incompressible liquid flow. Both retinas and pineal gland (“third eye” literally since it contains retinal pigments and serves as a genuine third eye in some species [K44] are magnetic structures. The practically always present vortex in center (“third eye” in my private terminology) could correspond to the magnetic flux tube structure emanating from the pineal gland whereas the very dynamical flow could correspond to the contribution of retinas. If the magnetic mirrors are universal electromagnetic bridges connecting us to other living beings, in particular to our friends and relatives, the meeting of the 4-D bodies of the deceased relatives would happen at the level of fields. The movement along the tunnel could correspond to the propagation along this kind of magnetic mirror.

I cannot resist the temptation of telling about a personal “tunnel experiences” taking place every-daily although this might be criticized as highly unscientific. For me science is attempt to identify the regularities of conscious experience and the only conscious experience I have is my own! As I close my eyes in a half-meditative state achieved by writing at computer terminal, I can see a dim flow consisting of points. Typically this flow enters to or emergences from a tunnel. It can be rotating spiral like flow or simple sink or source. Source or sink can be also linear structure. Earlier this experience was not stable and tends to fade away all the time, and after few minutes I was not anymore able to achieve it. Situation has changed quite recently: I can have the

experience almost anytime in peaceful state of mind. During the “great experiences” this flow was much more complicated and completely visible and formed a stable background of the ordinary visual experience and of hallucinatory visual images.

There is however no experience of entering into the tunnel in this case so that the tunnel need not be the same as encountered in NDEs.

### 5. OBE aspect

Blackmore explains OBEs [J163] as resulting from the replacement of ordinary self-center experience of world with bird’s eye of view model where brain sees own body from above. Bird’s eye of view is only a memory model so that extrasensory perceptions are predicted to be impossible during OBEs. There is however some evidence that patients can report very precise visual perceptions during OBE. It has been indeed argued, that some other senses than vision, namely [K85] [J163], could create indirectly these perceptions. It is however difficult for even the most hardborn materialist to understand how a clinically dead person could be able to effectively see by hearing, since this feat is impossible for even completely healthy person.

The idea of Blackmore about bird’s eye of view is very attractive as such and can be interpreted in TGD framework in quite different manner. Cognitive maps based on the canonical identification map [K42] typically exterior to inside and vice versa. Thus both a p-adic map of the external world realized inside brain and a p-adic map of body and its surrounding realized outside the body are possible and would give models of the external world and self. The inside-to-exterior map could provide a bird’s eye of view about body and its immediate surroundings.

Both exterior→interior and interior→exterior maps could contribute to the conscious experience even under the normal wake-up consciousness and the exterior contribution would thus represent genuinely extrasensory contribution to the conscious experience. When the ordinary sensory input and volitional activity ceases as during NDE, the contribution of the model of external world to the conscious experience becomes negligible. The ability to experience tunnel unstably during relaxed wake-up consciousness with eyes closed is consistent with the interpretation that these two components are competing. It is quite possible that during sleep the bird’s eye of view component also dominates but that no memories about this period are generated for the simple reason that the brain functions necessary for the generation of the memories are not active.

The notion of magnetic sensory canvas implies that we actually see at ELF frequencies. Same applies to other senses. This implies the possibility of experiences without any sensory input or even without any neuronal activity. The needed ELF MEs acting as sensory projectors would be generated in the dropping of ions from atomic space-time sheets to the magnetic flux tubes of magnetic body carrying field strength  $2 \text{ Gauss}$  (Earth’s magnetic field has nominal value  $5 \text{ Gauss}$ ). If the ion drops in high  $n$  cyclotron state the subsequent decay of the state by cyclotron transitions generates a bundle of parallel ELF MEs giving rise to the sensory projection. This representation can be generated by the entire body and would give rise to a three-dimensional vision about body as seen by the environment. There is some evidence for this kind of anomalous vision.

1. Yogis have reported altered states of consciousness in which they see their own body three-dimensionally, that is simultaneously from all directions.
2. Becker tells in his book “Cross currents” [J160] about a young cancer patient who told that he can see the interior of his own body. The patient could locate the calcium deposit left as tumor vanished. This supports the view that ELF MEs could project from the entire body to the sensory canvas.
3. Also the OBE experiences, for instance those associated with NDEs, could have a similar interpretation. The sensory input from eyes and even the input from neural activity could be 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.

What has been said applies also to other senses. Maybe a personal reminiscence is allowed. I As I was younger I often woke-up partially and realized that I hear my own snoring as an outsider: not a pleasant experience! Sometimes I 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 the outcome is a kind of double breathing with time lag.

Sensory canvas hypothesis provides a more concrete view about the situation. The magnetic mirrors connecting brain to sensory canvas should be there also in the absence of sensory input. Could it be that the out of body view is always involved but masked by the from the body view and after the physical death only out of body view remains?

The competition between bird's eye of view and sensory view has also EEG correlate. Delta waves in the EEG spectrum are natural EEG correlates for the external part of cognition. The reason is that this part of EEG frequency spectrum has a shape and intensity very similar to that for the so called sferics [F1], which correspond to meteorological electromagnetic perturbations typically associated with thunder storms. Could sferics be the electromagnetic correlates of discarnates?! The degree of the sensory alertness correlates directly with the ratio of the EEG net intensities in the delta band and in higher EEG bands [F1]. This is consistent with the competition predicted by NMP. Certainly in the NDE experiences studied by the Southampton team only delta band is present in EEG. Note that delta waves dominate also during deep sleep.

Also alpha band is a good candidate for communicating sensory information to higher level selves having magnetic sensory canvas receiving sensory input from several brains simultaneously. It is indeed alpha band in which detectable changes occur in remote vision and remote healing [J134]. Could it be that higher than alpha consciousness somehow transforms to alpha consciousness in physical death and could it be that alpha consciousness relates with the fact the lowest Schumann frequency associated with the perturbations of Earth's magnetic field is in the alpha band? It might be that magnetic transition frequencies are involved with the "vertical" communications from brain to the sensory canvas whereas Schumann resonances would be involved with the lateral communications between different sensory canvases. The fact that hypnagogic experiences involving also identification with other persons (personal experience) appear in the borderline between wake and sleep when dominating EEG frequencies are around 7.8 Hz supports this view.

#### 6. *Life review*

Blackmore explains the life review as an effect analogous to the lively episodal memories generated by stimulating temporal lobes. This explanation leaves open what exactly happens in the stimulation of the temporal lobes and what episodal memories are. To say nothing about the systematic review and evaluation.

In TGD framework brain and perceptive field are four-dimensional and it is quite possible that episodal memories are multitime experiences involving input which comes from the moment of the geometric time when the recalled experience happened and happens again at the level of sensory representation but not as real life event since this would involve macroscopic volition and induce miracle life events in the geometric future. The notion of 4-D body makes this idea concrete. In the physical death 4-D body becomes in some sense mature (about possible de-construction processes in shorter time scales). The volitional contribution essential for the illusion that world is 3-dimensional is not anymore present and entire 4-D body is experienced as a whole. Perhaps this is just what life review is.

Since geometric memories are in question, the review is only a narrative since our geometric past changes all the subjective time and the review is about geometric past subjectively now. Life review would be a temporal counterpart of the OBE experience in the sense that one sees one's geometric life history from outside in a 4-dimensional sense. This is possible since p-adic cognitive representations are four-dimensional and four-dimensional bird's eye of view could begin to dominate at the moment of death.

Also genuine subjective memories about time interval equal to the wake-up period of self and of order lifetime could be in question. This requires the occurrence of what might be called a p-adic phase transition to higher level self with much longer subjective memory: this view is in accordance with the vision about the physical death as a birth to a life in "other world". p-Adic phase transition could mean that the p-adic magnetic mirrors after the geometric time after physical death correspond to higher value of  $p$  and quite concretely, have lengths which are longer than during the physical life. This makes possible both geometric and subjective memories in much longer time scale.

### 7. Positive emotions

With the motivation coming from the OBEs associated with the temporal-lobe epilepsy, it has been suggested that brain-stress near NDE episode leads to the release of neuropeptides and neurotransmitters (in particular endogenous endorphins) which are responsible for positive emotional states like joy, peace, and love. Again the question concerns about the deeper mechanism. Presumably these neurochemicals are only correlates for the experiences in which extra-sensory component of the experience begins to dominate. It has been also suggested that the lack of oxygen is what gives rise to the NDE experiences [J163]. The observations of the Southampton team seem to exclude these explanations. Of course, one could claim that some core parts of brain are working even when the patient is clinically dead (no respiration, no heart beat, dilated pupils) and that these functioning parts of brain are able to generate NDE. If so, spiritual experiences would represent the lowest possible levels of consciousness, and even reptiles would have them: perhaps a vulgar skeptic could applaud here but I do not find this idea very convincing.

In TGD framework clinical death naturally implies that extrasensory component of the conscious experience begins to dominate. This picture is consistent with the view about brain as p-adic-real transformer rather than the seat of the entire conscious experience. The dominance of the positive emotions would simply mean that the negative emotions coming from sensory input would be absent.

### 8. Other worlds

The experiencing of “other worlds” requires a considerable amount of hand weaving in the standard neuroscience framework. Blackmore claims that imagined worlds are experienced as real because these experiences are the most stable. I believe that Blackmore is right in the sense that mental images (sub-selves) correspond to self-organization patterns which are stable asymptotic states of self-organization. I do not however believe that this is an essential point, and certainly Blackmore’s explanation fails if the interpretation of the Southampton team about NDEs is correct.

In TGD framework the other worlds might correspond to the emergence of magnetic mirror structures which correspond to higher value of p-adic prime than during the physical life. They would have much longer lengths and give rise to much longer subjective and geometric memories. Note that the MEs associated with magnetic mirrors are classical representation for light (which brings in mind Tibetan book of death!) so that one could say that the deceased becomes a light being in a well-defined sense. The meeting of the light being might mean an ability to communicate with and sensorily experience the presence of other light beings, natural if the deceased herself has transformed to a light being (but having still 4-D body in the geometric past, this is perhaps why angels have human body!).

Note also that the absence of sensory and corresponding cognitive mental images during NDE is analogous to the empty mind free of mental images which is the goal of the meditation practices. Perhaps soul could be identified as a self having no sub-selves, “irreducible self” as suggested in [K94].

### 9. After effects

The after effects induced by the spatio-temporally extended consciousness in which one sees one’s own life from outside are often dramatic. It is difficult to reduce these after effects to brain pharmacology.

My own “great experience” had many aspects common to NDEs and induced profound (not at all pleasant!) changes in my own life. In my case the direct experience of the higher levels of reality made possible the realization how magnificent the almost-boring everyday reality really is when seen through sharpened senses, how pathetically narrow the zone of wake-up consciousness is, and how ridiculously little the celebrated big science tells about reality. This realization resulted in a strong conviction that I am on a right track, and has given the courage to work these fifteen years as a ridiculed scientific dissident in a country in which vulgar skepticism is in the role of a scientific state religion and vulgar skeptics have taken the role of the mind police of science.

## 14.5 Conscious Hologram And Remote Mental Interactions

The notion of conscious hologram allows also a unified description of remote mental interactions.

### 14.5.1 Big Vision

The notion of conscious hologram, which is based on the generalization of the notion of Feynman diagram, provides a general view about remote mental interactions.

1. Brain can be seen as a part of a gigantic dynamical and fractal brain consisting actually of the entire universe. The same mechanisms that work at the brain level work also at larger length and time scales. Brains/bodies serve as “neurons” for the magnetospheric selves receiving information from several brains/bodies. In particular the fusion of the mental images defined by similar structures can give rise to stereo-consciousness, and the notion of species consciousness and even multi-organ consciousness associated with various kinds of organs makes sense.
2. The notions of super-genome and hyper-genome provide a concrete view about how transpersonal levels of self-hierarchy are realized. Super genes are magnetic flux sheets containing sequences of genes like text lines at the page of book. Hyper genes are flux sheets containing sequences of super-genes belonging to different organisms as genetic text lines. This picture conforms nicely with and generalizes Sheldrake’s species memory and “alike likes alike” rule. It also suggest a concrete realization of remote biological mental interaction based on activation of gene expression and nerve pulse activity.

The flux sheets associated with super-genome and hyper-genome have fields strengths of magnetic field of Earth. The correlation of the quality of remote cognition performance with sidereal time [J126] leads to the hypothesis that also the flux quanta of galactic magnetic field couple somehow to living matter.

3. Besides time mirror mechanism charge entanglement realized in terms of  $W$  MEs is a basic mechanism of remote mental interaction. The simplest model for the generation of nerve pulse is based on quantum jump leading to a state in which Bose-Einstein condensate of  $\text{Ca}^{++}$  and/or  $\text{Mg}^{++}$  becomes exotically ionized and generates charge flow through cell membrane. Quite generally, charge entanglement would be part of the ordinary bio-control realized in terms of  $\text{Ca}^{++}$  waves. Charged entanglement provides also a mechanism for the sharing of mental images between magnetic body and biological body. There is no reason why this mechanism could not work also at the level of other remote mental interactions than those that we are too familiar with to realize that remote mental interactions are in question. The typical time 13-15 seconds associated with the remote realization of intentions by Qigong masters [J107] could correspond to a typical duration of  $W$  entanglement.

The models for bio-photons bio [I37] and Gariaev’s findings [I30] suggest a tentative model for how remote mental interactions proceed. Charged entanglement via  $W$  MEs makes possible sharing of mental images. After a reduction of entanglement the generation of positive and negative energy MEs occurs and involves time mirror mechanism making possible remote metabolism and communications of declarative memories. In the case of ordinary bio-control magnetic body utilizes the metabolic energy resources of biological body.

4. Association mechanism works also for remote mental interactions and is even in the case of brain based on MEs and magnetic flux tubes with neuronal firing and metabolic activities being side products of the this mechanism.
5. One of the strange findings about remote mental interactions is that remote viewer can receive information about an object for which she knows only coordinates, which as such are meaningless numbers to her. It is also commonly reported that erroneous readings or interpretations of the target tend to propagate to other viewers. These findings suggest that magnetospheric (earthly or galactic magnetosphere could be in question) dynamical multi-brained selves act as kind of relay stations mediating the remote contact between remote viewer and object. If some brain knows the meaning of the coordinates of the target, this is enough to connect remote viewer to the correct target.

Empirical support for the notion of multi-brained collective levels of consciousness comes from the experiments of Mark Germaine [J140]. An operator and a subject person were involved. The

stimulation of the subject person consisted of a sequence of identical sounds containing now and then an odd-ball stimulus (now silence). The odd-ball stimulus generated an event related potential (ERP) visible in EEG and reflecting the conscious reaction. The operator was in a second room and by simple toss of coin decided whether to observe the stimuli in the computer monitor or not. The stimuli appeared in the computer monitor one second before they were heard by the subject person.

What was found that when the operator saw the odd ball stimulus from the computer monitor, the ERP was weaker on the average. An 11 Hz periodicity was the major component in the difference profiles.

The simplest explanation is that the brains of both the operator and of the subject person belong to a larger multi-brained self and that the evoked response represented partially the reaction of this self. When this multi-brained self had already seen the stimulus through the operator's eyes, it was not so surprised to hear this stimulus again through the ears of the subject person, and ERP was weaker.

The appearance of the 11 Hz periodicity suggests that this frequency is an important correlate for the entanglement of the subject person's mental images with those of some multi-brained magnetospheric self. The cyclotron frequencies of most bosonic ions in Earth's magnetic field are in alpha band so that the finding is consistent with the vision about a fractal hierarchy of generalized EEGs associated with the dark matter hierarchy [K33]. The notion of hyper-genome provides a detailed model for how transpersonal levels of self hierarchy control the behavior of groups of individuals. The hypothesis could be tested by looking whether the gene expressions of individuals having close personal relationship but not in a direct personal contact correlate.

### 14.5.2 Sketch For What Could Happen In A Typical Remote Viewing Experiment

Consider a situation in which a system consists of remote viewer A, person B knowing the position of target T and the coordinates XYZ for it. B gives the coordinates XYZ for person C in turn giving them to the remote viewer A. The following simplified sketch assumes that communication channels are permanent and that the intentions involved with the process are realized as p-adic space-time sheets in the brain of A, and very probably involve p-adic MEs as representations of the intentions.

1. Remote viewer A, person B knowing having target-XYZ association as two mental images in his brain, and target T have permanent bridges to a magnetospheric multi-brained self M. Therefore M knows the target-XYZ association via the brain of B.
2. Remote viewer A is a client of the multi-brained self M using the remote sensory services provided by M. A-M contact is more or less permanent: this is what it means to have the ability to remote view. Minimum requirement is the existence of magnetic flux quanta connecting A to M. The sharing of mental images requires generation of entanglement, say charge entanglement by  $W$  MEs. This would correspond the most primitive passive mode of remote viewing.  $W$  mode allows to share also mental images of primitive living systems like plants, and even those assignable to system regarded usually as in-animate. The reduction of charge entanglement makes possible remote mental interaction since resulting charge non-equilibrium generates currents: generation of nerve pulse and  $\text{Ca}^{++}$  waves would represent basic example of this kind.
3. One can imagine also active mode of remote viewing and this could be involved with telepathy: in this case M would not be involved. This mode involves intentional action (p-adic MEs are transformed to their real variants) and classical communications with the geometric past/future using neutral negative/positive energy MEs could realize declarative memories/"declarative" precognition as well as motor action based on classical communications using symbolic representations. The model for bio-photons suggests that  $Z^0$  and em MEs are generated after the reduction of charge entanglement. The ability to predict reasonable well the personal future could rely on "declarative" pre-cognition. The evolution from bicameral mind to modern consciousness [K96] could have proceeded from a mere sharing of mental images by  $W$  MEs to complex classical symbolic communications involving also neutral MEs.



4. Since M cannot be assumed to have anything comparable to a nervous system, A-M communications should rely on sharing of mental images. That is, the intention of A (p-adic space-time sheet in brain of A perhaps) to remote view and the questions of A about the target would be shared by M. T-M communications could involve classical communication with light velocity generating magnetospheric sensory representation about the target by self-organization. The 13-17 second delay of remote mental interactions [J107] could correspond to the typical duration of charge entanglement. Target could be also “non-living”: it is quite possible that magnetospheric selves form sensory representations also about “non-living” matter. The finding that meteor sounds have frequency spectrum in the 40 Hz band of thalamocortical resonance frequencies, rather than in the predicted 20-20,000 Hz band, supports the view that magnetospheric sensory representations at 40 Hz resonance band are associated also with the non-living matter [K53], [F3]. Also the vision about dark matter hierarchy conforms with the idea about Earth’s magnetosphere as a living organism.
5. Remote viewing by the sharing of mental images means that there are no sensory receptors associated with the passive mode of remote viewing: no such receptors have been identified [J142]. Various physiological correlates (say EEG patterns) of remote viewing should be reactions to the shared mental image rather than direct correlates of it. If primary sensory qualia are at the level of sensory organs, remote viewing differs from hallucinations in that there is no feedback to the retinas from cortex responsible for “qualiafication”: this could provide be a clear-cut test. At least in the case of living targets the laws that govern the ordinary sensory perception should hold true for the remote viewing. For instance, the known correlation of the AC performance with the spatial and temporal entropy gradients of the target should hold true for living targets. Even in the case of a non-living target similar correlation holds true if the sensory perception of magnetospheric selves obeys same laws as that of ours: there is some evidence for the correlation of the entropy of non-living target with the AC performance [J142].

### 14.5.3 About The Physiological Correlates Of Anomalous Cognition

In the article “Physiological correlates of Psi cognition” of Charles Tart [J50] some apparently contradictory findings about physiological correlates of anomalous cognition are described besides the experimental findings of Tart. Changes in EEG, galvanic skin response, finger pulse, and basal skin resistance are examples of possible candidates for the physiological correlates of remote mental interactions.

The findings are following.

1. The first class of experiments involves two persons: subject and agent. The agent is subjected to various kinds of stimuli inducing emotional response: sudden sounds, painful stimuli as in the experiments of Targ, etc.. Subject person is typically in a sound proof room and tries to remotely cognize when subject person experiences these stimuli. Various candidates for the physiological correlates are measured. The physiological correlates typically express a heightened arousal. For instance, in the experiments of Tart [J50] galvanic skin response occurred more frequently, and EEG became more complex with more beta waves and fewer alpha, theta, and delta waves.
2. In the second kind of experimental arrangement remote viewing or telepathy is involved but the second person, if present at all, is not subject to any stimuli inducing emotional reaction. Now the physiological correlates tend to be characteristic for a relaxed state of mind. The increase of the basal skin resistance is one such correlate.

At first these findings might seem to be contradictory. The paradox disappears if sharing of mental images is in question and if the mental images induce same emotional response in the subject person as in the agent.

The remotely perceived (possibly sub-conscious) stimulus or remote anticipation of the stimulus induces in the subject person an emotional reaction having as a correlate the reduction of skin resistance. In the experiments of Tart [J50] both the real electrical stimulus experienced by the agent and the electrical stimulus guide by the operator to an electrical resistance instead of

the agent, generates the arousal in the subject. This requires that both the operator, agent, and subject belong to the same multi-brained self so that the reaction of the subject can be interpreted as a kind of conditioned reaction of the multi-brained self expressed via the body of the subject.

#### 14.5.4 Local Sidereal Time, Geomagnetic Fluctuations, And Remote Mental Interactions

The article of J. Spottiswoode [J126] discusses two strange findings about remote mental interactions.

1. There is a statistical tendency of the anomalous cognition (AC) performance to concentrate in a 2 hour period around 13.30 of the local sidereal time (ST), which is the time measured using as a reference distant stars and thus running at a slightly different rate than the solar time: the lag is  $\Delta T = 24/365$  hours  $\sim 3.7$  minutes during 24 hours.
2. The anticorrelation between the level of geomagnetic fluctuations and AC performance has also a maximum during 2-hour period around  $\sim 13.30$  ST.

The fact that AC performance is associated with the same sidereal hour suggests the identification of the galactic magnetosphere as a conscious involved with remote cognition. For interstellar and galactic magnetic fields cyclotron time scales correspond to the time scales of human consciousness so that also these magnetic flux quanta could receive sensory input from biosphere and control it.

#### Support for the role of magnetospheric consciousness

The so called ap index measures the intensity of the fluctuations of the Earth's magnetic field. If the magnetosphere is a conscious entity, ap index can be interpreted as a measure for the level of arousal of the magnetospheric mind. The negative correlation between ap and AC performance tells that AC is most probable, when the magnetosphere is in a "calm state of mind". This is natural since only in this kind of situation the noise masks minimally the signals from the galactic magnetosphere.

The local magnetic noise produced by the modern high tech environment is much stronger than the geomagnetic noise but this does not matter. If artificial magnetic fields correspond to  $k_d = 0$  level of the dark matter hierarchy, they have no effect on higher levels of dark matter hierarchy. Note that the hypothesis is  $h_{eff} = nh$ , where  $n$  is product of distinct Fermat primes and power  $2^{k_d}$ .

#### Is there an ELF signal from the special direction masked usually by the geo-magnetic noise?

The obvious question is why the anticorrelation between anomalous cognition effect size and ap index is highest at 13.30 ST? What this finding means that a particular portion of the sky defined by a definite longitude is above the head of a successful anomalous cognizer independently of the time of year. Thus there should be something special in a direction at this longitude.

The simplest explanation for these findings goes as follows.

1. Suppose that there is a higher level conscious entity at the direction 13.30 ST at the galactic magnetic body such that various cyclotron frequencies involved with the communications with this entity correspond to a typical time scale of the anomalous cognition. This conscious entity could have size of galaxy or it could correspond to a flux tube of galactic magnetic body using the cognizer and target as sensory receptors and motor instruments just as our magnetic body might use neurons of our brain or our body parts.
2. Anomalous cognition could involve positive and negative energy signals to this magnetic body and back so that essentially instantaneous AC events would be possible.

3. The information transfer between two kinds of flux tubes is made possible by the topological condensation of the flux tubes of  $B_E$  or its dark variant at those of the galactic magnetic field or its dark variant and would be maximal when both are nearly vertical. Also geomagnetic noise would be transferred via wormhole contacts to the flux tubes of the galactic magnetic field and perturb these communications. Both AC and its anticorrelation with geomagnetic noise would be maximal when the flux tubes of of magnetic fields in question are approximately parallel. Since the flux tubes of  $B_E$  are approximately vertical, this the case when the galactic center is directly above the head. This would explain the special value of sidereal time. One can say that the magnetic flux tubes of the interstellar magnetic field define kind of cosmic umbilic cord which might serve as a correlate for the tunnel experience associated with NDEs.
4. If signals to geometric past and back are involved the time and length scales would measured using  $10^5$  years as unit. The signals themselves would be coded using frequencies characterizing time scales of neural consciousness as kinds of ripples to the very slowly oscillating background signal just as perturbations due to nerve pulses interfere with EEG rhythms. Since remote psychokinesis and anomalous cognition should rely on the same mechanism, the first guess for the time scale involved with these signals is as the time lag of 13 to 17 seconds involved with the remote realization of intentions by Qigong masters [J107]: the interpretation as a typical duration of charge entanglement was already proposed. It would not be surprising if the time scale of entanglement would determine also the scale of cyclotron frequencies. This would mean the importance of the frequencies in the range .06 to .08 Hz for anomalous cognition.

The following scenario suggests a possible manner to understand the time scale of remote PK.

1. If protonic cyclotron transitions generate the low frequency MEs in the range  $f_1 = .06$  Hz to  $f_2 = .1$  Hz, the strength of magnetic field must be in the range 13 to 17 nT (nanotesla). The magnetic flux tubes of an interstellar magnetic field in a direction with a longitude defined by 13.30 ST should be in question.
2. The ends of the magnetic flux quanta attached to structures within the inner magnetosphere co-rotate with Earth. The resulting twisting presumably tends to induce additional noise to the interstellar magnetic field or Earth's magnetic field or both.
3. The strengths of the typical disturbances of Earth's magnetic field are in the range 50-200 nT [J126]. The average strength for a given frequency component for the fluctuating part of the Earth's magnetic field increases at low frequencies. At the alpha band the strength of the Fourier component of fluctuations is about  $\sqrt{B^2(f)} \simeq 1 \text{ pT}/\sqrt{Hz}$  at alpha frequencies. Interestingly, the magnetic perturbation produced by brain at alpha band has a peak, which is slightly above the fluctuations of the Earth's magnetic field. This is perhaps not an accident in light of the expected role of the alpha band in remote mental interactions. The strength for the Fourier component  $B^2(f)$  for the fluctuations of  $B^2(t)$  [J24] is roughly  $\sqrt{B^2(f)} \simeq .1 \text{ nT}/\sqrt{Hz}$  at  $f_2 = .01$  Hz, and about  $\sqrt{B^2(f)} \simeq 10 \text{ nT}/\sqrt{Hz}$  at frequency  $f_1 = .06$  Hz.

What puts bells ringing is that the noise level 50-200 nT is by a factor 4 to 15 higher than the required interstellar static magnetic field at the lower limit corresponding to the 17 second period. These findings suggests that magnetic fluctuations tend to mask the positive effect of the interstellar magnetic field on AC. Only when the strength of the fluctuations of the Earth's magnetic field at the cyclotron frequency of the interstellar magnetic field reduces sufficiently below the strength of the interstellar magnetic field, the masking effect is small enough.

#### What is the origin of the interstellar magnetic field?

The idea about the magnetic umbilic cord connecting distant astrophysical objects to a single quantum coherent whole is sensible in the many-sheeted space-time. The TGD based model for

the galaxy formation assumes that the ordinary matter results from the decay of cosmic strings, which are objects carrying extremely strong magnetic fields (magnetic flux tubes and these objects belong to the same solution family of field equations). These cosmic strings form a complex network. For instance, this model explains gamma ray bursters [K101].

The huge energy production of gamma ray bursters is consistent with their huge distance only if one assumes that the energy is liberated in jets. In TGD framework the gamma ray bursts can be identified as jets resulting in the decay of split cosmic strings giving rise to the ordinary matter. The bursts are indeed known to originate in the regions, where new stars are born. This picture supports the idea about the existence of a fractal magnetic flux tube network connecting different astrophysical objects, and left as a remnant from cosmic strings, when their magnetic energy transformed to the ordinary matter and gave rise to the birth of stars. This network could give rise to galactic nervous systems in turn combining to the central nervous system of the Universe.

Surprisingly, this picture might be consistent with the constraints on the direction and magnitude of the interstellar magnetic field.

1. According to the online lecture of S. Oliver [E8], the measured values of the interstellar magnetic fields depend somewhat on the method with which they are measured (this might be a signal of the many-sheetedness). The interstellar magnetic fields vary in the range  $B_u = 1$  mGauss–  $B_l = .1$   $\mu$ Gauss [E11], which means that both electronic and protonic cyclotron time scales for all interstellar magnetic fields correspond to time scales relevant for human consciousness. The minimal values of  $k_d$  are  $k_d = 53$  for  $B_u$  and  $k_d = 66$  for  $B_l$  from thermal stability: .1 second time scale of alpha band is mapped to 50 s for  $B_u$  and to  $\sim 3$  days for  $B_l$ .
2. The synchrotron radiation associated with the diffuse emission from the whole sky but concentrated towards galactic plane corresponds to a field strength  $\sim .6$  nT. Zeeman splitting for hydrogen 21 cm line from condensing clouds gives fields in 1-2 nT range. In the plane of the galaxy the field is roughly parallel to spiral arms and its strength is 1-1 nT and too weak to correspond to the proposed magnetic umbilic cord. Also the direction of the spiral arm is different from the direction of the required magnetic umbilic cord.
3. The second guess is that the magnetic umbilic cord is orthogonal to the galactic plane. The direction of the galactic North Pole has the right ascension (identifiable as the sidereal time at the meridian of the rotating observer)  $RA=12.49$   $\delta = 27.4$  degrees:  $RA$  is not too far from 13.30 so that this guess might make sense. Taking into account that the rotation axis of is tilted by 23.5 degrees towards Sun this would mean that the direction of the magnetic umbilic cord is with accuracy of 3 degrees in the plane defined by the orbit of Earth around Sun. Interestingly, the magnetic field associated with the solar wind varies in the range .2 – 80 nT and average value is 6 nT.

According to [E11], galactic center carries a dipole like field with a strength of order 100 nT, not too far from 10-30 nT. Also this field has filament like structures (flux tubes), which might extend to long distances [E11]. The flux tubes of this field should intersect the galactic plane orthogonally. If the strength of the magnetic field inside the flux tubes stays constant rather than varying like dipole field strength, these flux tubes could give rise to the magnetic umbilic cords connecting us directly to the center of the galaxy. Galactic center, perhaps the immense black-hole region there, could be an monstrous brain having galaxy sized central nervous system! That the model for magnetospheric consciousness would generalize to the scale of entire galaxy would conform with the fractality of consciousness.

4. According to [E11], supernova remnants are accompanied by radial filament like structures carrying magnetic field in 1-10 nT and it seems that supernova wind might carry this field around galaxy: very natural if flux tubes carry the field. According to [E8], for individual sources such as supernova remnants like Cas A Minor, the field strength is 10-30 nT. This corresponds to the interval 5.6 to 17 seconds. That the field strength is of the same order of magnitude as the dipole field at the galactic center conforms with the idea about magnetic nervous system of galaxy connecting the center of the galaxy to the stars. This magnetic

field would be easy to observe in case of supernovae because super nova explosion has packed magnetic flux tubes to a very dense bundle.

### Connections with other effects?

There might be fascinating connections with other strange findings.

1. In Comorosan effect [K128] , [I77] the irradiation of a bio-matter with a laser irradiation lasting for a multiple of 5 seconds has anomalous effect on a catalyst action. 5 seconds corresponds to  $n = 3$  cyclotron transition for proton in a magnetic field of 10 nT. Comorosan effect occurs also in a non-living matter and suggests that the magnetic umbilic cord serves as a kind of cosmic clock.
2. The strength of the Earth's magnetic field in far-away in the plasma sheet is about 10 nT. Could this cosmic magnetic umbilic cord be connected with the plasma sheet and be in a synchrony with what happens there? Plasma sheet is known to be highly self-organizing structure containing in the velocity distributions of charged particles features like "wings" and "eyes" [F2]. In [K55] I have proposed that plasma sheet defines the "self model" of magnetospheric brain and is thus in a role analogous to the insula in the human brain. It would rather natural for the cosmic umbilic cord to couple with that part of the magnetospheric brain which corresponds to the highest level in the self hierarchy associated with the magnetic Mother Gaia.
3. Lungs contain magnetic particles giving rise to magnetic field of about 10 nT. The theory of magnetospheric sensory representations inspires the speculation that the moment of physical death is decided by magnetospheric self sending to lungs stopping signal at proton's cyclotron frequency associated with 10 nT magnetic field.

### 14.5.5 Could Magnetic Flux Tubes Make Possible Effective Holograms?

What conscious holograms really are? Are they genuine holograms or are they holograms only in the sense that the scattering of light beams from them is very much like scattering on ordinary holograms - that is like scattering from the original object. Could one imagine mechanism making possible scattering from the original object effectively represented by the hologram like structure?

To proceed notice that there is rather general belief that just some objects possessed by the patient is enough for healer- in some sense this object are holograms of the patient. Usually this belief is of course regarded as primitive *pars pro toto* magic. This belief might however have some justification in terms of negentropic entanglement expected to be fundamental aspect of remote mental interactions. In principle negentropic quantum entanglement can take place via arbitrary number of relay stations and magnetic flux tubes connecting the entangled objects would be the quantum correlate for it. Negentropic entanglement would serve as a correlate for attention, experience of understanding, etc., and it would correlate closely with metabolism: generation of ATP and associated high energy phosphate bond would generate negentropically entangled electron Cooper pair or add electron to negentropically entangled existing many-electron system and its decay to ADP would liberate metabolic energy quantum and destroy the negentropic entanglement.

Negentropic entanglement could actually mean that objects of the external world - say living beings - can act like parts of our biological body. There is a wide variety of psychological experiments which show how illusory is our view about what our body is. Quantum entanglement of object with its target having magnetic flux tubes as geometric correlates making object a relay station. The object - call it *O* - would only serve as a relay station connected to say person, call it *P*, possesses the object. The light scattering from the *O* could actually transform to dark photons and travel along flux tubes to *P*, where it is scattered back- say from DNA- and returns back along flux tubes and leaves *O*. Effectively this is like scattering from a hologram of *P* represented by object *O*. The flux tube connection would make various objects in our vicinity effective holograms. This is something that one actually expects since attention- both visual and auditory - has flux tubes connecting perceiver to the target of attention as correlates.

One can consider two options since the radiation to object could transform to positive or negative energy photons. In the first case scattering could be seen as ordinary scattering from

*P*. Negative energy photons would however represent signals traveling to the geometric past (analogs of phase conjugate laser beams) and scatter back from *P* as positive energy photons traveling to *O*. TGD based models of memory as communications with the geometric past and intentional action as a process in which negative energy signal to geometric past initiates neural activities (Libet's findings about active aspects of consciousness) involve similar mechanism. Also the remote metabolism based on sending of negative energy signals to a energy storage (analogous to population inverted laser) relies on the same mechanism.

Peter Gariaev's experiments irradiating DNA with red laser beam generate broad of radio waves, which in TGD Universe could correspond to photons with same energy but with large Planck constant. These photons have biological effects on organisms of the same species and even on closely related species. TGD based proposal is that the scattered laser beam defines a collection of frequencies serving as addresses for parts of DNA activating gene expression.

If this represents a basic mechanism of genetic expression, one can quite well imagine that an organism - call it A - whose DNA is somehow damaged, could utilize the healthy DNA of another organism - call it B - by sending to it the counterpart of laser beam which scatters and generates the superposition of dark photon beams serving as an address activating the DNA of A. A would effectively use the DNA of B and B would effectively become part of A: s biological body. This mechanism could explain why the mere presence of healthy organisms of the species can induce the healing of organism which is not healthy. It could be the basic mechanism of healing: patient could remotely use the healthy DNA of the healer to generate signals activating her own genes.

Some further comments and questions are in order.

1. The relay station mechanism could universal in biology. The transformation of ordinary photons to dark photons at flux tubes defining the magnetic body of DNA is assumed in the model explaining the photos taken by Peter Gariaev and his group about DNA sample showing the presence of what looks like macroscopic flux tube structures [K1].
2. The mechanism could also explain phantom DNA as real DNA connected by flux tubes to the chamber that contained the original DNA. The laser beam arriving to the empty chamber would travel along flux tubes to the place, where the removed DNA is, scatter and return back. This would create the scattering pattern assigned with the phantom DNA.
3. One can even ask whether the basic mechanism of homeopathy relies on relay station mechanism. Homeopathically treated water would be a collection of flux tube connections to the molecules, which were present in the first stage of the preparation process of the homeopathic remedy. Since the dark photons travel with light velocity, the times for travel of photons would be so small that the scattering of incoming light via the relay station mechanism would almost instantaneous so that the original molecules would be effectively present.
4. For instance, the de-differentiation of cells which looks to my rather mysterious phenomenon, means rejuvenation. Could one imagine that the genetic programs are replaced with those in geometric past and similar mechanism is at work. Could the rejuvenation mechanism involve scattering of the counterpart of phase conjugate laser light from non-differentiated healthy cells of the geometric past? If so, one should try to achieve the same effect directly at the level of cells. One could try to induce de-differentiation of the cells of the owner of the object serving as a relay station in the same manner. Healing of say cancer cells by de-differentiating them to omnipotent state. In the experiments involving Becker's DC current just this happened. In this microscopic situation might be can demonstrate the effect really convincingly.

### 14.5.6 Two Attempts To Understand PK

In quantum theory context one can try to explain retro PK (psychokinesis) and perhaps even PK using quantum measurement theory. It seems however that quantum theory is not enough and feedback loop to past allowing to observer to affect the quantum system generating random number. In TGD framework intentional action based on negative energy signal to geometric past would be a rough manner to state what this feedback to geometric past is. For instance, intentional generation of motor action would involve a negative energy signal - say in EEG frequency range -

from the “personal” magnetic body to the brain of geometric past, where it would initiate neural activity leading to motor action.

My attempt to concretize this picture in TGD framework - inspired by an unpublished article by Brian Millar relying on the observational theory of PK first proposed by Walker [J64, J65] (for an earlier article discussing his vision see [J32] ) - led to following two options restricting the consideration on PK in which operator tries to increase or decrease the number of 1: s or 0: s in a random sequence of bits generated by transitions of microscopic quantum system to two alternative final states labelled by bit.

1. For the first option observer (operator of experimenter) performs state function reduction for the quantum superpositions of two states resulting in quantal microscopic process and entangled with bits in data file: one can say that before the reading of the file it contains qubits. This requires further entanglement with observer’s quantum states.

Standard quantum measurement theory alone does not suggest any PK effect since the entanglement with observer does not affect the probabilities of the outcomes of microscopic quantum process. To achieve a non-trivial effect the measurement interaction generating entanglement with the observer must be able to modify the probabilities of the outcomes. This interaction could be called feedback loop in time. This picture seems to me more or less equivalent with that of Brian Millar.

“Too-good-to-be-true” option would be that the observer’s intent transferred backwards in geometric time (feedback loop using the terminology of Brian Millar) can affect directly also the bits in data file so that they become superpositions of the originally quantum measured (read) bit, and then perform the quantum measurement as above. In this case PK effect could be observed directly by comparing the file subject to PK with its unaffected copy. The size of the effect would be characterized by the induced mixing. Of course, this kind of idea would have looked completely crazy for few years ago and perhaps even now.

The fact however is that quantum entanglement and quantum superposition have been now demonstrated for increasingly larger systems. Of course, the observer-bit interaction might be extremely weak due to the large energy needed to change the direction of bit classically.

I am a dilettante as a parapsychologist and in order to compare the two options in more detail I have used as background the article “Correlations of Random Binary Sequences with Pre-States Operator Intention: A Review of a 12-Year Program” (see <http://tinyurl.com/oyjvjbw>) [J85] tells about experiments of Jahn and others in which operator tried to affect the RNG output by intentional action: single cycle consisting of an attempt to increase the number of 1s, an attempt to decrease it, and no intention to either direction. Retro PK experiments have been also done: see the articles “PK Effect on Pre-Recorded Targets” (see <http://tinyurl.com/ya92afub>) [J113] and “Addition effect for PK on pre-recorded targets” (see <http://tinyurl.com/yau3ruul>) [J114] of Schmidt. In these experiments the background philosophy seems to be conform with the first option.

There is also a report (see <http://tinyurl.com/owrfolq>) [J63] about an experiment in which chicken was labelled to a robot preprogrammed for months ago to wander randomly around the room: the path of robot was claimed to change so that it stayed near the chicken. Also Libet’s experiments [J31] support propagation of intent backwards in geometric time in time scale of about .1 seconds.

In the sequel I will consider the quantum measurement theory option and the “too-good-to-be-true” option in more detail. I will also discuss a possible mechanism for intentional action changing the direction of bit represented as a magnetized region.

### Quantum measurement theory option

PK selects the outcome of a quantal microscopic process such as radioactive decay producing a superposition of two states (mapped to superposition of bits by entanglement - qubit in fact) and later to bit by state function reduction. Data file can be said to contain quantum superpositions of bits corresponding to the two outcomes of quantum process and observer (experimenter or operator in PK experiment) entangled with these state pairs in PK experiment and observes/state function reduces the state with click telling whether the outcome was desired.

This stage should bring in the effect of intention and change the probabilities for the outcomes. Standard quantum measurement theory does not allow this: experimenter acts as a passive selector of the outcome. Therefore some kind of feedback interaction propagating to geometric past and affecting the probabilities of outcomes in quantum superposition is needed.

If the data are read before experiment state function reduction takes place qubits become bits. One can also copy the file to a second one and check that the two files are identical. In this case standard measurement theory tells that the effect of observer cannot change the situation and null effect is obtained. This can be of course tested experimentally. Maybe this has been done.

If this option explains the experiment with chicken and robot, the reading of the random number sequence determining the path of the robot before the experiment implies that the labeling of the chicken to robot would have no effect on robot. The interpretation of Libet's findings about neural activity beginning before conscious decision could be that quantum superposition of neural states corresponding to "I do it" and "I don't do it" is generated a fraction of second before the conscious decision which selects either of these options. Does the intentional action propagating to geometric past generate this superposition? Conscious decision "I shall do this or that" would followed by the choice between "this" and "that".

### **"Too-good-to-be-true" option**

Suppose that the data file is copied and second copy is read by human observer to guarantee state function reduction (according to the standard quantum measurement theory: in TGD framework state function reduction does not require human observer).

In this case the feedback loop of the observer (operator or experimenter) realized as negative energy signals to geometric past must be able to modify the states of the binary digits directly and induce a superposition of binary digits presumably containing a very small contribution of opposite binary digit for a given original digit. After this state function could take place just as in the experiment above. Now the test would be direct: compare the data file with its copy not subject to the action of observer. Statistical procedures would not be necessary and direct demonstration of PK would become possible.

In chicken and robot experiment the chicken could affect the path or robot even if the file or its copy have been read by human observer. In Libet's experiment decision "I do it" would first generate quantum superposition of options "I do it" and "I don't do it" ("Should I do it?") and select "I do it".

I do not know whether this option even deserves to be killed. Certainly this should be very easy.

### **How the intention to increase/decrease the number of 1: s or 0: s could be realized?**

Can one imagine in TGD framework any mechanism allowing to increase the number of 1: s or 0: s? The basic vision is following.

1. One can consider magnetic fields or their wormhole counterparts accompanying necessarily elementary particles. Ordinary magnetic fields would correspond to single sheeted magnetic flux tubes carrying conserved magnetic flux. Wormhole magnetic fields consist of a pair of flux tubes carrying opposite monopole fluxes at different space-time sheets and have wormhole contacts at their ends transferring the monopole flux between the sheets. Flux tubes or pairs wormhole magnetic flux tubes play a key role in TGD inspired quantum biology and proposed also to be a basic space-time correlate of intentional action. In the recent case flux tubes would connect the observer (operator or experimenter) to the device storing the bits. For wormhole flux tubes the flux tubes at the two sheets could have  $M^4$  projections, which do not overlap at all so that bits could interact with either flux tube but not with both simultaneously.
2. If bits are realized as magnetized regions, the magnetic interaction between bits and the magnetic field carried by flux tube (or either of the opposite fluxes associated with the wormhole magnetic field) is a natural candidate for the interaction defining quantization axis of spin, and also for the interaction inducing a small mixing of the bits by Larmor precession induced by a small perturbation of the flux tube magnetic field. This perturbation



could be the TGD counterpart of Alfvén wave (see <http://tinyurl.com/nfqj2ng>) inducing geometrical oscillation of the flux tube and therefore the direction of the magnetic field. State function reduction after the perturbation has ceased would produce either value of the bit. The strength and duration of perturbation determines how large the probability of bit reversal is.

If one assumes that magnetic interaction is in question, the most natural choice for the representation of bit is as magnetized region of data tape with direction of magnetization determining the value of the bit. This restriction can be criticized but will be made in the following.

1. The energy needed to turn the bit must be above thermal energy but the minimization of energy costs requires that this energy is not much above it and is therefore larger than  $5 \times 10^{-2}$  eV which by the way is also the order of magnitude for the energy gained by elementary charge in the electric field of cell membrane. This energy is considerably smaller than metabolic energy quantum with nominal value of .5 eV. Therefore metabolic energy of observer could provide the energy needed to turn the bit. Note that p-adic length scale hypothesis strongly suggests a hierarchy of metabolic energy quanta coming as octaves.
2. Classically the effect of the small perturbation of the external magnetic field on spin is Larmor precession (see <http://tinyurl.com/bvxnz8q>) [D1] due to the torque  $\tau = -\mu \times B$ . A simple model is obtained by assuming that the magnetic moments in magnetized region is simply the sum of elementary magnetic moments of (say) electrons, which in magnetized state are parallel:  $\mu = N_e \mu_e$ , where  $N_e$  is the number of electrons in the magnetized region defining the bit. The mutual interaction of spins forces them to have same direction so that they are not free.

Classical torque is time derivative of angular momentum and one has total angular momentum  $J = (Nm/ge)\mu_e$ , where  $g$  is so called g-factor not too far from unity. This gives  $d\mu_e/dt = \mu_e \times B$ ,  $m\mu_e = (ge/m)s$ , where  $s$  is the spin of the electron. The situation reduces to single electron level and the oscillation of the magnetized regions takes place with the Larmor frequency  $\omega = egB/2m$  of electron.

This model is of course highly oversimplified but gives a good idea about what happens. The Larmor frequency of electron is given by  $\omega = egB/2m$  and in the “endogenous” magnetic field of 2 Gauss proposed to explain [K86] the effects of ELF em fields on vertebrate brain [J47] ( $2/5$  of the nominal value of the Earth’s magnetic field) is  $f = 6 \times 10^5$  Hz. One expects that the flux tube magnetic fields and their perturbations are considerably weaker so that the perturbation gives rise to a rather slow change in the direction of the magnetic moment classically.

At quantum level the evolution of the magnetic moment reduces to a unitary evolution of electron’s spin by standard Hamiltonian defined by magnetic interaction energy  $E = -\mu \cdot B$  and if perturbation acts only a finite time the final state contains a small contribution from opposite value of spin.

3. If all magnetized regions representing bits interact simultaneously with flux tube, the net effect to the spin/ bit average is zero since the probabilities for the inversion of magnetic moment are same for the values of bit. Therefore it is not possible to realize the intention to increase or reduce the total number of 1s/0s in this manner.
4. Wormhole magnetic fields provide a possible solution to the problem. If the  $M^4$  projections of the two flux tubes involved do not overlap energy minimization favors the attachment of the magnetized region with the flux tube for which the energy  $E = -\mu \cdot B$  is smaller - that is negative. Since the fields of flux tubes are in roughly opposite directions, bits 1 and 0 tend to condense at different flux tubes. Hence a small short lasting perturbation associated with either flux tube can only reduce the number of 1s or 0s but not both and it would be possible to realize the intention “reduce the total number of 1: s or 0: s” equivalent with the intention “increase the total number 0: s or 1: s”. This if the observer’s intention boils down to a selection of the wormhole flux tube carrying the perturbation so that wormhole flux tubes would represent bits at the fundamental level.

The consideration of the energetics for the flip of the magnetization direction brings in naturally the hierarchy of effective Planck constants  $\hbar_{eff} = n\hbar$  (see <http://tinyurl.com/y7c8e6x8>) suggested by the vacuum degeneracy of Kähler action [K37] [L24].

1. For ferromagnets the Weiss mean field theory predicts that in absence of external magnetic field both magnetization directions have same energy. External magnetic field splits the degeneracy. One could say that if one regards the magnetized region as big spin, both spin directions have same energy and external field - now emerging from the observer as flux tubes - removes the degeneracy and defines direction for the quantization of spin. The mean field theory of Weiss (see <http://tinyurl.com/yddtp6gh>) [D2] based on the expression of free energy as function of magnetization as  $F = aM^2 + bM^4 - HM$  is minimized and gives  $M$  as function of  $H = B/\mu$  representing the external magnetic field. For  $H = 0$  one obtains remanent magnetization and clearly both signs of remanent magnetization correspond to the same free energy. This theory is of course thermodynamical theory and it is not clear whether it applies to the recent situation (zero energy ontology quantum theory at least formally a “square root” of thermodynamics).
2. The energy needed to turn the spin of single free electron (for ferromagnet electrons have strong exchange interaction and are not free) must be above thermal energy but the minimization of energy costs requires that this energy is not much above it and is therefore larger than  $5 \times 10^{-2}$  eV, which by the way is also the order of magnitude for the energy gained by elementary charge in the electric field of cell membrane. For electron Curie temperature is 843 K, which corresponds to thermal energy  $E \sim 6 \times 10^{-2}$  eV. This energy is considerably smaller than metabolic energy quantum with nominal value of .5 eV. Therefore metabolic energy of observer could provide the energy needed to turn the spin direction of single electron (note that there is a strong exchange interaction with other electrons). p-Adic length scale hypothesis allows to consider a hierarchy of metabolic energy quanta coming as octaves.
3. Suppose that magnetized region behaves like single big spin so that the magnetic field of flux tube manages to change the directions of all spins simultaneously so that the contribution of exchange interactions is not affected and the change in the energy of the system in external field is due the change of single electron energies only. The large value for the number  $N_e$  of electrons gives for the total energy needed to turn the bit  $E_{tot} = N_e g e B / m$ . For micrometer sized region  $N_e$  is of order  $N_e = 10^{12}$  for one conduction electron per atom. The magnetic field associated with the flux tube is expected to be much weaker than the remanent magnetization of order 1 Tesla. For  $B = 1$  nT one would have  $E_{tot} = .3$  eV, which is of the order of metabolic energy quantum. The electronic cyclotron frequency is in this field 30 Hz and in EEG range.
4. Magnetic flux tubes are identified as carriers of dark matter and dark photons. This suggests that dark photons representing metabolic energy quanta are involved with the effective value of Planck constant  $\hbar_{eff} = N_e \hbar$  (for TGD based view about dark matter see [K37] and [L24]), and that the transition can be regarded as an absorption of single dark photon turning the entire magnetized region. In terms of singular covering of the embedding space, dark photon can be regarded as a pile of sheets of covering of space-time sheet each containing single ordinary photon. These photon space-time sheets should be somehow attached to the electrons of the magnetized region.
5. The attempt to imagine how multi-sheeted photon/magnetic flux tube interacts with the conduction electrons responsible for ferromagnetism, forces to ask whether also they are dark with the same value of effective Planck constant and reside at various sheets of the singular covering having the size of the magnetized region. Only the first sheet associated with the double sheeted structure describing electron would multi-furcate and second sheet would carry external magnetic field, and perhaps also the TGD counterpart of the Weiss mean field interpreted as effective description of quantum mechanical exchange forces and having order of magnitude of 100 Tesla. Weiss mean field could allow an identification as return flux of the magnetic field generated by the multi-sheeted electron state. If so, the multi-furcations of space-time sheets predicted by the vacuum degeneracy of Kähler action

and predicting hierarchy of effective Planck constants comings multiples of  $\hbar$ , would play a crucial role in the condensed matter physics. Also the TGD inspired model of fractional quantum Hall effect [K79] ) encourages to consider this possibility seriously.

The signature for the many-electron states associated with multi-sheeted covering is a sharp peak in the density of states due to the presence of new degrees of freedom. In ferromagnets this kind of sharp peak is indeed observed at Fermi energy (see <http://tinyurl.com/yddtp6gh>) [D2]. Sheets of multi-sheeted covering could also carry Cooper pairs and this could give rise to effective Bose-Einstein statistics of Cooper pairs. In TGD photons emerge from fermions as wormhole contacts with throats carrying fermion and anti-fermion. This raises the question about realizability of Bose-Einstein statistics in Bose-Einstein condensation. If Bose-Einstein condensate corresponds to multi-furcation of space-time sheet, one obtains Bose-Einstein statistics effectively.

As such this model says nothing specific about the temporal direction of the intentional action although it is clear that the situation is four-dimensional in accordance with basic assumptions of TGD inspired theory of consciousness and with zero energy ontology. Most naturally, the negative energy signal to the geometric past could induce a magnetic perturbation propagating along either flux tube.

### Summary

Both models are consistent with the general vision discussed by Brian Millar and thus leave open the question whether it is experimenter or operator, who is responsible the PK effect. Experimenters are not completely objective robots, and successful experimenters could have a dream about demonstrating PK convincingly whereas the operators are chosen in “Big Pot” approach randomly. Skeptic experimenters trying to replicate the experiment would tend to produce null result. Experimenters could prove PK by producing it themselves (not my original suggestion)! Taking this seriously, one faces the question whether similar situation could prevail also in other experiments than those of parapsychology.

## 14.6 TGD Inspired Model For OBEs

It is good to develop the model for OBEs by first summarizing what OBEs are and then listing the basic TGD specific ingredients of the model and then proceed by making questions (I hope that reader does not feel them to be leading).

### 14.6.1 OBEs, Autoscopy, Heautoscopy, And Other Strange Experiences

#### Phenomenological characterization

The phenomenological characterization of OBEs [J12] has been discussed in [J182]. A precise definition of OBE is to have sensation of being outside the body. Autoscopic experience involves also a sensation of seeing a mirror double of the body or part of it or at least experiencing its presence. There is a form of AS in which some internal organs are perceived. In one form of AS only the presence of double is experienced. AS experiences are often accompanied by physical difficulties such as migraine episodes and epilepsy.

Heautoscopy refers to an experience of meeting one's alter ego, doppelganger. The main differences to AS is that in AS the double is mirror image and that alter ego is experienced to have also duplicated features of psychological self.

OBEs are classified to parasomatic and asomatic experiences according to whether the person experiences of having body or not. In aparasomatic experience a detachment from both the physical and parasomatic body is experienced. Blackmore suggest that OBE starts when sensory input from the body ceases while person remains conscious [J162]. This brings in mind the notion of subtle body of spiritual practices identified as the body experienced during lucid dreaming [J130]. The notions of guardian angel and ba-ka double of ancient Egypt, could relate to the double body too.

There is also a classification of OBEs to asensory, naturalistic and supernaturalistic ones. Asensory experience lacks sensory percepts about environment, naturalistic one involves perception

of familiar surroundings, and supernaturalistic other-worldly realms like heaven or visits to other planets and contacts with aliens.

One can distinguish between natural and enforced OBEs. Natural OBEs are triggered by exhaustion, illness, traumatic events, NDEs, meditation, etc.. Enforced experiences can result from intoxication, anesthesia, hypnosis, etc..

### OBEs induced by electric stimulation

Relatively recently OBEs and AS experiences have been produced by an electric stimulation of the angular gyrus [J72]. Angular gyrus is located in the parietal lobe, near the superior edge of the temporal lobe, and is involved in processes related to verbal communication and cognition and also with the transformation of written language to internal monologue. The experience developed to a full fledged OBE as the intensity of electric stimulation was increased. The electric stimulation induced responses in vestibular and sensory-motor systems, two of three systems which govern body balance.

According to experimenters, OBE and AS frequently involves what they call pathological sensations of position, movement and perceived completeness of one's own body. These include vestibular sensations such as floating, flying, elevation and rotation, visual body-part illusions (illusory shortening, transformation or movement of an extremity) and the experiences of seeing one's body only partially during OBE or AS. Authors believe that these experiments yield neurological evidence about the common neurological mechanism behind OBEs and AS experiences.

[J182] [J13] has criticized the interpretation of experiments.

1. Only single subject person was studied. She suffered from temporal lobe epilepsy and the epileptic region was at distance of about 2 cm from angular gyrus. Hence one can ask whether genuine OBEs were in question and whether the results generalize to healthy persons.
2. The OBE was not typical. For instance, body was seen only partially and the conscious attempt of the subject person to examine it more closely led to its disappearance. The environment was not perceived.
3. The claimed localization of the spot inducing OBEs to angular gyrus might be an illusion. Same researchers have represented results in which the OBE is induced in a different manner. Interestingly, the experience is associated with the generation of 4 Hz theta wave, which corresponds to the dominating EEG band during sleep.
4. The reductionistic conclusion that OBEs can be reduced to neuropathology and are thus "only" hallucinations is not justified. What has been shown is that electric stimulation of angular gyrus helps to induce the OBE and this leaves a lot of room for theorizing.

### Explanations of OBEs and related experiences

The explanations for OBEs can be divided to two classes.

1. Something is assumed to leave the body.  
This something could be something physical or non-physical ("astral" ). In some cases people who have had OBE share reported of having perceived objects that were actually there and having experienced events and dialogue that truly happened. Charles Tart has documented the case of Miss Z [J51] who in controlled experiments was able to deliver the randomly selected five digit number which was in a position which could be seen only from the position out of her body. Telepathy would be an alternative explanation for this.
2. Nothing leaves the body.  
Parapsychological explanations involve remote sensing and hallucinations. Psychological explanations regard OBEs as basically hallucinations. The observation that electrical stimulation generates both AS and OBE could be seen as a support for this interpretation. Of course, one can ask what hallucinations really are. Furthermore, the reports about seeing internal organs during AS experience [J160] are not easily explainable as hallucinations.

TGD based model does not fit into either category. The model involves the notion of magnetic body serving as the third person receiving visual stimulus from the body and reflecting it back to the brain where it is processed. In this model the conflict between hallucinatory character of AS and OBEs and a real perception of body from outside is only apparent. The basic mechanism allows to develop also a more detailed model for dreams, hallucinations, third person aspect of wake-up consciousness, and directed attention.

### 14.6.2 Questions

In the following the model is developed by posing questions about OBEs.

#### **Where the information processing giving meaning to what is seen is carried out?**

Seeing is much more than just receiving the photons on retina, since a lot of information processing is needed to give meaning to what is seen. This essentially involves a decomposition of visual input to recognized objects having relations to each other and to the past of perceiver. This applies also to the visual percepts during OBEs. The most natural candidate for the system processing the visual stimulus and giving it meaning is the brain of the subject person.

Sharing of mental images allows to consider an alternative interpretation based on telepathy. The sensory organs in other bodies receive the visual stimulus and other brains do the information processing. For instance, “unconscious” victim of accident could share the fused mental images of people around the place of accident. This would explain the case of Miss Z studied by Tart [J51] as telepathy.

#### **Are OBEs “only” hallucinations?**

In TGD framework the first possibility is that the sensory stimulus is always artificial and comes from brain to eyes and other sensory organs by back projection. OBE would be a dream like cognitive representation, simulation rather than a real percept. REM is expected to always accompany OBEs in this case.

There is an objection against this idea. If person is unconscious or has NDE, it is questionable whether she is able to construct such high level cognitive representation as the representation of the state of her own body as seen by outsider is, and even transform it to a sensory representation. One can also ask what hallucinations really are. In TGD framework hallucinations must be generated by an artificial sensory stimulus so that hallucinations and genuine OBEs might involve the same basic mechanism.

#### **Does OBE originate from an actual sensory stimulus?**

The well-known fact that body parts indeed contain holograms about other body parts [I79] (see the discussion in [K48]) and the TGD view about the relationship between dark and living matter [K32] allows to consider seriously the possibility that OBE originates from an actual sensory stimulus.

The dark photon laser beams emanating from the body would be received by a magnetic body containing dark matter at some level in the hierarchy of magnetic bodies and would be reflected back to the receiving sensory organs along MEs possibly parallel to magnetic flux tubes rather than space-time sheets along which ordinary visual input arrives.

It is quite possible that several magnetic bodies in the hierarchy are involved. The magnetic bodies involved need not always correspond to a personal magnetic body and could receive input from several biological bodies and remote vision and telepathy might involve signals from brain reflected to a second brain via multi-brainy magnetic body. Magnetic bodies could be associated also with “dead” matter.

In this picture the case of Miss Z could be understood in two alternative ways. A dark photon beam possibly created by the visual representation of the random number (does “dead” matter generate sufficiently intense beams of this kind?) and reflected by personal magnetic body could be in question. Alternatively, the magnetic body involved could receive the information about random number from the brain of the experimenter and reflect it to the brain of the subject person.

### Why does electrical stimulation induce OBEs?

Electrical stimulation of angular gyrus induces OBEs just as the stimulation of neurons of temporal lobe induces long term sensory memories. In neurological “brain only” approach the interpretation would be that the responses in the vestibular and somatosensory system induce the AS and OBE as hallucinations. In TGD framework the response in vestibular and somatosensory system would be interpreted as a response to an actual experience of being in a detached position and orientation, and brain would process genuine sensory data about being in detached position.

One might think that the temporal ordering between the experiences and these responses would allow to decide which causes what. In TGD framework negative energy signals propagating backwards in the geometric time are however a basic element of brain functioning and this criterion need not be apply.

One imagine two mechanism generating OBEs.

1. The mechanism inducing visual OBE and related experiences could simply turn off the ordinary sensory input so that only the dark photon beams from the magnetic body and reflected back from biological body would contribute to the visual stimulus. This would occur automatically during dreams and NDE experiences.
2. The sensory input from the magnetic body could be amplified. Time mirror mechanism (see **Fig. <http://tgdtheory.fi/appfigures/timemirror.jpg>** or **Fig. ??** in the appendix of this book) could be responsible for this amplification [?]. During epilepsy strong electric fields generated by brain during epilepsy induce starvation of neurons and the electrical stimulation of angular gyrus could have the same effect. Starving neurons would generate a beam of phase conjugate (negative energy) dark photons received by magnetic body in order to get metabolic energy. The magnetic body would be in a state analogous to a population inverted (possibly many-sheeted) laser defining a hologram like representation of the body. The receival of negative energy photons would induce a cascade like induced return to the ground state and amplify the dark photon beam arriving from magnetic body so that it would not be masked by the ordinary visual input anymore and would give rise to a percept.

### 14.6.3 Dark Matter Hierarchy, Zero Energy Ontology, Negentropic Entanglement, OBEs

Dark matter hierarchy, zero energy ontology, and the notion of negentropic entanglement lead to new insights also about OBEs.

#### Basic ingredients of the TGD inspired model

The model of OBEs involves several ingredients that are specific to TGD.

1. Magnetic bodies and field bodies are excellent candidates for the “third person” seeing the ordinary body. Magnetic body could receive a visual stimulus from ordinary body and reflect it back as a visual stimulus during OBE processed by the brain of the subject person. Thus body would see itself from the perspective of the magnetic body. Also dreams and hallucinations might involve the same mechanism. In the case of hearing sounds created by subject person could be reflected back to her ears or more plausibly, microwave hearing [I35] could be involved.
2. Topological light rays (“massless extremals”, MEs) are an element of TGD having no counterpart in Maxwell’s ED and play a key role in TGD inspired theory of consciousness. The interpretation of MEs has remained somewhat obscure. The development of TGD based model for dark matter residing at magnetic flux tubes and characterized by large value of Planck constant implying quantum coherence in even macroscopic length and time scales changed the situation in this respect. The model for dark matter as macroscopically quantum coherent phase is discussed briefly in this book in chapter [K77] and more extensively in the book “Genes, Memes, Qualia, and Semitrance” [K32]. MEs can be identified as space-time correlates of Bose-Einstein condensates (“laser beams”) of dark photons. It is however still unclear whether ordinary laser beams actually correspond to dark photon Bose-Einstein

condensates and become visible only in de-coherence to ordinary photons. Negative energy MEs can be identified as correlates for phase conjugate laser beams of dark photons. The so called time mirror mechanism is universal building block of basic biological and brain functions [?].

3. Bio-systems as conscious holograms is one of the key ideas of TGD approach [K17]. Bio-holograms [I79] suggest themselves as primary sensory stimuli quite generally. Biological body could generate dark photon “laser beams” received by magnetic bodies and reflected back to retina or perhaps to pineal gland [J55], the “third eye”. This would explain AS as well as the images of internal organs [J160]. Also other systems, at least living systems, could be seen from the perspective of the magnetic body. Remote vision hypothesis testable by using living targets not visible in ordinary sense. This would give also rise to telepathy if reflection occurs from magnetic bodies of another person.
4. In TGD framework sensory organs are identified as seats of primary sensory experience and brain only constructs symbolic representations about percept, in particular identifies objects of perceptive field. This does not exclude a considerable back projection to sensory organs modifying the sensory input. Dreaming involves back projection to sensory organs inducing artificial sensory experiences as simulation. One possibility is that dreams and hallucinations represent direct back projection to sensory organs along neural pathways. An alternative view is that the projection involves dark photon beams generated by brain and reflected back from the magnetic body. If OBEs are hallucinations, the visual sensory memories of the subject person about herself could serve as building blocks to generate simulation about what person looks like when seen from outside.
5. Sharing and fusion of mental images is one of the basic notions of TGD inspired theory of consciousness [?, K17]. One can ask whether OBE involves sharing of the visual experience of other persons involved about subject person. If this were the case, the presence of other persons would be necessary to have OBE. Sharing of mental images would explain the case of Miss Z as telepathy.

### Dark matter hierarchy

The identification of dark matter as a hierarchy of quantum phases labeled by the values of Planck constant [K37] provides additional insights about OBE experiences. Planck constant is quantized and can have arbitrarily large values and since Compton length and other analogous quantum lengths and times scale as Planck constant, this means macroscopic and macro-temporal quantum coherence and a reduced rate of dissipation.

Also the magnetic body controlling biological body (actually onion-like hierarchy of them) is assumed to carry dark matter and (forgetting ontological delicacies) dark matter could be seen as the agent responsible for the quantum control of ordinary matter in living systems. The value of Planck constant becomes also a measure for the evolutionary level of the living system and great leaps in evolution can be identified as transitions increasing the maximum value of  $\hbar$  in “personal” hierarchy of magnetic bodies [K33].

### Zero energy ontology and causal diamonds

Zero energy ontology is second new element of quantum TGD and states that all physical states have vanishing net values of conserved quantum numbers. Zero energy ontology provides a firm justification for the notion of negative energy signals consisting of (say) phase conjugate photons propagating to the geometric past. These negative energy signals are crucial element of the time mirror mechanism playing a central role in the general mechanism for intentional action, remote metabolism, and long term memory.

Causal diamond (CD) defined roughly as the intersection of future and past directed light-cones serves as an embedding space correlate for zero energy state. Space-time sheets representing zero energy states are inside CD and the future *resp.* past boundaries of CD carry positive *resp.* negative energy parts of zero energy states.

What is important from the point of view of consciousness theory is that CDs serve as embedding space correlates of selves and sub-CDs as those for sub-selves (mental images). Sub-CDs are very much analogous to music instruments in the sense that the frequencies which come as harmonics of the fundamental frequency defined by the proper time distance between tips of CD (coming as powers of two) resonate with the geometry of CD and put it to “ring”. Sub-CDs could be seen as an analog of radio receiver as far as sensory representations are considered and sending antenna as far as the motor control of biological body is involved. This allows to communicate sensory data from brain to sub-CDs at magnetic body CD in a highly selective manner. MEs (massless extremals) mediating the communications between magnetic body and biological body are also very much like strings of a music instrument. This picture generalizes the earlier music metaphor applied to axonal pathways.

A more precise definition of CD is as the Cartesian product of the intersection of future and past directed light-cone with  $CP_2$ . The hierarchy of Planck constants brings in additional structure. There is identification of preferred  $M^2 \subset M^4$  defining a preferred time direction (rest system/quantization axis for energy) and spin quantization axis. The preferred geodesically trivial sphere  $S^2 \subset CP_2$  and the selection of point assigned with  $CP_2$  at the future and past boundaries of CD gives rise to a selection of quantization axes of color isospin and hyper charge.

Sensory representations are a key element of the consciousness theory and the moduli space of CDs characterizing what kind of CDs are possible brings in new representational resources.

1. The moduli space of sub-CDs involves the position for the either tip of the sub-CD and the naïve expectation is that this position could code for the position of the perceptive field. If so the representation would be very concrete and since the size of CD is already for electron with .1 lightseconds the representations is realized automatically in astrophysical scale.
2. The moduli space of sub-CDs assignable to the mental images with another tip fixed could represent geometric qualia. Without any further restrictions this space corresponds to proper time constant hyperboloid of future light cone. The values of time parameter come in powers of two. One can however quite well consider the possibility that only a discrete lattice of the hyperboloid is realized- at least in the intersection of real and p-adic worlds.
3. A Lorentz boost for sub-CD induces scaling of frequency and scaling of the object in the direction of the boost. Therefore boost coded to the fundamental frequency of CD could code for various shapes of a figure obtained by scaling. Boost of sub-CD leaving the other tip of sub-CD invariant could also code for the velocity of object. Also the velocity of the object of the perceptive field could be coded to the shape of sub-CD by performing corresponding Lorentz boosts to it [K88].
4. The moduli space of CDs contains also the choice of quantization axes of energy (preferred rest system) and spin as well as the choice of quantization axes of color isospin and hyper-charge identifiable as flag manifold  $SU(3)/U(1) \times U(1)$ . Mathematician Barbara Shipman has proposed that this flag manifold is involved with the representation of geometric data in honeybee dance [A20] and I have proposed a model for what might be involved [K44].

The moduli space of CDs is thus highly relevant for the representation of the geometric data associated with the objects of the perceptive field and the this data would be communicated using MEs with harmonics of the fundamental frequency of sub-CD so that sub-CD would act like radio receiver. This includes the position of the real object codable to the position of sub-CDs at magnetic body, the velocity of the object of the perceptive field codeable to the Lorentz boost changing the shape of sub-CD and represented as scaling of the frequency assigned with the stationary object. Also the shape of perceptive field would represent this kind of geometric data. This picture supports the interpretation of sub-CDs as spotlights of attention giving information about many-sheeted space-time inside the regions defined by the sub-CDs. It would seem that sub-CDs are dynamical objects created, destroyed, and shifted in quantum jumps. This picture is also consistent with the explanation for the arrow of psychological time based on zero energy ontology [K120].



### Negentropic entanglement

The third new element is the notion of negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) making sense when entanglement probabilities are rational or even algebraic numbers. Negentropic entanglement makes sense in the “intersection of real and p-adic worlds” consisting of partonic surfaces whose mathematical representations make sense both in real sense and p-adically. Negentropic entanglement is possible also between different number fields in accordance with the idea that cognition corresponds to p-adic number fields and cognitive representations are realized in the interactions of realities and p-adicities. Living matter is identified as matter in the intersection between real and p-adic worlds. This view together with zero energy ontology allows precise definition for the idea that intentional acts transform p-adic space-time sheets to real ones and for the reversal of this transformation [K61].

It is natural to assume that negentropic entanglement is what makes living matter living and is involved with the sharing of mental images and with the formation of sensory representations by entanglement. Negentropic entanglement can be also time-like. MEs are excellent candidates for mediating this kind of entanglement whereas magnetic flux tubes would naturally mediate space-like negentropic entanglement. The sequence of negentropic entanglements would have as its upper ends sub-CDs at highest layer of the magnetic body and sensory organs as its lower ends. Even sensory organ could have negentropic entanglement with the real object of the perceptive field and this might be crucial element in the construction of the sensory representations. For instance, the deduction of distance of the object of perceptive field might rely on interferometry using the dark variants of visible photons with wave length which is of the order of the distance to the object.

### OBEs in more general framework

A general model for the remote mental interactions follows from a model for the living matter by assuming that also other biological bodies can serve as targets for the control action of the magnetic body or communicate sensory information to the magnetic body. The notion of negentropic entanglement favors biological systems as targets but it is of course an open question whether also “dead” matter could have negentropic entanglement with its magnetic body. Ordinary intentional action would represent a particular case of remote mental interaction in this framework.

Consider now OBEs in this general framework.

1. During OBE experiences the mental images constructed by brain about biological body could be absent due to the absence of the metabolic energy feed to the appropriate parts of brain taking care of the construction of cognitive mental images about biological body and communications of them to the magnetic body. The simplest representation would be in terms of bit sequences with bit 1/0 represented in terms of population inverted state/ground state of many-sheeted laser. Negative energy signals to the geometric past would be used to read these signals by inducing partial reduction of the population in inverted states. In absence of metabolic energy feed 1: s would gradually transform to 0: s. It is however essential that time-like negentropic entanglement is involved besides classical communications. This would make it possible to share the mental images.
2. In absence of these cognitive mental images to the magnetic body, magnetic body would not anymore provide strict cognitive representations of biological body and virtual world experiences would result. Since only magnetic body would contribute to the bodily experience, the low rate of dissipation due to large value of  $\hbar$  would explain the pleasant experience about the absence of the sensory noise.
3. This general picture could also explain why OBEs seem to correlate with neural disorders such as epilepsy and disorders relating to perturbed body image. During this kind of disorders the feedback provided by the sensory and cognitive input would be lacking from the brain regions suffering the neural disorder and magnetic body would be solely responsible for the body image. The lacking strict correspondence between the conformations of magnetic body and biological body would mean that the experience is hallucination from the point of view of biological body. At the embedding space level the “conformations” of the magnetic body could be rather abstract and represented in terms of positions and other moduli of sub-CDs.

#### 14.6.4 A More Detailed Model For OBEs

In the following a more detailed model for various aspects of OBEs is developed.

##### **Do bio-photons result from the de-coherence of dark photon beams?**

Bio-holography provides support for the body as a hologram (more precisely, dark photon 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 [I79] (for a TGD based model see [K17, K48]). This suggests 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): this of course need not correspond to a conscious vision at our level of self hierarchy.

The biological function of bio-photons [I37] is poorly understood, and they are an excellent candidate for ordinary photons resulting when dark photon beam de-coheres. TGD based model of bio-photons can be found in [K51] and the identification as dark photons is discussed in [K32]. The findings of Peter Gariaev about the effects of visible laser light on DNA [I30] and so called phantom DNA effect [I28] provide a further support for the biological importance of bio-photons (see the discussions in [K32, K51]).

##### **What is the mechanism of out-of-body hearing?**

Mechanism could be even more general and work also in the case of other qualia. In particular, hearing might involve similar reflection of sound waves at larger space-time sheets from the magnetic body and heard as “other-worldly” sounds.

A more plausible option is that the auditory sensation is generated by dark microwave photons reflected back from magnetic body. Microwave [K85] [I35] is indeed a well-known but poorly understood phenomenon and the generation of microwaves by plants after sunset correlates also with taos hum [I47] (see the discussion in [K53]) which does not generate any response in microphones but reflects the features of the acoustic environment.

The auditory and visual hallucinations of schizophrenic persons would represent in this framework a genuine sensory input. The notion of bicameral mind introduced by Jaynes [J124] discussed in TGD framework in [K96] would fit also nicely with this picture. The “god” controlling the behavior of bicameral by giving explicit commands would correspond to some magnetic body, not necessarily that of the subject person, but a magnetic body receiving input from several brains in the social group and representing collective consciousness.

##### **Where are the sensory receptors giving rise to the primary sensory experience?**

The simplest guess is that the visual stimulus from the magnetic body is received by eyes. The fact that REM accompanies visual dreaming supports this view in the case of dreams. The receiving sensory organ could be also pineal gland [K21, K89], “third eye”, the seat of the soul according to Descartes [J55]. Pineal gland is known to contain retinal pigments and its counterpart in more primitive animals is known to function as a genuine eye. A simple test in the case of artificial OBEs is to look whether the electric stimulation of OBEs generates also REM.

If OBE hearing is indeed microwave hearing, the identification of the primary sensory receptors is not obvious, although their existence cannot be denied.

The insect olfaction relies on infrared light as discovered by Callahan [I74] (see the discussion in [K44]). One might therefore wonder whether also humans possess olfactory receptors sensitive to IR light, and whether the emission of dark IR photons reflected from magnetic body could play some role in olfaction and in the generation of olfactory hallucinations. One can even ask, whether the molecular recognition mechanism underlying chemical senses relies on IR light. It is known that human nose contains so called vomeronasal organ [J2] sensitive to odors having sexual or social meaning but that these odors do not give rise to a conscious experience.

It is known that blind persons can learn to “see” when their skin is stimulated by electromagnetic fields representing the environment. Perhaps dark photon beams could induce also tactile sensations. Quite generally, the earlier proposal that information in all sensory modalities can be transformed to field patterns represented by MEs could sharpen to the hypothesis that the

information in various sensory modalities allows a representation as dark photon beams inducing corresponding sensory qualia in the interaction with appropriate sensory receptors.

### **What is the mechanism causing the kinesthetic sensations during OBEs?**

The model should also explain sensations of lifting, flying experiences, and the experiences of being in translational or rotational motion. The motion of the magnetic body with respect to the physical body should induce this kind of sensations. The basic idea is simple: generalize the mechanism allowing to hear the motion of a sound source. Generalizing from sound waves to dark photon beams, the sensation in question would be basically due to the Doppler shift of the dark photon beams travelling between biological body and the moving magnetic body. The change of the dynamical hologram resulting in the interference of a bodily reference beam and Doppler shifted reflected beam in quantum jumps could be responsible for the sensation.

This model could also resolve an objection against the hypothesis that sensory receptors experience the primary qualia. The objection is based on train illusion. When you sit on a train and look at second train which starts to move, you can have an illusion that it is your train that moves. The illusion is not a mere belief but involves a sensation of acceleration in the entire body. There are two options.

1. The sensation is a response to various bodily activities induced by the belief of being in an accelerated motion.
2. The sensation is caused by a primary sensory input induced by the acceleration. This sensory input must be produced artificially in the case of train illusion.

Consider first a genuine accelerated motion of the biological body. One could argue that in absence of visual, auditory or other sensory information about being in accelerated motion, there is no belief about being in accelerated motion so that acceleration is not perceived at all for option a). This makes option a) implausible. For option b) the acceleration of the biological body with respect to the object defining the rest system is directly perceived. The Doppler shift of the dark photon beams radiated from biological body and reflected back from the rest system would induce the sensation. Reflection could occur either from the rest system or a magnetic body associated with it.

One can imagine two mechanisms creating an illusory acceleration for option b).

1. If the fixation of the attention to the moving train means the presence of dark photon laser beams connecting biological body and train or a magnetic body associated with it, the Doppler shift of dark photon beams could induce the sensation of acceleration.
2. Directed attention could cause a personal magnetic body to mimic the motion of train so that the relevant part of it deforms in the direction of moving train to keep the distance to the moving train fixed. This would induce train illusion by the same mechanism as in case 1).

For both mechanisms the reflection of dark photon beams becomes the fundamental mechanism of directed attention. Attention would mean a formation very concrete bonds between subject and object or a representation of object at the personal magnetic body: the rays connecting the eyes of cartoon characters would represent a very profound idea about consciousness. Both views about attention mean a clear-cut deviation from the prevailing neuro-scientific thinking according to which the experienced world is virtual and completely detached from the real world.

Cliff illusion might be an appropriate name for the disgusting feeling in stomach which one feels on the brink of a precipice. Sensory imagination about falling down is in question and could be induced by the deformation of the personal magnetic body such that it mimics free fall.

The floating sensations and strange deformations of personal body during OBEs could also correspond to the deformation dynamics of the magnetic body which could be also caused by external influences. If the size of the magnetic body is measured using Earth radius as a natural unit and if the personal magnetic body co-rotates with Earth, the variation of the effect of the solar wind could induce periodic deformations of the magnetic body as in the case of Earth's magnetic field. This could reflect itself as diurnal alterations in the shape of the body experienced during

OBEs: a contraction during day time and an elongation during night time. Sunspot maxima induce magnetic storms and these could have strong effects on the shape of the body perceived during OBEs.

### **What is the mechanism making possible to see internal organs?**

Becker tells in his book “Cross currents” [J160] 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. The simplest explanation is that magnetic body at some level of hierarchy reflects the dark photons emitted by the internal organs.

Usually this does not occur and one should understand why the emission occurred in the case of the cancer patient. There is evidence that bio-photons leak out from non-healthy organs [I37]: this might mean that organs send more intense dark photon beams reflected at the magnetic body.

Time mirror mechanism involving time reflection instead of ordinary reflection suggests itself as an alternative explanation. The cells suffering starvation generated phase conjugate dark photon beams in order to get metabolic energy. This in turn induced a cascade like emission of positive energy dark photon beams from the magnetic body instead of mere time reflection.

## **14.6.5 The Role Of The Magnetic Body In The Case Of Other Brain Functions**

During the construction of the model of OBEs it became clear that the reflection of dark photon beams from the magnetic body could serve as a building block of several ordinary brain functions. It has been already found that dark photon beams could define a fundamental mechanism of directed attention.

### **Dreams and hallucinations and magnetic body**

The reflection of dark photon beams from the magnetic body could be involved also with dreams and hallucinations so that the neurological similarity of AS experiences and OBEs does not mean that both are hallucinatory. The “subtle body” assigned by many spiritual traditions with the dreaming state (for a nice summary see [J130] ) would correspond to the magnetic body. In this case mental images constructed in brain would induce dark photon beams sent to magnetic body and reflected back. The mechanism would also naturally explain autoscopic and heautosopic experiences, in particular the ability to see internal organs.

### **The relationship of EMDR experiences to OBEs**

Near-death experiences are not the only manner to get convinced about life after death. So called eye-movement de-sensitization and reprocessing (EMDR) discovered by Francine Shapiro [J25] induces what could be interpreted as after-death communications (see the discussion in [K87] ). The experiences of subject persons are claimed to be induced by this therapy in a highly reliable manner: according to [J25] 98 per cent of patients willing to participate the therapy had after death communication experience. It does not matter what the religious convictions of the subject person are and the experiences are actually rather easy to induce. It does not matter if the loss is traumatic or not or whether it is recent or occurred for decades in past.

The experiences resemble near death experiences (light tunnels, beautiful landscapes) and involve spiritual contact with the deceased. The EMDR technique involves getting the patient to move his or her eyes in a particular rhythmic fashion while at the same time attending to a particular aspect of the traumatic memory. How EMRD works is poorly understood as yet: possibly the fact that the shifting of eyes leads to increased brain processing is of importance. Notice that rapid eye movements REM are also involved with dreams.

A possible explanation is that EMDR experiences involves visual communication using dark photon beams and/or their phase conjugates with the 4-D magnetic bodies of the deceased ones located possibly in the geometric recent or past via the magnetic mirrors associated with them. Essentially the same mechanism as involved with long term episodal memories could be in question: the only difference would be that the magnetic mirrors now mediate information not from own 4-D body from the 4-D body of the deceased.

### Third person aspect of conscious experience

Our conscious experience involves so called third person aspect giving a symbolic bird's eye of view about ourselves. Magnetic body could take the role of the third person. At the fundamental level this representation could be based on sensory stimuli originating from body and reflected back to sensory organs. It would be completely masked by the ordinary sensory input in wake-up state but distilled by brain from the dominating sensory input and coded to a cognitive representation to minimize the amount of irrelevant information. A strong interference of this kind of sensory representation with ordinary sensory input would be obviously highly undesirable. The third person aspect could be present always and be based on the reflection of dark photons along MEs parallel to magnetic flux tubes.

### Feedback to primary sensory organs via reflection from magnetic body

One objection against the hypothesis that primary sensory organs are seats of sensory qualia is that sensory stimuli are only the raw material sculptured into actual sensory perceptions and that directed attention chooses what aspects of sensory stimulus are amplified and which neglected. I have proposed that there is a feedback by projections to the primary sensory organs from brain generating artificial sensory stimuli modifying the primary sensory input. This feedback could be realized also as a reflection of artificial dark photon beams generated by brain from the magnetic body and received as such by eyes or received by brain and channelled to eyes via MEs parallel to visual pathways.

### Does imagination involve feedback via magnetic body?

One can wonder, whether also imagination could involve reflection of dark photon beams from the magnetic body. In TGD framework the hypothesis that sensory qualia are generated at primary sensory organs and brain constructs only symbolic representations about experiences circumvents the basic objections such as the experience of phantom leg. In this framework imagination and cognition can be identified as symbol generating activities which are not initiated at sensory organs but at some higher level of the hierarchy starting from sensory organs and ending at the associative areas of cortex.

Imagination could however involve also transformation of symbolic representations to dark photon beams reflected back from the magnetic body. This input would not contribute to sensory input but might be abstracted from the sensory input and might serve as a kind of feedback. In absence of ordinary sensory stimuli the input from the magnetic body would dominate and imagined mental images would transform to dreams or hallucinations.

### Sensory memories and magnetic body

In some exceptional cases often associated with a serious damage in cognitive areas of brain the feedback from the magnetic body could give rise to a genuine sensory representation making possible direct sensory memories. Examples are autistic persons with ability to remember visual scenes music pieces in every detail and also reproduce them.

One explanation is sharing of sensory mental images of geometric past. An alternative explanation is that the information about sensory memory is communicated from the geometric past in symbolic form and transformed to a dark photon beam reflected back from the magnetic body. The fact that angular gyrus is involved with the translation of written language to internal speech and the abstraction of meaning of visual metaphors supports the view that a transformation of linguistic statements to concrete images projected to the magnetic body occurs in this process.

I have proposed a mechanism [K88] explaining synesthesia. The association of different sensory modalities could also occur via a transformation of sensory input in given modality to dark photon beam reflected from magnetic body and generating a sensation in another modality. Synesthetes are also known to be capable of amazing sensory memory feats [J154] and I have proposed an explanation based on time mirror mechanism [K88]. Also in this case neurons in certain region of left brain hemisphere suffer starvation which should be lethal by standard wisdom.

As a matter fact, the starvation mechanism seems to be a very general mechanism: Callahan has found evidence that insects find more easily the plants suffering from under nutrition [I64] (see

the discussion in [K46] ). Even the fasting common in spiritual practices could be seen as a method to get body entangled with magnetic bodies by using time mirror mechanism.

### 14.6.6 Psychedelics Induced Experiences And Magnetic Body

There is a book about psychedelic induced experiences titled as “Inner paths to outer space” (<http://tinyurl.com/gnb4bp9> ) written by Rick Strassman, Slawek Wojtowicz, Luis Eduardo Luna and Ede Frecska [J103]. It took some time to realize that I have actually have met the Luna and Frecska.

The natural TGD inspired hypothesis to be discussed in sequel in detail goes as follows.

1. Psychedelics bind to the same receptors as the neurotransmitters with similar aromatic rings (weaker assumption is that neurotransmitters in question possess aromatic rings). This is presumably consistent with the standard explanation of the effect of classical psychedelics as a modification of serotonin uptake. This binding replaces the flux tube connection via neurotransmitter to some part of the personal magnetic body with a connection via psychedelic to some other system, which might be even in outer space. A communication line is created making among other things possible remote sensory experiences.

Magnetic fields extending to arbitrary large distances in Maxwell’s theory are replaced with flux tubes in TGD framework. The magnetic bodies of psychedelics would carry very weak magnetic fields and would have very large  $h_{eff}$  - maybe serving as a kind of intelligence quotient.

2. This would be like replacing the connection to the nearby computer server with a connection to a server at the other side of the globe. This would affect the usual function of transmitter and possibly induce negative side effects. Clearly, TGD inspired hypothesis gives for the psychedelics much more active role than standard hypothesis.
3. Psychedelics can be classified into two groups depending on whether they contain derivative of amino-acid trp with two aromatic rings or phe with one aromatic ring. Also DNA nucleotide resp. its conjugate have 2 resp. 1 similar aromatic rings. This suggests that the coupling between information molecule and receptor is universal and same as the coupling between the two bases in DNA double strand and consists of hydrogen bonds. This hypothesis is testable since it requires that the trp:s/phe:s of the information molecule can be brought to same positions as phe:s/trp:s in the receptor. If also protein folding relies on this coupling, one might be able to predict the folding to a high degree.
4. A highly suggestive idea is that molecules with aromatic rings are fundamental conscious entities at the level of molecular biology, and that more complex conscious entities are created from them by reconnection of flux tubes. DNA/RNA sequences and microtubules would be basic examples about this architecture of consciousness. If so, protein folding would be dictated by the formation trp-phe contacts giving rise to larger conscious entities.

This model meets of course strong objection: finite light velocity does not allow communications with outer space in standard physics framework. In TGD framework Zero Energy Ontology changes the situation. Second objection is that the communications require huge amount of energy unless they are precisely targeted. The third objection is that quantum coherence in very long, even astrophysical scales is required. In TGD framework these objections do not apply.

#### Some background about psychedelics

Psychoactive drugs can be classified into three basic types. Some raise the activity level (excitation), some calm down (inhibition), and some change the character of consciousness profoundly. Psychedelics/hallucinogens [J103] belong to the third group. Psychedelics (such as psilocin, psilocybin, DMT, LSD) containing aromatic rings and many of them (such as psilocin, psilocybin, DMT) attach to serotonin receptors.

As the official term “hallucinogens” implies, psychedelic induced experiences are regarded as hallucinations in the materialistic world view although the denial of the reality of subjective

experiences themselves requires a really hard-nosed skeptic. The title of the book reveals that the question posed in the book is whether these experiences could be about real world, kind of sensory input from distant parts of the Universe. The indigenous people using ayahuasca and similar psychedelics have regarded these experiences involving meeting of representatives of other civilizations as perceptions about real worlds. Also Terence and Dennis McKenna, who are pioneers of systematic study of the effects of various psychedelics, shared this view. In the materialistic ontology of standard physics this kind of interpretation is of course excluded. That hallucinations are in question is “obvious”, too obvious actually!

The classical psychedelics are psilocin and psilocybin contained by mushrooms, DMT found in ayahuasca, and mescaline found in peyote cactus. DMT is an endogenous psychedelic and there is pumping of DMT through blood-brain barrier so that DMT could have important brain function.

The aromatic ring structures of psychedelics and neurotransmitters (<http://tinyurl.com/d8636or>) involved provide a more concrete view about the situation.

1. Classical psychedelics are derivatives of two basic chemical groups: tryptamine and phenethylamine which in turn derive from the amino-acids trp and phe.
2. Trp (<http://tinyurl.com/y967c489>) is characterized by pair of aromatic rings (6-cycle and 5-cycle). Psychedelic psilocin (<http://tinyurl.com/yanyvhgl>), <http://tinyurl.com/blkp76t>, DMT (<http://tinyurl.com/osfg9r3>) have 2 aromatic rings. Neurotransmitter serotonin (<http://tinyurl.com/14h2g2y>) has also two aromatic rings.
3. Phe (<http://tinyurl.com/kr5cvud>) has single aromatic ring (6-cycle). Psychedelic mescaline (<http://tinyurl.com/cgw7nuv>) has single aromatic ring. Neurotransmitters dopamine (<http://tinyurl.com/bvxmwch>) and norepinephrine have one aromatic ring. Note that both serotonin, dopamine, and norepinephrine (<http://tinyurl.com/yaxyj9q6>) are associated with mood disorders: clearly control in long time scales is in question, which in TGD framework suggests very large size scales for the parts of magnetic body involved.
4. Remarkably, DNA and RNA nucleotides can be classified to those with two aromatic rings (pyrimidines A and G) and their conjugates with one aromatic ring (purines C, T and U). Note that also his and tyr are amino-acids (<http://tinyurl.com/jsphvgt>) with single aromatic ring (<http://tinyurl.com/yb492da6>). Information molecules involve often aromatic rings. For instance, hormones involve often complex rings structures. Also hydrophobic second messengers (such as cAMP) (<http://tinyurl.com/yajhj9zb>) involve aromatic rings.
5. LSD (<http://tinyurl.com/c1l2ox7>), which is synthetic psychedelic, has 3 6-rings and one 5-ring.
6. The classification of the neurotransmitter receptors (<http://tinyurl.com/cqyoref>) provides further insights. They are classified into two groups. Ligand gated receptors can be excited and inhibited by certain neural transmitters. G-protein coupled receptors (<http://tinyurl.com/y9qesr87>) modulate the actions of excitatory (glutamate, aspartate) and inhibitory neural transmitters (GABA, glycine). Most neural transmitters bind to G-protein coupled receptors and this is true for classical psychedelics and for serotonin, dopamine, and norepinephrine.

The first guess is that the presence of aromatic rings determines the character of the transmitter receptor pair and that G-protein coupled receptors having aromatic rings are above ligand gated receptors in the hierarchy and control them. They would correspond to two different levels in the hierarchy of magnetic bodies. Note that also LSD binds to G-protein receptors.

According to the book [J103], pineal gland might be in a special role concerning psychedelics.

1. Pineal gland is the only nucleus of brain, which does not appear as left-right pair: this suggests that its functions relate to a control of the entire brain in long time scales. Descartes regarded pineal gland as the seat of soul. Pineal gland is also known as “third eye” and in lower species it indeed serves the function of eye.

2. Pineal gland is responsible for the production of melatonin: the production rate varies with a circadian rhythm. Melatonin is a serotonin derived hormone and therefore has 2 aromatic rings: this suggests that the amount of serotonin is higher in pineal gland than elsewhere in brain. Melatonin helps in sleep disorders and affects also other parts of brain. One can ask whether melatonin is involved with establishing of distant flux tube connections during sleep - not only in pineal gland but also in other parts of brain - and whether these connections are built up during sleep.
3. There is some evidence that pineal gland can produce DMT from tryptamine (<http://tinyurl.com/osfg9r3>) *believed* to be released during dreaming, during spiritual and mystical experiences, and during the time of death. Taking the title of the book seriously, one can ask whether this eye is able to see also to cosmic distances possibly using large  $h_{eff}$  photons and whether DMT is involved.

### Could instantaneous communications in cosmic scales be possible in TGD Universe?

In TGD inspired ontology the notion of magnetic body with astrophysical, galactic or even super-galactic size changes the situation completely. The basic communication tool would be touch of magnetic bodies generating reconnections and making possible signalling from the biological body to the member of distant civilization. The perception of the biological body of alien would differ in no manner from that of my neighbor since the mechanisms would be the same as involved with the transfer of sensory data to my personal magnetic body and control commands from there to biological body (at least through genome).

The basic objection against the possibility suggested by the title of the book is that finite light velocity poses absolute upper bound for the distance of objects with it is possible to be in contact during “trip”. One must be however very cautious here: the assumption that signals propagate only to singlet direction of time is essential also and derives from classical thermodynamics. In TGD framework second law continues to hold true but the arrow of geometric time for zero energy states changes in each state function reduction occurring to the either boundary of CD. Hence instantaneous communications (“remote seeing” !) using reflection in time direction become possible even over cosmological distances and define among other things the mechanism of memory in TGD Universe.

Time consuming and expensive space travel would become un-necessary: our magnetic body giving us cosmic size together with zero energy ontology making possible instantaneous “seeing” of both future and past by reflection of photons in time direction would be enough. Memory and anticipation would be basic examples about seeing in time direction. This view would also resolve Fermi paradox. We could be actually in a continual contact with the distant civilizations but without realizing it. One can ask whether similar contacts could take place in psychedelic induced experiences. Memories and future plans would be examples of “seeing” in time direction. The continual re-creation of the Universe by quantum jumps would of course mean that the actual future/past need not be same as those which are “seen”. Shamans identify various plants as conscious entities teaching them - in TGD framework this would translate to magnetic bodies of representatives of distant civilizations remotely teaching the representatives of more primitive civilizations.

What is the precise meaning of the catchy phrases “communications with geometric past/future”, “time reflection”, and “seeing in time direction”.

1. The recent view about state function reduction in Zero Energy Ontology leads to a precise identification of self as conscious entity. Self corresponds to a sequence of state function reductions leaving the passive boundary of causal diamond (CD) invariant and also Zero energy states correspond to superpositions of state pairs at opposite boundaries of CD. State function reduction leaves the member of the state pair at either boundary of CD (call it passive boundary) invariant - this is the counterpart of Zeno effect.

In the analog of unitary evolution following each reduction the position of active boundary is shifted to geometric future and the state at it is changed. This is the counterpart of unitary time evolution at active boundary. The increase of the temporal distance between the tips of CD gives rise to the experienced flow of time. Negentropy Maximization Principle



(NMP) eventually forces the first reduction to the opposite boundary of CD: self dies and re-incarnates at the opposite boundary and growth of the CD continues at opposite direction. The new self has arrow of time opposite that for the old one. The first state function reduction generates negentropic entanglement and can increase the value of  $h_{eff}$  so that evolution becomes possible.

2. In this framework geometric memories correspond naturally to time reversed sub-selves defining mental images. The space-time region (active boundary of CD) wherefrom they receive sensory information is indeed in geometric past of the self so that the interpretation as episodal memory makes sense. Also classical communications are naturally associated with sub-self and its time reversal. Note that precognition is memory from the point of time-reversed self. During sleep we precognize our geometric future.

Consider now communications with distant objects in this framework.

1. Negative energy signal would mean death of sub-self representing mental images and its re-incarnation in the geometric past accompanied by negative energy signal received by the new sub-self. The death of the time-reversed sub-self generates a sub-self with original arrow of time receiving the accompanying positive energy signal. The dying sub-self sends a signal received by its re-incarnation!
2. Communications with distant parts of the cosmos would be experiencing the time reversals of one's own mental images! We would be quite literally cosmic entities. Study of cosmos would be study of our own minds. In this situation mind is only conscious about itself. If Mind is conscious about other Mind it must fuse with it to single Mind by generating negentropic entanglement, otherwise it has no experience about other Mind. As far as conscious experience is involved, there is only one Mind. This is the TGD analog for One Mind theory and is able to avoid the paradox.

If the sub-self representing self model dies as one falls in sleep and re-incarnates as its own time reversal at the opposite boundary of CD, sleep could involve communications with distant parts of the Universe. Pineal gland generating DMT could play a key role in this process.

### Why information molecules containing aromatic rings should be so important?

I have considered the question of the title in [L45] [K86] (<http://tinyurl.com/yatfreqe>). The basis idea is that aromatic ring can carry the analog of supra-current as electron pair and this current generates a dipole magnetic field represented as flux tubes around the ring. This makes molecules with aromatic rings basic conscious entities in living matter. The flux tubes can carry dark matter and if there are several molecules with aromatic rings near each other, reconnections can take place and give rise to larger structures with building bricks connected by pairs of flux tubes carrying supra currents and dark cyclotron photon signals.

DNA would be the fundamental structure of this kind. Each base-pair would contain  $1+2+1+1=5$  (two rings from sugars) aromatic rings and longer DNA sequences would define larger conscious entities. Microtubules contain also aromatic rings assignable to 2 amino-acids phe and trp appearing in the tubulin molecules. Of course, all proteins contain these aromatic rings possibly integrating by flux tube connections to larger conscious entities. In this picture it would not be surprising if the basic information molecules would also involve aromatic rings.

DNA letters A,G and their conjugates T,C have the ring structures of trp and phe respectively and base pairs in the double DNA strand correspond to trp and phe ring structures connected by hydrogen bonds. Could the information molecule-receptor protein coupling rely on similar couplings with trp and phe playing the role of fundamental plugs. This hypothesis predicts that more complex information molecule-receptor pairs should have geometries in which trp:s and phe:s can meet each other naturally. Also protein folding could involve similar trp-phe self-couplings by hydrogen bonds determining the folding to a considerable degree. Protein folding would be determined basically by the generation of negentropic entanglement dictated by NMP and its understanding would require quantum theory of consciousness.

### Psychedelic-receptor complex as plug-in to cosmic internet and a new perspective on remote seeing?

If one - just for fun - takes seriously the claims of shamans, one must ask whether our brain has well developed tools available for building contacts with distant civilizations and what these tools might be. The receptors of neural transmitters are obviously the natural candidates for the pathways to cosmos. In the case of neural transmitters these would serve as pathways to the personal magnetic body (with onion-like structure). Neural transmitters could be however replaced with psychedelics if they have a geometric structure allowing a binding to the corresponding receptors. If psychedelics have flux tube connections to very distant parts of the Universe, a connection is generated.

1. One can argue that evolutionary pressures have forced living matter to develop highly standardized connections to various parts of the personal magnetic body and possibly also other magnetic bodies. Personal magnetic body has astrophysical size and EEG frequencies would correspond to communications in Earth size scale. Receptors serving as Josephson junctions emitting Josephson radiation with frequency characterised by  $h_{eff}$  are natural candidates for plug-ins.
2. The model for cell membrane as Josephson junction leads at the microscopic level to the view that the proteins associated with various ion pumps, channels, and receptors (of also neurotransmitters in postsynaptic junction) define Josephson junctions to which magnetic flux tubes are associated and characterized by local value of Josephson frequency, that is membrane potential and Planck constant  $h_{eff}$ . As the information molecule is attached to a receptor, a connection to some part of the some magnetic body would be generated and split as the molecule is not present. These connections are possible in the scale cell, organelle, organ, organism, population and maybe even in the scale of cosmos. Psychedelics affect serotonin receptors so that serotonin spends longer time in receptor.
3. The simplest picture is that the connection corresponds to a pair of flux tubes. As the connection is broken, the pair has suffered reconnection cutting it to two U-shaped closed flux tubes. When molecule is attached to the receptor, these U-shape closed flux tubes reconnect. The actual situation is of course expected to be more complex but the basic principle would be this.
4. Neurotransmitters and also other information molecules can be seen as molecules at the ends of flux tubes having ends in some fixed subsystem X. The attachment of neurotransmitter to the receptor would build a flux tube connection between postsynaptic neuron and X. The magnetic bodies in question characterised by passwords defined by collections of cyclotron frequencies corresponding to a hierarchy of space-time sheets. The Josephson frequency associated with the receptor is inversely proportional to  $h_{eff}$ . The natural guess is that it corresponds to the cyclotron frequency of the magnetic body part for electron, proton, or some ion associated with it. Josephson frequencies should serve as kind of passwords and receptors would be in one-one correspondence with these passwords defining gateways even to the outer space if the value of Planck constant is large enough.

The basic difference to ordinary view is that information molecules build only connections: after the establishment of a connection dark supracurrents and dark photons take care of the communication. Attaching the information molecule to receptor is like clicking a link in web.

5. Psychedelics would replace the ordinary neural transmitters building up this kind of flux tube connections in the normal situation so that the connections could be to quite different places.

One might be able to test this crazy hypothesis.

1. Pineal gland could still serve as the “third eye” but utilizing large  $h_{eff}$  photons. Fishes and birds are able to navigate to their birth places. The strongest assumption is that the flux tubes connect birth place and place of migration.

This mechanism could involve dark electron Cooper pairs at the magnetic flux tubes of Earth’s magnetic field generated by visible photons with energies above energy of red light making

possible to move along magnetic flux tube. As the direction of flight ceases to be along it and spin direction of cyclotron Bose-Einstein condensate changes, cyclotron transitions would induce dark photon emission at energy of visible photons in turn generating visual sensation serving as a signal allowing to correct the direction of flight. This would explain why radiation at MHz frequency leads to disorientation (cyclotron transitions are induced resonantly).

This need not be enough. Could also “remote seeing” by pineal gland using the dark light coming along flux tubes (or maybe even active variant of this process by sending light which is reflected back in time direction). What about remote seeing in the “usual” sense of the word: could psychedelics help also in this process?

2. The role of DMT is especially interesting. Body synthesizes it and pumps it through blood-brain barrier. I learned in private discussion that the experiences induced by DMT are relatively predictable (Terence Mac Kenna has described it as a sudden “dropping” to another world somewhere “below” through some kind of wall) whereas other psychedelic substances induce rather unpredictable experiences.

Could it be that DMT corresponds to a permanent connection to some fixed external magnetic body or to a higher layer of level of personal magnetic body with permanent reconnection to some part other magnetic body? DMT as also other psychedelic substances would only help to induce the signal as Josephson radiation. This would be analog to the higher probability of remote mental interaction due to pre-bonding. What happens during sleep: is this connection generated during sleep: what about concentration of DMT during sleep in various brain regions.

3. The information molecule-receptor complex would be associated with the communications to a part of magnetic body determined by the flux tube assignable to the information molecule and possible communications from magnetic body as sensory experiences such as psychedelic experiences and mediated by radiation in opposite time direction. Also control commands from magnetic body - assumed to be realized as signals in opposite time direction as compared to sensory signals - are important and a natural assumption is that the commands initiating gene expression enter through genome via flux sheets traversing through DNA: the time scale for gene expression is slow and also other mechanisms are very probably involved. If both genome and cell membrane can (on general grounds it seems that they must do so) send signals in both time directions, the general vision about motor action as time reversal of sensory perception implies that cell membrane receives also control commands.

More generally, the complex formed by reacting biomolecules and catalyst could form a complex receiving control commands from the magnetic body. A temporary fusion of a catalyst molecule and of reacting molecules could serve as the analog of the information molecule-receptor complex. The protein Josephson junction associated with this complex would receive in a resonant manner cyclotron radiation from the magnetic body inducing a transition to a state in which the potential barrier preventing the reaction would be lower.

4. An interesting but ethically questionable test for the hypothesis would be following. Transfer neurotransmitters associated with the of subject B to the brain of person A, and see what effect they have on conscious experience of A. If the proposal is correct, person A would have flux tube connection to the magnetic body of B, and might receive some memories of B for instance. Could transplants induce similar effects? Heart transplants are reported to have strange effects suggesting that heart (having a lot of neurons) has emotional memories.

Irrespective of whether one takes seriously the thought game leading to this proposal, one must admit that it would provide deep for the notion of “information molecule”.

### Still about the mystery of DMT

In FB I got a link to a very interesting article about DMT (N,N-Dimethyltryptamine, see <http://tinyurl.com/y8qrp8tc>). DMT (see <http://tinyurl.com/osfg9r3>) is psychedelic or hallucinogen - depending on one's attitudes. DMT is used for spiritual and healing purposes in many

cultures. The effect is short-lasting: from 5 to 15 minutes. DMT induces mystical experiences, euphoria, dynamical geometric hallucinations of geometric forms, experiences about meeting of higher intelligences, extraterrestrials, elves, and even God.

First some facts about DMT.

1. DMT is found in both plants and animals and is the only naturally occurring psychedelic. Its occurrence in the pineal gland of rodents and therefore also of mammals has been reported.
2. Chemically DMT is a structural analog of serotonin and melatonin and involves aromatic 6-cycle and 5-cycle with common edge appearing in amino-acid tryptophan (see <http://tinyurl.com/przan6k>). Also DNA nucleotides A and G have this double cycle structure but have however more than one nitrogen atom.
3. The biosynthesis of DMT from amino-acid L-tryptophan (occurring endogenously in plants but not in animals) has been detected in rabbit's lungs. Whether DMT is produced by brain is still an unsettled question. It has been even argued that DMT is mere waste.

In TGD framework aromatic cycles serve as indication that molecule contains paired valence electrons with the value of  $h_{eff}/h = n$  higher than its standard value: this explains the delocalization of electrons to longer than atomic length scale.  $n$  would serve as a kind of intelligence quotient: the larger the value of  $n$  is, the larger the maximal value of entanglement negentropy of the system is (understanding of this statement requires going outside the framework of the mathematical framework of standard physics: I call this framework adelic physics [L97] [L98] (see <http://tinyurl.com/ybp74yf8>).

In this picture the interpretation as a waste does not look sensible and the proposal that DMT is produced by brain or some other parts of body looks more reasonable. Biology does not usually manufacture anything without purpose. Especially so, if the manufacturing process requires metabolic energy. The biosynthesis of DMT from tryptophan does not occur spontaneously and requires N-methyltransferase enzyme as a catalyst. Also the highly non-trivial positive effects of DMT on consciousness suggests that it cannot be waste.

To understand what the purpose of DMT could be, one must have some idea about sensory perception in TGD Universe (I have already earlier written about DMT and psychedelics [L35] (see <http://tinyurl.com/ycualn43>).

1. TGD view about sensory perception relies on the idea that sensory qualia are at the level of sensory organs: this view makes sense if one accepts macroscopic quantum coherence [L84] (see <http://tinyurl.com/yb99u6u8>). TGD based view about time (zero energy ontology (ZEO)) allow to circumvent basic objections such as phantom leg: pain in phantom leg would be sensory memory of pain and in geometric past when the leg still existed. These sensory memories can be produced by stimulating temporal lobes in any subject person. One also avoids the challenge of explaining why structures consisting of essentially identical neurons can produce so different sensory qualia.
2. This model however requires virtual visual feedback from brain realized as dark photons, which leak to ordinary photons identifiable as biophotons with energied in visible and UV range. The presence of virtual visual input could explain why the retina has inverted structure not expected in engineerish thinking.

Sensory percept would be an artwork created by the perceiver. This conforms with the fact that when congenitally blind people receive their vision, they report only seeing of diffuse light. The percept would be a standardized sensory mental images emerging as an outcome of iteration in which dark photons signals travel forth and back and give rise to a pattern recognition by transforming sensory input to standardized input nearest to it.

3. Dark photon signals would travel along magnetic flux tubes between brain to sensory organs and even between brain and magnetic body (MB) in much longer scales. Flux tubes would give rise to a connection network analogous to a telephone network. This network would have permanent part and dynamical part consisting of switches allowing to connect two flux tubes to single flux tube by a short bridge. Information molecules such as neurotransmitters,

hormones, and messengers could act as switches/bridges: when the information molecule attaches to a receptor, the bridge is formed and signals can propagate.

Also nerve pulses could induce flux tube bridges between neurons of the neuronal pathway by using neurotransmitters and learning as amplification of synaptic connections would be essentially the gradual stabilization of these flux tube bridges. Nerve pulse patterns need not serve as communications inside brain but could only make possible communications in much shorter time scales using dark photons. For 1 meter long axons about million forth and back signals are possible during millisecond.

Nerve pulses would however frequency modulate Josephson radiation from the generalized Josephson junctions defined by membrane proteins serving as ion channels. This modulation would code nerve pulse patterns to signals to MB mediated by EEG: EEG could also have fractally scaled variants corresponding to various layers of MB. This would explain the function of EEG.

4. Virtual sensory input need not always end up down to the sensory organs: there would be some kind of blocking stopping the virtual sensory input to higher level so that one would have only almost sensory percept: an imagined sensory experience. The virtual sensory input associated with imagination could proceed along different route than that associated with the buildup of percept. Also imagined motor actions would be halted motor actions. During REM sleep the blocking would not be present and the virtual sensory input would enter to sensory organs, in particular retina.
5. Pineal gland represents a kind of photoreceptor, “third eye”, which still serves as eye in some animals. Could the dark photons involved with imagination be received in pineal gland. Could they continue to travel to sensory organs during dreams and hallucinations? Pineal gland would be an organ of imagination besides serving as seat of soul! What is nice from the point of view of biological economy is that pineal gland would not be useless evolutionary remnant but would have found a new function.

Accepting this schematic view one can ask about the possible function of DMT.

1. DMT molecules could make possible REM dreams by providing the bridges making possible the propagation of dark photons to the retina. Pineal gland would be the natural relay station. Same mechanism could work for other sensory modalities if dark photons mediate the virtual sensory input transformed to ordinary percept at sensory organs. Also hallucinations would rely on this mechanism.
2. MB has very large layers, there is even evidence that galactic magnetic field is in contact with personal MB (personal MB could have flux tubes inside flux tubes of galactic magnetic field). Since magnetic field in Maxwellian world extends to infinity and since in TGD systems have field identity (field body/MB), one can even image that there are connections to distant civilizations with very weak magnetic field strengths at corresponding flux tubes carrying dark matter.

These connections could make possible a genuine sharing of sensory experiences and the encounters with ETs and alike could be genuine remote meetings! We might have these encounters during sleep quite routinely but would not remember anything since the sensory information would stop at the third eye! Only during dreams situation might change but also now sensory input would be virtual and represent imaginations.

**Remark:** I have told many times that I am working intensely and close my eyes lightly, I see a dim flow consisting of points and resembling an incompressible hydrodynamic flow. There are vortices and the flow goes back and forth. The flow lines are mathematically equivalent with field lines of a magnetic field in Maxwell’s theory and in TGD with flux tubes of MB in 1-1 correspondence with the points of the flow. Could this be seeing MB with the “third eye”?

## 14.7 Connection To The Work Of Researchers In Forefront

Here some examples about the work of other researchers possibly relevant for understanding remote mental interactions in TGD framework is discussed briefly.

### 14.7.1 Simon Shnoll

Shnoll and collaborators [E2, E6, E7, E3, E9, E4] have discovered strange repeating patterns of random fluctuations of physical observables such as the number  $n$  of nuclear decays in a given time interval. Periodically occurring peaks for the distribution of the number  $N(n)$  of measurements producing  $n$  events in a series of measurements as a function of  $n$  is observed instead of a single peak. The positions of the peaks are not random and the patterns depend on position and time varying periodically in time scales possibly assignable to Earth-Sun and Earth-Moon gravitational interaction.

These observations suggest a modification of the expected probability distributions but it is very difficult to imagine any physical mechanism in the standard physics framework. Rather, a universal deformation of predicted probability distributions would be in question requiring something analogous to the transition from classical physics to quantum physics [K8].

The hint about the nature of the modification comes from the TGD inspired quantum measurement theory proposing a description of the notion of finite measurement resolution in terms of inclusions of so called hyper-finite factors of type II<sub>1</sub> (HFFs) and closely related quantum groups. Also p-adic physics -another key element of TGD- is expected to be involved. A modification of a given probability distribution  $P(n|\lambda_i)$  for a positive integer valued variable  $n$  characterized by rational-valued parameters  $\lambda_i$  is obtained by replacing  $n$  and the integers characterizing  $\lambda_i$  with so called quantum integers depending on the quantum phase  $q_m = \exp(i2\pi/m)$ . Quantum integer  $n_q$  must be defined as the product of quantum counterparts  $p_q$  of the primes  $p$  appearing in the prime decomposition of  $n$ . One has  $p_q = \sin(2\pi p/m)/\sin(2\pi/m)$  for  $p \neq P$  and  $p_q = P$  for  $p = P$ .  $m$  must satisfy  $m \geq 3$ ,  $m \neq p$ , and  $m \neq 2p$ .

The quantum counterparts of positive integers can be negative. Therefore quantum distribution is defined first as p-adic valued distribution and then mapped by so called canonical identification  $I$  to a real distribution by the map taking p-adic  $-1$  to  $P$  and powers  $P^n$  to  $P^{-n}$  and other quantum primes to themselves and requiring that the mean value of  $n$  is for distribution and its quantum variant. The map  $I$  satisfies  $I(\sum P_n) = \sum I(P_n)$ . The resulting distribution has peaks located periodically with periods coming as powers of  $P$ . Also periodicities with peaks corresponding to  $n = n^+n^-$ ,  $n_q^+ > 0$  with fixed  $n_q^- < 0$ , are predicted. These predictions are universal and easily testable. The prime  $P$  and integer  $m$  characterizing the quantum variant of distribution can be identified from data. The shapes of the distributions obtained are qualitatively consistent with the findings of Shnoll but detailed tests are required to see whether the number theoretic predictions are correct.

The periodic dependence of the distributions would be most naturally assignable to the gravitational interaction of Earth with Sun and Moon and therefore to the periodic variation of Earth-Sun and Earth-Moon distances. The TGD inspired proposal is that the p-adic prime  $P$  and integer  $m$  characterizing the quantum distribution are determined by a process analogous to a state function reduction and their most probable values depend on the deviation of the distance  $R$  through the formulas  $\Delta p/p \simeq k_p \Delta R/R$  and  $\Delta m/m \simeq k_m \Delta R/R$ . The p-adic primes assignable to elementary particles are very large unlike the primes which could characterize the empirical distributions. The hierarchy of Planck constants allows the gravitational Planck constant assignable to the space-time sheets mediating gravitational interactions to have gigantic values and this allows p-adicity with small values of the p-adic prime  $P$ . "A Possible Explanation for Shnoll Effect" (see <http://tinyurl.com/ya9y6txx>) [K8].

What makes Shnoll effect so interesting is that it involves interaction of very long length scales with microscopic scales - even nuclear physics length scale as in the experiments of Shnoll. Similar situation prevails machine-mind interaction involving intention to affect sequences of random numbers generated by microscopic systems via quantum transitions. The proposed model suggests a mathematical description of the statistical distributions modified by the intentional action but leaves the interaction mechanism open. A possible mechanism could be a realization intentions as actions via a mapping taking p-adic space-time sheets representing them in long length scales to real space-time sheets in short length scales. In the recent case the field patterns would represent space-time sheets carrying classical fields inducing the desired effect at microscopic level on particles that have topological sum contacts to these sheets. Classically gauge forces would be in question and at quantum level modifications of various reactions rates caused by these fields.

This map would be carried out by the quantum counterpart of canonical identification or

its variant [K106]. The map would be characterized by resolution defined by power  $p^N$  of prime  $p$ . For powers of  $p^n$ ,  $n > N$ , the map would be continuous from p-adics to reals and for  $n < N$  it would be discontinuous and would correspond to the identification of reals and p-adic numbers via common rationals. I have discussed this kind of option based on ordinary canonical identification - actually one of the first ideas related to p-adic physics - in [K75, K73]. The main objection was that this map is not general coordinate invariant. This could however make sense since cognition breaks General Coordinate Invariance via a selection of a preferred coordinate system and bringing in the number theoretic anatomy of coordinate variables. I have also proposed (see <http://tinyurl.com/yc3jnxg>) that the generation of cognitive representations and realization of intentional actions using canonical identification and its inverse could define the analog of T-duality of string theories, which also maps long and short scales to each other.

A more concrete model for the intentional action is obtained if one requires consistency with the model based on time mirror mechanism (see **Fig.** <http://tgdtheory.fi/appfigures/timemirror.jpg> or **Fig.** ?? in the appendix of this book) as a key element of intentional action. Canonical identification maps p-adic space-time sheet representing the intention and having the size of CD assignable to intentional agent and characterized by a typical macroscopic time scale (actually astrophysical since already electron corresponds to Earth sized CD with time scale of .1 seconds) to a much smaller space-time sheet representing a flux tube connection and possible accompanying massless extremal connecting the biological body of the operator and target. The classical fields carried by these space-time sheets would induce the microscopic effect realizing the intention.

### 14.7.2 Michael Persinger

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/y83pq5v1>) by Todd Murphy [J8]. Persinger's work (for references to the articles by Persinger and collaborators see the Wikipedia 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 take place in amplitude windows [K33].

The modulation of magnetic field would probably induce FM of cyclotron frequencies. The TGD inspired model for hearing [K85] suggests this kind of modulation as a way to represent 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.

The article "TGD Based View about Classical Fields in Relation to Consciousness Theory and Quantum Biology" (see <http://tinyurl.com/ycoczvmx>) contains a section considering a model for the findings of Persinger and collaborators using "God helmet". The spiritual experiences induced by "God helmet" could be interpreted as subjective experiences generated when the personal magnetic body receives an additional layer. For instance, manic-depressive bipolar cycle might be understood as a cycle in which euphoric period means the emergence of a new layer appears to the magnetic body and depressive period means its disappearance. I have also commented other findings of Persinger. God helmet might provide a technical tool to test the notion of magnetic body.

### 14.7.3 William Tiller

William Tiller in Stanford University has carried out impressive experimental work with what he calls intention imprinted electronic devices (IIED), and his results challenge that standard assumption that the intentions of experimenter do not affect the experimental apparatus [J180, J171, J172].

### Experimental arrangement

The goal was to try to imprint a specific intention into a simple, low tech electronic device so as to influence the companion, specific, well-designed, target experiment. The intentional imprinting was attempted in a meditative state. The intentionally imprinted device, IIED, was sent to a laboratory located at distance of about 1500 miles where colleagues had set up the experiment. The device was placed about 6 inches from a continuously running and computer-monitored target experiment and switched on (total electrical power rate was less than 1 microwatt). Over a time period of about 1-4 months the recorded results from the target experiment changed in the directions of the specific intention and the change eventually reached the selected magnitude of the specific intention. Also an identical, but not intention imprinted device was used and the results were compared in order to achieve more objective measurements about the effects of human consciousness on electric devices.

The targets used were purified water, some bio-molecules, and larvae of flies. These targets were either unshielded or shielded from radiation. For the latter purpose they were closed inside a grounded Faraday cage (FC), which screened rather effectively the radiation coming at microwave frequencies whereas for ultra low frequency (ULF) fields the screening is virtually absent (skin depth behaves as  $1/\sqrt{\pi\sigma f}$  at low frequencies and  $f = 2\pi\sigma$  (in units  $\hbar = c = 1$ ) defines kind of critical frequency above which screening occurs effectively). The targets could be affected by control device (CD) or by identical IIED generating microwave radiation. Radiation was generated either at single frequency (7.3 MHz) or at three frequencies (5.0, 8.0 and 9.3 MHz) [J173].

In the case of purified water the spatial distributions of physical parameters like pH, temperature, and conductivity were measured as a function time. In the case of bio-molecules the possible effect on thermodynamical activity, which measures the thermodynamical energy of single molecule, was measured. In the case of fly larvae the effect on the larval development time was studied. The results from various arrangements were compared with control targets (no FC, no CD, no IIED).

I have discussed a TGD based model for Tiller's findings the chapter

"Biosystems as conscious holograms" [K17] (see <http://tinyurl.com/ydx4fuk5>). The basis idea is that a connection between the magnetic body of operator and target is formed and the intentional imprinting involves magnetic fields and possibly also corresponding cyclotron frequencies. If one accepts the canonical identification as a map taking intention represented by p-adic space-time sheet to action represented by real space-time sheet in much shorter scale then the space-time sheets create would be microscopic space-time sheets carrying magnetic fields giving rise to the cyclotron frequencies.

The basic experimental results were two-fold. First of all intended effects were achieved. Secondly, the "conditioning" of the laboratory resulted as an unexpected effect and continued even after the removal of the target and IIED.

### Direct effects of the intentional action

1. IIED imprinted by intention to increase/decrease the pH of water gradually induced a shift in the pH of purified water to the intended value, increased the in vitro thermodynamic activity of bio-molecules, and a reduction of larval development time.
2. For bio-molecules and larvae four simultaneous side-by-side treatments were tested: i) an unshielded sample, ii) a shielded sample, iii) a shielded sample with an "on" control device, iv) a shielded sample with an "on" IIED. Just the shielding of em radiation affected the thermodynamic activity of the bio-molecules, and just adding less than about 1 microwatt of microwave radiation via control device reduced the thermodynamical activity and lengthened the developmental time. Thus the microwave radiation acted as a stressor having entropic effect. When the control device was replaced with IIED, the degradation caused by microwave radiation was overcome.

### "Conditioning" of the laboratory

Quite unexpected phenomena arose from a repeated conduct of IIED in a given laboratory space. By simply continuing to use IIED in the laboratory space, it became "conditioned in some very fundamental way". Three signatures heralded the onset of the "conditioning" process.



1. Oscillations of air and water temperature, and of pH and electrical conductivity of water with large amplitudes with the periods of oscillations in 10-100 minute range developed. The amplitudes of pH- and temperature oscillations was  $\sim \Delta pH = .1$  pH-unit and  $\Delta T \sim 1 - 3$  K units respectively. Even more remarkably, the oscillations were sustained in the locale even after the removal of the IIED suggesting kind of phantom effect analogous to phantom DNA effect. Oscillation amplitude had peaks at the harmonics of fundamental frequency  $f_l = 1/T_l$ ,  $T_l = 36.6$  minutes with three lowest harmonics being very clearly visible [J172]. Also  $T_l = 51.2$  minutes appears as fundamental period in some experiments. The ratio of these periods is 1.4 and rather near to  $\sqrt{2} = 1.41$ , which might relate to p-adic length scale hypothesis.
2. When an pH-increasing IIED with intention to increase pH by one unit was turned on in an almost unconditioned space located several hundred feet away from a strongly conditioned space, a well-defined pattern of pH-oscillations in an unconditioned space emerged. This pattern was accompanied by a highly correlated pattern of oscillations in strongly conditioned space. This kind of highly correlated oscillations were not observed in several unconditioned spaces - also located several hundred feet away.
3. The targets were subject to the action of a vertically aligned magnetic field in the range of  $10^{-2} - 5 \times 10^{-2}$  Tesla, such that the direction of the field could be reversed. In an unconditioned space the change of the direction of the magnetic field did not affect the pH. In the strongly conditioned space the effect on pH was different for the opposite directions of the applied field and the difference in pH values was about .6 units. One can say, that the target had become sensitive to the effects of external magnetic fields.

#### TGD based model for intentional imprinting

The model obtained by combining the model for Shnoll effect based on the canonical identification as a map taking intentions to actions with time mirror mechanism would suggest that intentional imprinting generates flux tubes between the target and magnetic body (MB) of operator and also those between target and biological body (BB) of the operator. These flux tubes would correspond to the images of p-adic space-time sheets representing the intention and having astrophysical size scale (or the order of the size of CD associated with operator). These flux tubes would connect BB and MB also to the nearby environment of IIED. The fact that nearby environment remains intentionally imprinted when target and IIED are moved away could explain why the effect remains as oscillations even when IIED is removed and why synchronous oscillations take place.

Negative energy signals would tend to generate negentropic effects eliminating the entropic effects if microwave radiation. This could explain why IIED reduces the entropic effects caused by microwave radiation. Cyclotron frequencies define natural candidates for the time scales involved. The magnetic fields in question would be of order 10-100 pT. The mechanism of compensation of the effects of cyclotron photons remains open. The simplest possibility is that microwave photons generated by IIED correspond to large  $\hbar$  phase conjugate photons with energies in the range of energies of microwave photons. The effects of negative energy large  $\hbar$  photons, which have suffered phase transition to ordinary positive energy microwave photons could induce the negentropic effects.

#### 14.7.4 About the double-slit experiment of Dean Radin

Dean Radin and his team have done a very interesting experiment [L83] (see <http://tinyurl.com/h44rns8> and <http://tinyurl.com/q7nbxnk>) testing the idea that observer induces state function reduction.

##### Experiment

The experiment is a modified double slit experiment. In double slit experiment a laser beam arrives to the screen via two slits and interference pattern is generated as if photons would behave like waves localized at screen. If one adds detectors at the slits, either detector fires and detects the passing-by by photon, and interference pattern disappears with optimal detection efficiency.

The idea is to add a subject person ( $S$ ) at distance of two meters.  $S$  imagines of measuring that electron passes through either slit. One can say that  $S$  intends to add a “detector” to either slit or both of them so that a state function reduction selecting either slit occurs. This experiment differs from experiments in which  $S$  tries to affect the ratio of frequencies of 0:s and 1:s in random series of bits:  $S$  does not try to force the electrons to pass by either slit. There is a feedback represented as sound/yellow light whose height/intensity coded for the amount of the reduction of the height of the peak. There are two kinds of participants: meditators and those who have no experience in meditation.

The results of the experiment are thoroughly discussed in the Youtube lecture or Radin (see <http://tinyurl.com/h44rns8>). To my opinion the results are amazing. In one experiment it was found that the height of the peak of the Fourier transform of the intensity distribution of the diffraction pattern is reduced. In second experiment the depth of bottom of the through of distribution was reduced. As if the intention would induce with some probability to perform the measurement selecting the photon path. The effect was small but appeared systematically for a group consisting of meditators. For persons without experience in meditation the effect averaged out also in this case it was present in the beginning of the experiment when subject person were not bored by the repetitive character of the experiment. The longer attention span of meditators could partially explain this.

Even more amazing finding was that in a variant of the experiment realized in internet the results were also positive although the persons intending to induce the experiment.

### Arguments of skeptic

The standard argument of skeptic is that statistics is poor, that the experiment is even fraud, etc... One can however consider more refined and more imaginative objections. Let us make a digress from the usual behavior of skeptic and assume that the effect was real.

If the meditators could induce the measurement by intention, one expects that also the experimenter could have done it. To how high degree the outcome was due to the experimenters and how much due to the meditators? Experimenter also had the theoretical expectation that meditators are better in inducing the slit detection. Could the wish that the theory is correct have caused subconscious intention about performing the detection in the case of meditators or not doing it in the case of non-meditating subject persons?

In the case of net experiment situation becomes even more problematic. One can imagine that also in this case the intention of experimenter could induce the detection - at least if experimenter is near to the system. Should experimenters have spent the period of experiments in Mars or at least in a distant holiday resort! Experimenters studying remote mental interactions are usually not rich people and presumably they did not do this.

The experimenter effect is well-known in parapsychology. Some experimenters are extremely successful. Could one think that they have strong intentional powers? Ironically, this would demonstrate the reality of paranormal effects of this kind but in a way that can never convince the skeptics. There is evidence for this kind of effect in the testing of new medicines. Good results are obtained when the testers are enthusiastic and dream of a positive result. When they do same tests after some years, the results are worse.

### TGD based model

The challenge is to understand how the  $S$  imagining a measurement telling that photon went through either slit could realize this intention. What does the detection mean and what it demands?

1. The measurement should involve a state function reduction selecting between the slits entangled with observer. In principle it is enough to have an interaction of photon in either slit localizing the path of the photon to that slit. It is enough that photon interacts with charged particles in either slit with some probability. This measurement is of course not optimal since the interference diagram is only partially changed. Only some fraction of these measurements take place and produce single slit pattern so that the observed pattern is a weighted average of double slit and single slit patterns. In principle one can estimate the probability for single slit pattern from the data.

2. Quantum classical correspondence requires that in order that the intention to detect could be realized, one must have a physical connection from the  $S$  to both slits or at least either of them. Also charged particles assignable to the connection should be involved to make scattering of photon possible. Also entanglement entangling detector fires/does not fire with corresponding states of some other system, say the  $S$  would be needed.

How could one realize these connections in TGD?

1. In TGD framework the magnetic flux tubes serve as correlates of entanglement and directed attention [L65]. To direct attention to a system means to connect with it by flux tubes. Flux tubes carry dark charged particles essential for TGD view about quantum biology.
2. Every system has U-shaped flux tubes emanating from it and acting as kind of tentacles scanning the environment. As a U-shaped flux tube from system A encounters another similar flux tube from system B, a reconnection takes place if the quantized fluxes are same. The outcome is a pair of flux tubes connecting A and B. The flux tube pair can carry Cooper pairs with members of the pair at the flux tubes. The photons from laser could scatter from the charged particles.
3. The dark particles the flux tube are dark with  $\hbar_{eff}/h = n$  [?, K78] satisfying an additional condition implying that  $n$  is proportional to the mass of the charged particle in turn implying that cyclotron energies  $E_c = \hbar_{eff}eB/m$  are universal and assumed to correspond to biophoton energies in the range of visible and UV: bio-photons would result in the phase transition transforming dark photons to ordinary photons.

In order that photon scatters from the charged particles it must have the same value of  $\hbar_{eff}$  as the particles at magnetic flux tubes emanating from the  $S$ . Some fraction of laser photons could satisfy this condition. Note that if perturbative quantum theory applies, the classical predictions are same as lowest order quantum predictions so that  $\hbar_{eff}$  makes it visible only in higher orders assuming that perturbation theory works when  $\hbar_{eff}/h = n$  holds true. Unfortunately, it is not possible to estimate the probability that photon enters to the flux tube. Note that the probability depends also on the density of the flux tubes.

The effect is reported in net experiments for which distances can be long and there is no visual contact. Can one understand this?

1. If there quantum entanglement between A and B already exists one can increase the distance without spoiling the entanglement. But how to achieve the entanglement if the systems are at large distance from beginning?
2. The length of the magnetic flux tubes is not a problem. The size scale for the layers of magnetic flux tube corresponding to EEG frequency 7.8 Hz is circumference of Earth. The condition that the size of the flux tube is at least of the order of the cyclotron wavelength  $\lambda$  for cyclotron photons at the flux tube implies that length of the flux tube is of the order of the size scale of Earth for EEG frequencies.

In fact, our MBs could have much larger layers if biological rhythms have cyclotron frequencies as counterparts. The size scales could be of order light-life-time or even longer. This changes totally the view about the role of length scales in biology and consciousness. There is some evidence that galactic day defines the natural rhythm for precognitive phenomena: precognitive phenomena tend to occur at galactic midday. Galactic cyclotron frequencies (the galactic magnetic field is of order nT) could correspond to bio-rhythms up to 12 hours.

In net experiment the problem is how to generate the connection to a correct target. The same problem is encountered in the attempts to explain the claimed results of remote viewing experiments. Could the density of flux tubes of personal magnetic body (MB) be so high that the connection is generated with high enough probability.  $S$  receives data through the web. Could this help to build the desired connection.

1. Skeptic would explain the reported positive result in web experiments by saying that the results were actually induced by the intention of the experimenter who was near to the system. This might of course be the case.

2. The first possibility is that an entanglement is generated between the camera monitoring the system and slits involving flux tubes. The communication of the image from the camera to computer builds another flux tube bridge. The radiation reflected in satellite to the computer at Earth involves propagation along flux tubes. At the receiver ends similar bridges are build. There is therefore a flux tube connection with the computer of used by  $S$ , who generates the last piece of the connection. This kind of flux tube connection would be between all communicating systems. Also the experiments would belong to this entanglement network.
3. MB has layers with size scale of order Earth size. Could it be able to meet the challenge by using the information coming from web. Could the U-shaped flux tubes be so dense as to be able to build a contact with the experimental arrangement with high enough probability? If they are to represent Maxwellian magnetic field in good approximation, they should be dense. What is important that these flux tubes correspond do different space-time sheets for distinct observers: this is actually the basic distinction between the field concepts of Maxwell and TGD.

Could it be that the feedback from  $S$  at her computer via the net to the computer at the other end generates quantum correlated events and this correlation has as correlates magnetic flux tubes connecting the distant systems.

4. The hyper-imaginative option is that  $S$  can delegate the problem with collective consciousness assignable to the magnetosphere of Earth and having all the engineering knowledge that Earth has! Could we be neurons of a gigantic brain of Mother Gaia, which would help  $S$  to realize their intention. Can single neuron realize its intention on a distant neuron in brain in the similar manner? Could some kind of resonance mechanism be involved?

## Chapter 15

# How to test TGD based vision about living matter and remote mental interactions?

### 15.1 Introduction

The proposed theory of living systems and remote mental interactions involves a large number of general ideas which represent something new and one should be able to invent tests. Since the basic mechanisms of remote mental interactions are same as those of TGD inspired model of living matter, there is no special reason to restrict the tests to remote mental interactions. The emphasis is on new physics predicted by TGD. The following is an attempt to list the most important ideas and imagine possible tests. Most tests are tests of the proposed new physics suggested to be crucial for living matter. I do not possess the required background to propose any detailed experimental protocols and my hope is that I would be able to represent the basic ideas so clearly that others could invent way to test them.

Chi (life energy) and Yin (intent) provide a good example about what is involved. Usually one just tries to find correlates chi and intent by using various kinds of detectors [J132]. The detector for a given speculative effect could be physical detector measuring fields, particle currents etc., chemical methods could be used to detect the effects, biological materials and even human body could serve as a detector. If one takes TGD seriously, one can reduce the test for chi and intent to a tests for its new physics correlates. The general vision also suggests optimal choices of targets of remote mental interactions.

While preparing this chapter I learned about two articles providing reviews about empirical testing of notions of chi and intent. The first article by Kevin Chen - titled *An analytic review of studies on measuring effects of external Qi in China* [J132] - summarizes the various methods of measuring external Chi (EQ). Second article is by Lian Sidorov and Kevin Chen and titled *Biophysical Mechanisms of Genetic Regulation: Is There a Link to Mind-Body Healing?* [J170]. The main message of the article is that intent has a direct effect on DNA and that electromagnetic fields play an important role in both communication and energy metabolism. It would be interesting to combine existing general ideas with the experimental input discussed in these articles.

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> [L30].

### 15.2 Zero Energy Ontology

Zero energy ontology (ZEO) is one of the cornerstones of TGD and has become part of TGD during last six years. Zero energy states are identified as superpositions of pairs of positive and negative energy states assigned with the future and past boundaries of causal diamonds (CDs) and correspond in ordinary ontology to physical events with positive and negative energy parts

of the state identified as counterparts for the initial and final states of the event. Effective 2-dimensionality allows a further reduction to the level of partonic 2-surfaces: also their 4-D tangent space data matter. Symmetry considerations lead to a beautiful view about generalizations S-matrix to U-matrix in terms of orthogonal basis of M-matrices, which in turn are expressible as products of hermitian square root of density matrices and unitary S-matrix [K66]. One can say that quantum theory is “complex” square root of thermodynamics.

Therefore one should try to find tests for ZEO.

### 15.2.1 The Hierarchy Of CDs

The basic assumption is that the sizes of CDs come as integer multiples of  $CP_2$  scale  $R$  and for prime multiples of  $R$  correspond to secondary p-adic length scales  $L_{p,2} = L_{p,1}\sqrt{p}$ ,  $L_{p,1} = R\sqrt{p}$ , where  $R$  denotes  $CP_2$  scale. For electron with  $p = M_{127} = 2^{127} - 1$  one has  $T_{p_2} = .1$  seconds and defines a fundamental bio-rhythm. This time scale should have preferred role in physics. More generally the secondary p-adic time scales assignable to elementary particles should define time scales relevant to macroscopic physics. The corresponding size scale can be assigned to the magnetic body of the elementary particle. Also it should be possible to assign to quark mass scales special biological time scales as has been indeed done [K11]. h predictions could be tested.

### 15.2.2 Generalization Of Standard Conservation Laws In ZEO

ZEO together with sub-manifold geometry provides a new view about conservation laws and resolves the problem posed by the fact that gravitational interactions do not seem to respect energy conservation in cosmological time scales. Conservation laws holds true only in the scale associated with given CD, not universally (this would allow only single infinitely large CD).

Superconducting coherent states involve quantum superposition of states with different numbers of Cooper pairs and therefore break the super-selection rule associated with fermion number in ordinary ontology. In ZEO they could be understood without giving up the superselection rule associated with fermion number.

Experimental tests should try to prove that quantum number conservation is a length scale dependent notion. For instance, creation of matter from vacuum is possible in ZEO, and one might hope that its occurrence could be in some scale for CDs artificially.

### 15.2.3 Breaking Of Second Law In Standard Form

In standard physics second law states that all systems are entropic but a system can reduce its entropy by feeding its entropy to the environment. Negentropic entanglement carries genuine information and life can be seen as islands of negentropy in the sea of entropy. This forces to generalized second law. The proposed generalization (see <http://tinyurl.com/ybg8qypx>) [L17] [K61] can be characterized as maximally pessimistic.

The generation of negentropic entanglement is assumed to be accompanied by generation of compensating entropic entanglement. The modified form of second law is suggested by the mechanism of directed attention based on negentropic entanglement assignable to magnetic flux tube connecting self and target. Negentropic entanglement prevails during the attention but disappears after state function reduction giving rise to entropy at the level of ensemble. Second law would hold true above time scale assignable to the duration of negentropic entanglement.

There are also other reasons to reconsider second law. The breaking of second law in standard form since the arrow of geometric time can change locally. Living systems are indeed accompanied by syntropic effects as realized by Italian quantum physicist Fantappie [J133, J175]. These effects could be understood as entropic effects but with a reversed arrow of geometric time. The mechanism would be based on negative energy signals. Phase conjugate laser waves are known to obey second law in reversed direction of geometric time. Cooling effects due to the absorption of negative energy signals inducing the breaking of the standard form of the second law are predicted to be possible. One can also imagine a spontaneous excitation of atoms generating radiation in the return to ground state in a situation when there is a target able to receive negative energy signals emitted in spontaneous excitation.

Standard form of second law assumes that quantum coherence is absent in the scales in which it is applied. Both the hierarchy of Planck constants and negentropic entanglement however make possible macroscopic quantum coherence characterized by the scale involved and the natural guess is that the time scale associated with causal diamond in question defines the scale above which one can expect second law to hold. There is evidence for the breaking of second law in time scale of .1 seconds [D5].

#### 15.2.4 Negative Energy Signals

Zero energy ontology allows to assign to zero energy states an arrow of time naturally since one can require that states have well defined single particle quantum numbers at either upper or lower boundary of CD. Also the spontaneous change of the arrow of geometric time is possible. The simplest possible description for U-process is that U-matrix relates to each other these two kinds of states and state function reductions can occur at upper and lower boundaries of CD meaning reduction to single particle states with well defined quantum numbers. The precise correlates for the generation of geometric arrow of time are not completely understood.

Negative energy signals to geometric past would serve as counterparts for time reversed states in the case of radiation and phase conjugate laser waves are natural counterparts for them. The signal property requires a dissipative process proceeding in preferred time direction and this kind of process has been assigned to sub-CDs and should proceed as state function reduction sequence in preferred direction of time determined by the quantum arrow of time for the zero energy state. This process would be essential for the experience of flow of time in preferred direction and for generation of arrow of geometric time as explain in previous chapter and also in [K9]. For phase conjugate laser beams the reversed time direction for dissipation is observed.

Negative energy signals make possible remote metabolism as sucking of energy from remote energy source provided resonance conditions for transitions are satisfied. The counterpart of population inverted laser could serve as ideal source and the negative energy signal could serve as a control switch inducing phase transition like process taking the excited atom like systems to ground state (induce emission). This process should occur in living matter. Anomalous excitation of atomic state by absorbing energy by remote metabolism and subsequent generation of radiation could also serve as a signature. It could also lead to cooling effects breaking second law.

Negative energy signals would also make possible realization of intentional action by initiating the activity already in geometric past. This would be very desirable in rapidly changing circumstances. The time anomalies of Libet for active aspect of consciousness could be interpreted in terms of time mirror mechanism [J31] and further experiments in longer time scales might be perhaps carried out.

Negative energy signals could be also essential for the mechanism of long term memory. They would induce a breakdown for a system analogous to population reversed laser via induced emission meaning generation of strong positive energy signal [K90].

### 15.3 P-Adic Physics

#### 15.3.1 P-Adic Length Scale Hypothesis And Mersenne Hypothesis In Living Matter

p-Adic length scale hypothesis states that favored primary p-adic length scales proportional to square root of p-adic prime correspond to primes which are near powers of two:  $p \simeq 2^k$ . Favored secondary p-adic length scales would correspond to favored CD sizes coming as octaves. Mersenne primes are in special position. This leads to rather specific predictions in the case of living matter since the length scale from 10 nm to 5  $\mu$ m contains as many as four electron Compton scales  $L_e(k) = \sqrt{5}L(k)$  characterized by Gaussian Mersennes, which correspond to ordinary primes with  $k = 151, 157, 163, 167$ . This can be seen as a mathematical miracle and it is interesting that it associated with the biologically most interesting length scale range. This leads to Mersenne hypothesis [K11] stating that in living matter the p-adic length scales associated with both ordinary and Gaussian Mersennes are important. Besides this the hypothesis states that those values of Planck constant come as proportional to

$$r = 2^{k_i - k_j} ,$$

where  $k_i$  and  $k_j$  are primes characterizing two Mersenne primes. This predicts a large number of preferred time and length scales which might be relevant in living matter. Also this hypothesis could be tested.

### 15.3.2 Negentropic Entanglement

Negentropic entanglement is suggested to be a basic characteristic of living matter whereas the hierarchy of Planck constants would make possible macroscopic quantum coherence. Negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) and dark matter hierarchy allow to circumvent the basic objection against viability of computation: even technological applications can be dreamed of. At this moment the only support comes from proposed applications to particle physics and from the modelling of living matter and is only indirect. The basic challenge is to learn whether Nature has chosen negentropic entanglement and hierarchy of Planck constants as its tools. The next challenge would be to develop technological tools for handling them.

For instance, phase transitions changing Planck constant from ordinary to larger one would effectively mean disappearance of ordinary matter and this could serve as a signature. Negentropic entanglement makes possible abnormally long duration of entangled period resembling that appearing in Orch Or of Hameroff and Penrose [J118] and anomalously low dissipation could serve as a signature of both negentropic entanglement and of hierarchy of Planck constants.

Negentropic entanglement could be associated with many-particle states at magnetic flux tubes. Either non-local single particle excitations of Bose-Einstein condensates of bosonic states (Cooper pairs of electrons say) or many-fermion states can be considered [K82]. Metabolic energy quantum liberated in  $\text{ATP} \rightarrow \text{ADP}$  would generate the excitation. NMP does not tell whether a transfer of negentropic entanglement from high energy phosphate bond to flux tube takes place or whether the negentropic entanglement is created in the process. Exactly the same process would take place in photosynthesis as a first step and there is evidence for non-local excitations of electrons [I15]. Whether electrons or their Cooper pairs are in question will be known probably very soon. The general prediction is that metabolic energy transfer always takes place via a transfer of dark photon. The decays of these photons to ordinary photons should produce bio-photons with energy around 5 eV and IR photons with this energy could have biological effects.

### 15.3.3 Shnoll Effect As Evidence For P-Adic Physics?

In Shnoll effect [E2] the expected probability distribution with single peak develops several peaks and the effect depends on periods assignable to solar system. The effect is very general and appears even for atomic nuclei. There exists no standard physics explanation for it.

1. The TGD inspired model of Shnoll effect [K8] as a statistical effect is based on the interpretation of probability distribution having integer valued argument as p-adic valued distribution and the replacement of the parameters and variables with their images under canonical identification. For electron the magnetic body has size scale of the Earth so that this effect should be mediated by the magnetic body assignable to the CD and could be seen as evidence for these notions.
2. The oscillatory character of the effect with periodicities assignable to solar system inspires the question whether the transformation of intention to action mediated by canonical identification might be involved. If so this mechanism would apply also to experimental situations involving effect of intent on both living and inanimate systems. The prediction is the appearance of characteristic number theoretical signatures in the form of probability distributions. It has however turned out that the idea about p-adic-real phase transitions is not mathematically sound.



## 15.4 Magnetic Body As Carrier Of Dark Matter

Magnetic body carrying dark matter is certainly a central concept.

### 15.4.1 Dark Matter As A Hierarchy Of Phases With Large Value Of Planck Constant

1. Dark matter is identified as a hierarchy of phases with effective value of Planck constant coming as a multiple of ordinary Planck constant. A more stringent hypothesis inspired by spin glass degeneracy is that given multiple of Planck constant correspond to an effective local singular covering of the embedding space. In biological systems the values of Planck constant could be rather larger: the condition that a photons with given frequency correspond to energies above thermal energy at physiological temperatures allows to estimate  $\hbar$  as ratio of thermal energy with the photon energy for ordinary value of  $\hbar$ . This dark matter must be distinguished from galactic dark matter (which could be actually magnetic energy) assignable to long flux tubes like structures around which galaxies concentrate like pearls in necklace. The values of Planck constant proposed for flux tubes mediating gravitational interaction between bodies with masses  $M$  and  $m$  is gigantic:  $\hbar > GMm/c$  and can be assigned to dark energy rather than to dark matter.

It is assumed that at partonic 2-surfaces the sheets of multiple covering become completely degenerate and partially degenerate at two kinds of preferred 3-surfaces.  $n_1$ -fold branching occurs both at space-like ends of space-time surface assignable to CD boundaries and  $n_2$ -fold branching at light-like orbits of wormhole throats at which induced metric changes its signature. At partonic 2-surfaces branching to  $n_1 n_2$  surfaces occurs. There is mathematical analogy between 3-surfaces and partonic 2-surfaces with 2-branes which are also obtained as piles of copies of surfaces which degenerate to single one. Now the degeneration of 3-branes would occur only at the 3-D boundary of the brane.

2. Living matter would be ordinary matter controlled by dark matter at magnetic flux quanta assignable to living system. Magnetic body would have onion-like layered structure. For instance photons with energies in EEG range would correspond to parts of magnetic body with the scale of wavelength which is now of the order of Earth radius.

Tests for the presence of dark matter.

1. The basic prediction is the existence of scaled versions of standard model physics. Particles with large Planck constant would have same masses as ordinary ones but scaled up Compton wave lengths would make possible macroscopic quantum phases in much lower densities as usually. The proposal is that living matter involves scaled variants of electroweak physics and hadron physics. Also p-adically scaled variants with scale mass spectrum can be considered and resonant interactions between members of the two fractal hierarchies are natural when the scales co-incide.
  - (a) The scaled variant of QCD like physics is needed if color qualia are due to quark color. This is achieved by coding A, T, C, G to spin states of  $u$  quark pairs assignable to flux tube pairs in the model of DNA as TQC. Findings of mathematician Barbara Shipman [A20] suggests that the mathematics of colored quarks are involved with the honeybee dance via so called flag manifold  $SU(3)/U(1) \times U(1)$  parametrizing different choices of color quantization axis. Could the presence of dark  $u$  quarks at the ends of flux tubes attach to DNA and lipid layers be tested? For instance, could it be detect the presence of quark charge equal to  $2/3$ ?
  - (b) The prediction would be that at space-time sheets corresponding to given value of Planck constant long ranged color and/or electroweak interactions are present meaning the presence of new long range forces. Could these be partially responsible for the coherence of living matter: could color confinement play an essential role? Elementary particles are pairs of magnetic monopoles separated by Compton length: could also second monopole containing only neutrino pair be made visible by a suitable experimental arrangement?

Maybe even ordinary condensed matter physics could involve  $Z^0$  force below atomic length scale [K34].

2. One motivation for the hierarchy of Planck constants was the evidence that water behave as  $H_{1.5}O$  in atto-second scale. The explanation was that 1/4 of hydrogen nuclei (protons) are dark. Could these experiments be carried out in other time scales and living matter? I have proposed that the rich anomaly spectrum of water above freezing point could be understood if it is a multiphase system containing also dark components [K34]. Could one test this hypothesis by concrete model building and comparison with experimental facts?
3. Dark nucleons correspond to the states of DNA, RNA, tRNA, and amino-acids and vertebrate code has simple realization for dark nucleons. Could one prove experimentally the existence of dark nucleons? Perhaps as a dark plasma like phase?
4. Quantum coherence in unexpectedly long scales is predicted to be possible for dark matter. For instance, super-conductivity at temperatures at which it should not exist, becomes possible [K19, K20, K83, K84]. I have proposed a model of high  $T_c$  superconductivity and also its biological variant based on electron pairs with large Planck constant and Compton length of order cell membrane thickness. Josephson current through cell membrane is one testable prediction. EEG would be partially determined by these Josephson currents. It is now known that photosynthesis involves macroscopic quantum coherence in unexpectedly long length scale. The model is in terms of large  $\hbar$  electron Cooper pairs. Also this model should be testable.
5. With inspiration coming from the model of quantal effects for ELF photons on vertebrate brain, EEG photons are identified as dark photons and bio-photons as their decay products [K11]. This identification predicts that the energies of these photons are in visible and UV range. Could it be possible to see the emission of dark EEG photons with these energies in metabolic book keeping?

### 15.4.2 Tests For The Notion Of Magnetic Body

What kind of tests can one imagine for the notion of magnetic body?

1. The existence of magnetic bodies.
  - (a) Could one photograph dark matter at magnetic bodies? The mechanism would be transformation of ordinary photons to dark photons scattering from dark charged particles and transformation back to ordinary photons. Peter Gariaev might have already done this [K1]. This kinds of experiments might be continued and refined.
  - (b) How the existence of magnetic flux tubes connecting two objects - say living organisms - could be tested? What happens to flux tubes when the cells of living organism are taken far away from the organism. The experiments of Cleve Backster (see <http://tinyurl.com/43wbd6>), who introduced the notion of primary perception in the study of electrical reactions of plant which was harmed or threatened to be harmed suggest that this connection continues. Do the flux tubes remain intact and imply correlations between the distant cells and organism or - in the case that they are loops - are they split by reconnection mechanism? Could the flow of biologically important ions occur between the ends of flux tubes (it could also be that only electrons and protons and perhaps some dark nuclei - even quarks participate the flow). Could one use markers for the ions to test the existence of this kind of flows.
  - (c) How to measure the presence of the flux quanta of magnetic fields of magnetic bodies via the interaction of ordinary matter with classical electromagnetic fields created by dark particles? The description of this interaction (see <http://tinyurl.com/y9exp84r>) is in terms of topological condensation to multiple space-time sheets [K109]. Now embedding space effective covering and space-time has sheets analogous to those of Riemann surface of function  $z^{1/n}$ . This multi-sheetedness does not correspond to ordinary many-sheetedness. If all physics reduces to that associated with partonic 2-surfaces then

classical fields carrying different values of Planck constant should interact since different sheets co-incide at partonic 2-surfaces. The (effective) value of Planck constant defined as the number of sheets of covering can depend on the region of 3-surface. Are there rules governing this change?

- (d) Could one demonstrate the presence of magnetic monopoles at flux tube ends? Even elementary particles should possess magnetic body with largest flux tubes having length scale defined by the p-adic secondary p-adic length scale characterizing particle and characterizing the size scale of CD assignable to elementary particle. Also smaller layers of magnetic body should be present: in particular that corresponding to the primary p-adic length scale of order Compton length. Secondary p-adic length scale corresponds to a time scale of .1 seconds for electron, the fundamental biorhythm. Could one identify bio-rhythms assignable to quarks which are more massive than electron. The QCD estimates for u and d quark masses are about 5 MeV and 20 MeV and this gives an idea about secondary p-adic time scale which should be a negative octave of .1 seconds. 12.5 ms (80 Hz) and 2.5 ms (400 Hz) are the estimates for the secondary p-adic time scales.
- (e) Magnetic body having fractal onion-like structure would play a key role neuroscience. The effects of ELF em fields on vertebrate brain at multiples of cyclotron frequencies were the original motivations for introducing the hierarchy of Planck constants. EEG would serve as communication and control tool in the system defined by magnetic body and biological body. EEG frequencies should correspond to linear combinations of harmonics of Josephson frequency for cell membrane as electronic (at least) superconductor and harmonics of cyclotron frequencies for dark ions. This leads to a rich spectrum of quantitative predictions about EEG spectrum and attempts have been made to understand the dependence of EEG spectrum on state of consciousness. For Calcium ion the cyclotron frequency is 15 Hz.
- (f) Also magnetic body has dynamics - highest layers of body can disappear or reappear or completely new layer can emerge- and one can ask whether this dynamics could be experienced directly. The effects induced by Persinger's God helmet [?]ould have interpretation in terms of dynamics of magnetic body. Also OBEs could be understood as effects related directly to magnetic body [K108]. One can also ask whether astrophysical phenomena could effect directly the magnetic bodies and therefore conscious experiences. Effects of solar storms and auroras represent basic examples of this kind of effects. Maybe this could be tested?

## 2. The dynamics of flux tubes.

- (a) Phase transitions changing Planck constant would induce shrinking of magnetic flux tubes. These could correspond to volume changing transitions of gel phase in living matter. Bio-catalysis would rely on these phases transitions and they would allow bio-molecules in the dense soup of bio-molecules to find each other [K11].
- (b) Reconnection of magnetic bodies second fundamental dynamical process playing key role in living matter.  $ATP \leftrightarrow ADP$  process would be involved with reconnection. ATP as a molecule of consciousness would accompany negentropic entanglement. Information molecules attaching to receptors would represent ends of flux tubes attaching to receptors and forming longer connected flux tubes. This would be basically generation of qualia in the length scale defined by the distance of the cell sending the information molecule and the cell receiving it. Remote sensory perception would rely on the same mechanism. One should be able to test the hypothesis that the stretching of flux tubes accompanying the diffusion of information molecule from sender to target represents deeper level of the dynamics of information molecules? The transfer of dark particles along the flux tube could be one possible signature.

If it is possible to demonstrate the existence of magnetic flux tubes by studying the flow of dark particles between two systems, one could try to test whether changes in the flow pattern by reconnection could become manifest via the flows.

- (c) Also remote mental interactions should involve generation of flux tubes between the biological and magnetic bodies of the target and operator and reconnection for loops

could be the mechanism. Quantization of magnetic flux is necessary for this mechanism to work. Particle flows between target and operator would be one signature. For living target the coherence of counterparts of EEG would be second signature.

### 15.4.3 Bio-Superconductivity

#### TGD inspired model of high $T_c$ superconductivity

TGD inspired view about high  $T_c$  electronic superconductivity and its biological counterparts are discussed in [K19, K20, K83, K84]. Also the TGD inspired model for ordinary high  $T_c$  electronic superconductivity relies on flux tubes assigned with stripes found to serve as kind of highways carrying supra currents. High  $T_c$  superconductivity involves two critical temperatures:  $T_c$  and  $T_{c1}$ . Below the higher critical temperature  $T_{c1}$  Cooper pairs with large Planck constant are assumed to be present but magnetic flux tubes are assumed to be rather short and closed (the phase is antiferromagnetic) so that macroscopic supra currents cannot flow. Around the lower critical temperature  $T_c$  flux tubes fluctuate and form by reconnection longer flux tubes and percolation type process giving rise to macroscopic supra currents becomes possible. By p-adic length scale hypothesis the basic dimensional parameters could correspond to cell membrane thickness (10 nm) and cell nucleus length scale ( $2.5 \mu\text{m}$ ) even for ordinary high  $T_c$  superconductivity.

An analogous mechanism is expected to be at work for cellular system and give rise to electronic supra current. Also biologically important bosonic ions should give rise to cyclotron Bose-Einstein condensates with large value of Planck constant. In the case of fermionic ions Cooper pairs would be required. Another possibility is formation of exotic ions when some neutral color bonds between nucleons in nuclear strings become charged. The energy change should be relatively small- of order keV- and there is evidence for this kind of states: nuclear reaction rates vary with a period of year explainable in terms of the variation of the distance from the Sun effecting also the intensity of X ray radiation from Sun.

#### Leakage of supra currents as basic mechanism

The basic element of the proposed vision is remotely induced leakage of supra currents from magnetic flux tubes to atomic space-time sheets. This same mechanism works for both endogenous biological self-organization and remote mental interactions which would form a standard element in the construction of our sensory representations. The most economic experimental strategy would be a direct verification of this basic mechanism.

An especially dramatic effect would be the appearance of ions from magnetic flux tubes to the target of remote mental interaction not present in the target initially. Sue Benford has found evidence for the appearance of S, Mg, and Al in X ray films which were exposed to the radiation coming from so called torsion generator [I62]. Intentional effort was involved with the experiment. What happened was that dots and tracks with typical size scale of one millimeter appeared in the X ray film. The dots and tracks did not allow identification as tracks of charged particles, and the exposed regions contained S, Mg and Al not present elsewhere. The leakage of energetic superconducting ions to atomic space-time sheets dissipating their energy by emitting electromagnetic radiation and ionizing the atoms is the natural explanation for the effect [I62, I24]. Note that both X ray films and nuclear emulsions contain gelatin which is an organic compound and might increase the sensitivity of the system.

#### Time reversal for the leakage of supra currents

The time reversal of the mechanism generating the leakage of supra currents could be especially important for healing. This mechanism is consistent with the presence of remote bound state entanglement and anomalous production of metabolic energy when binding energy is liberated.

The mechanism would be accompanied by a mysterious disappearance of marker ions in the tissue, and manifest as time reversed function of various molecular machines certainly detectable. Phase conjugates of (that is time reversed) microwaves at critical frequencies could induce the healing process. For instance, de-differentiation of cells might be induced in this manner.

As explained earlier, geometric time reversal could typically involve generation of anomalous radiation by excitation of atoms or molecules by emission of negative energy photons. Rotating

magnetic systems (Searl machine) would be especially interesting for proving that time reversal indeed occurs. One could try to demonstrate that biological rhythms correspond to dissipation-healing cycles (wake-up sleep period and metabolic cycles being basic examples).

#### 15.4.4 Direct Supra Currents Along Magnetic Flux Tubes

Direct supra currents along magnetic flux tubes are also predicted besides Josephson currents. Direct supra currents would be excellent candidates for the currents of Becker (see <http://tinyurl.com/ybnjk9bq>) [L22]. This model assumes that living matter is a semiconductor having underlying regular liquid crystal like structure.

The lipid layers of cell membranes are indeed liquid crystals and the braiding of magnetic flux tubes induced by the flows of the 2-D liquid formed by lipids is central in the model of DNA as topological quantum computer. According to Mae-Wan Ho liquid crystal patterns provide memory representations: in TGD one would achieve the same by the storage of liquid crystal flow patterns to the braidings of flux tubes. For the direct quantum currents the assumption of actual semiconductor structure might be un-necessarily strong.

Magnetic flux tubes can also carry longitudinal electric field and one can construct a simple model for the quantum states of charged particles in this kind of electric field. Large value of Planck constant is natural for long flux tubes. Flux tubes could have size scale of body or of even magnetic body. The model provides unexpected insights about character of quantal currents, allows to understand the amplitude windows for the effects of ELF em fields on vertebrate brain, the effective semiconductor property of living matter, and the effect of needles in acupuncture as metabolic effect. Disease as a loss of negentropic entanglement, healing as a regeneration of negentropic entanglement, the association of negentropic entanglement with ATP and high energy phosphate bond perhaps assignable to a Cooper pair like state, vacuum zero point kinetic energies as fundamental metabolic quanta, and loading of metabolic energy batteries by acceleration of charged particles in electric field so that they can be kicked to smaller space-time sheets are the basic of the model (it is essential that the currents are non-ohmic!). The challenge is to test the model for DC currents and the models of healing and acupuncture.

The model also proposes that the interaction of radiation fields is based on acceleration of charged particles on flux tubes having also topological sum contacts to “massless extremals” representing space-time correlate for radiation fields. The optimal situation is achieved when the electric field of ME is parallel or antiparallel to flux tube and ME therefore orthogonal to it. If the flux tube is near critical voltage for the generation of quantal DC current, the perturbation caused by the radiation field can induced by the quantal DC current accelerating charged particles and loading metabolic batteries by kicking them to smaller space-time sheets. This would directly correspond to the generation of ATP responsible for negentropic entanglement and generating eventually liberating metabolic energy. The killer prediction is that the biological effects are caused only at the second half of the cycle. In the case of EEG theta waves there is indeed evidence for this [J184].

### 15.5 TGD View About Consciousness And Biology

In the following TGD based view about consciousness and biology is summarized with emphasis on mechanisms. Proposals for tests are made when possible.

#### 15.5.1 The Notion Of Conscious Hologram

Living system as conscious hologram is a metaphor emphasizing the fractal structure of sensor and cognitive representations. The model to be discussed relies heavily on the notion of magnetic flux tube and negentropic entanglement.

##### Attention

What is attention? What are its characteristic properties? What could be the quantum physical correlate for it. The naïve view western view is that attention and perception is directed: there

is observer and observed. The “Eastern” view says that observer and observed are one and same thing and this distinction applies only to memory about attention.

The proposed identification for the correlate of attention as negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) having as space-time correlates magnetic flux tubes corresponds to the “Eastern” view: I have made also an attempt to explain how asymmetry between perceiver and perceived could emerge [K4]. Directing attention to an object of external world means formation of flux tubes connecting perceiver to the object. Qualia prevail as long as this attention continues. There is a resemblance with Orch Or of Hameroff and Penrose [J118] and with active information of Bohm [J125]: attention is the activity.

This view about attention means that ordinary sensory perception is a non-local process involving in an essential manner also the target.

The test would be finding whether (for instance) visual attention implies “intentional imprinting” in the object of attention. This relates directly also to the proposed mechanism of remote mental interactions. In the case of hearing our ability to tell whether the sound comes from external world or not is a mystery if one believes that qualia are product of some neural activity. The flux tube model would assign also to hearing flux tubes which are attached to some object oscillating with the sound wave, even molecules of air. How it is possible to identify the sound source “correctly” if anything that oscillates with sound wave can serve as target of attention? The natural definition of source is in terms of intensity maximum. Both ears are needed to identify the direction of maximum intensity.

### Model for qualia

Directed attention involves qualia. The qualia correspond to quantum number increments during the process leading from ZEO counterpart of initial prepared state to the final entangled states (identified as states at lower and upper boundaries of CD). State function reduction which eventually happens reduces the negentropic entanglement at the upper end of CD and after this there is possibly a memory of qualia, not genuine qualia anymore. Flux tubes connecting observer and observed are the correlates for the sensory perception and generation of qualia. This leads to sensory capacitor model in which the analog of dielectric breakdown amplifies the polarization between the ends of flux tubes. Besides this the process involves scaling up the lengths of the sensory capacitor flux tubes: perhaps by a phase transition increasing the value of Planck constant.

Various electrets and strong electric fields characterizing biomatter could relate to sensory perception at molecular and cellular level. Cell membrane could give rise to sensory perception of external world during nerve pulse which indeed involves dielectric breakdown. One might hope of finding at test for the generation of polarization in longer length scale during generation of qualia.

### Fractality of sensory percepts and EEGs

The model of qualia suggests fractal sensory percepts. Sensory perception would be a process propagating from long to short length scales and generating qualia transforming to memories about qualia. Cell membranes and DNA could be end points of this process and lipids of the cell membrane liquid crystal would form pixels for a representation of external world analogous to that provided by computer monitor. In case of ordinary cells this representation would be about chemical environment, in the case of neurons about the external world. How this representations relates to our conscious experience?

It might be that negentropic entanglement in the scale of magnetic body is involved so that the process generating qualia begins from the level of magnetic body and proceeds downwards.

EEGs consisting of dark large  $\hbar$  photons with energies in visible and UV range are used to communicate sensory data to magnetic body as Josephson radiation from cell membranes with frequencies characterized by the value of Planck constant. The radiation would propagate along flux tubes and flux sheets. What is the precise meaning of this communication? Is it communication of symbolic representation constructed by brain and therefore communication of memories?

The fractal onion-like structure of magnetic body requires fractal hierarchy of analogs of EEG which could be called XYGs. Even weak bosons and gluons could give rise to the analog of EEG in appropriate length scales if dark matter hierarchy is realized. Biophotons are tentatively

identified as decay products of large  $\hbar$  EEG photons and their scaled variants. Could this be tested somehow?

Fractality of memory representations would mean that scaled down “stories” lasting much shorter time than the real episode are formed and could be formed as several copies. This could be one of the key elements of intelligent behavior. There is evidence for this has been found by Yamaguchi *et al* [J184, J183] in the case of theta waves. TGD based explanation in terms of phase transitions generating scaled versions of the real time representation of the event is discussed in [K4]. It might be possible to test this aspect of memory representations in terms of EEG waves as in the work of Yamaguchi.

### Fractality of sensory representations

The notion of conscious hologram means that practically any part of body can represent any other part of body or even external world. Concerning the notion of conscious hologram at the length scale of body, Kirlian imaging with simultaneous electrical stimulation of other body parts, in particular ear, is very promising manner to test the hypothesis [I79]. It is also known that ear forms kind of fractal miniature of body with respect to acupuncture points so that stimulation of particular part of ear electrically creates sensation that particular part of body is stimulated [J151].

PLR spectroscopy [I30] provides a precise and accurate manner to prove the viability of the notion of conscious hologram empirically. What is needed is the analysis of the frequency spectrum: does it really contain the predicted differences of cyclotron harmonics. If this approach and its variants really work it becomes possible to determine experimentally the densities of super-conducting ions and Cooper pairs at parallel space-time sheets.

At the level of remote mental interactions the stimulation of brain electrically could induce in other brain nerve pulse pattern or even experience correlating with the nerve pulse pattern or even experience in the stimulated brain. Even water near criticality could provide this kind of representations. In Imaging laboratory at Hilversum, Holland the following experiment has been performed with success. The experiment involves water droplet near freezing point. A person with abilities of a healer asks for Universe to express something in the structure of the droplet. What results are beautiful fractal patterns representing say plant leaves, even a picture about the laboratory’s architecture has been generated in this manner. Also the work of Emoto [L126] and work carried out in Aerospace Institute in Germany [I13]

### 15.5.2 TGD View About Metabolism

TGD view about metabolism involves two new elements. First of all, TGD leads to the idea of universal metabolic quanta. These would make possible metabolism before the development of a complex chemical machinery which also would rely on universal metabolic energy quanta. Secondly. ATP seems to have two roles as a molecule of consciousness and as a metabolic quantum? These roles are very closely related and the connection with the modification of second law of thermodynamics is suggestive.

### Many-sheeted space-time and universal metabolic energy currencies

The dropping of particle to a larger space-time sheet liberates energy which is the difference of the energies of the particle at two space-time sheets. If the interaction energy of the particle with the matter at space-time sheet can be neglected, the energy is just the difference of zero point kinetic energies. This energy depends on the details of the geometry of the space-time sheet. Assuming p-adic length scale hypothesis one obtains a general formula for the difference of zero point kinetic energies. These energy increments define ideal candidates for universal metabolic currencies and under certain additional conditions (say resonance with energies of some important molecular transitions) these currencies could be predecessors of the standard metabolic currency of order 5 eV. There is a more detailed treatment of universal metabolic currencies in [K11]. A model for how universal metabolic currency 5 eV assign to the dropping of proton from atomic space-time sheet is discussed in [K51].

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries

of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant  $\hbar_{eff}$  so that cyclotron energy would be liberated. In the following only the “dropping” option is discussed.

The hypothesis predicts the existence of anomalous lines in the spectrum of infrared photons. Also fractally scaled up and scaled down variants of these lines obtained by scaling by powers of 2 are predicted. The wavelength corresponding to 0.5 eV photon would be  $\lambda = 2.48 \mu\text{m}$ . These lines should be detectable both in laboratory and astrophysical systems and might even serve as a signature for a primitive metabolism. One can also consider dropping of Cooper pairs in which case zero point kinetic energy is scaled down by a factor of 1/2.

Interestingly, the spectrum of diffuse interstellar medium exhibits three poorly understood structures [I6]: Unidentified Infrared Bands (UIBs), Diffuse Interstellar Bands (DIBs) [I3], and Extended Red Emission (ERE) [I83] allowing an interpretation in terms of dropping of protons or electrons (or their Cooper pairs) to larger space-time sheets. The model also suggests the interpretation of bio-photons in terms of generalized EREs.

It must be emphasized that the identification of metabolic energy quanta as increments of zero point kinetic energies is untested and allows variants. Magnetic flux tubes are in longitudinal degrees of freedom effectively one-dimensional boxes, and the energy increment for the longitudinal excitations could replace the increment of zero point kinetic energy in the transfer of the particle between space-time sheets. Also excitations in transversal degrees of freedom (increment of cyclotron energy) are possible. These excitation energies could define universal metabolic energy quanta. This option emerges in the model for the generation of negentropic entanglement giving also the connection with the findings about effects of ELF em fields on vertebrate brain. The model predicts that metabolic energy transfer always involves generation of dark photon absorbed by magnetic flux tube so that negentropically entangled non-local single particle excitation is created. One expects that IR photons with energy around 0.5 eV (metabolic energy quantum) have biological effects. Also bio-photons resulting from the transformation of dark photons to ordinary photons at this energy are possible.

### Plasmoids as prebiotic life forms

A natural conjecture is that plasmoids involving charged plasma at magnetic flux quanta define prebiotic life forms [?]. The minimum prerequisites for life would be present if the proposal for universal metabolic quanta is correct. Even dark nuclei could be regarded as plasma like structures so that even genetic code and nuclear counterparts of basic biomolecules could be involved.

The model of high  $T_c$  super-conductivity and the general vision about dark matter hierarchy have led to a rather precise model for magnetic body as an intentional agent utilizing biological body or its part as motor instrument and sensory receptor [K33]. Dark matter plasmoids and plasma oscillation patterns as representations of control commands are one important aspect of the model. The prediction is that plasmoids should have been predecessors of ordinary life forms. There is laboratory evidence that plasmoids behave like life forms [I57, I41]. Very high temperatures catastrophic for ordinary life forms could prevail at magnetic flux quanta associated with plasmoids. This forces a radical reconsideration of the question how pre-biotic life have evolved and forces to ask whether even the hot interior of Earth could have served or still serve as a seat of life.

The old Expanding Earth hypothesis explains the observation made already at the time of Wegener that all continents fit to a structure covering entire Earth if the radius of Earth were one half of the recent radius. A phase transition increasing the value of Planck constant for the space-time sheet of Earth by factor two could explain this finding and leads to a rather non-trivial vision about early life at Earth (see <http://tinyurl.com/y7uuy119>) [L118].

ATP cannot serve as a correlate of negentropic entanglement during prebiotic period but this does not mean that negentropic entanglement would not be possible. One should understand why ATP makes possible negentropic entanglement. Negentropic entanglement allows states with negative binding energy which are not bound states in the usual sense. Why high energy phosphate bond would be example of this kind state? Understanding this might help to understand the conditions under which negentropic entanglement is possible. The laboratory evidence for plasmoids as prebiotic life forms [I41, I56] raises hopes that one could learn to create situations in which



negentropic entanglement prevails.

In situations in which the target is in-animate matter, universal metabolic quanta might be relevant for the realizations of remote mental interactions.

### Controlling metabolism by IR laser beams and DNA functioning by maser beams?

One could also test the “dropping” of ions to larger space-time sheets. If the dropping ions have dissipated their energy this means that system acts like a maser at wavelength defined by the reduction of the zero point kinetic energy liberated in the dropping of the ion. The pumping process would correspond to the leakage of the supra currents to atomic or some other space-time sheet, and induced emission to the dropping induced by the photons already present.

1. The effectiveness of metabolic energy production in which proton drops and absorbs a negative energy photon of energy about .5 eV could be amplified by a beam of coherent IR light “kicking” protons back to the atomic space-time sheets. The irradiation by phase conjugate beam would “steal” energy from living system by inducing the dropping without locally usable energy. Whether living systems can “steal” energy from other life-forms in this manner could be tested. The “stealing” of the metabolic energy (there is probably a fractal hierarchy of “energy currencies”) from cancer cells by phase conjugate laser light might be the first principle explanation for why Priore’s machine works.
2. The dropping of ions from say  $k = 151$  space-time sheet to larger space-time sheets creates microwaves with frequencies corresponding to zero point kinetic energies about  $2^{-15}/A$  eV,  $A$  atomic number. For electron the energy is about 1/16 eV. These processes could define exotic forms of metabolism, perhaps at the level of DNA. This process could be amplified by an external microwave beam or its phase conjugate and phase conjugate beam could induce the correction of genetic errors.

The transformation of photon energy to metabolic energy 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.

3. The scaling law of homeopathy [J43] states that high and low frequencies accompany each other and are in a constant ratio for which TGD predicts several values determined as ratios of zero point kinetic energies and cyclotron energies at magnetic flux tubes. The scaling law can be understood as follows: dropping of ions to cyclotron states generates with the zero point kinetic energy and cyclotron photons. Low frequency photons can interact resonantly with the system for which the internal excitations have same low frequency. This generates internal excitation with wavelength which is of the order of system size and this excitation couples resonantly to photons with wavelength equal to system size: thus high frequency photons result.

Thus one might achieve the above proposed effects using also low frequency irradiation. For instance, irradiation by kHz waves in order to achieve generation of bio-photons and irradiation by ELF waves in order to achieve generation of microwave photons. In fact, I started to develop the vision about living system as a macroscopic quantum system from the finding of Blackman [J47] and other pioneers of bio-electromagnetism that ELF radiation has delicate effects in the functioning of living matter. It seems that the basic mechanism might be the dropping of ions between space-time sheets or its time reversal. This mechanism could be tested also for remote objects.

### 15.5.3 The New View About DNA

The new view about DNA and cell involves several aspects.

1. The first vision about DNA was inspired on many-sheeted space-time alone and on the idea about the role of magnetic body of DNA. There was also a proposal about hierarchy of codes

containing as a successors of genetic code memetic code assignable to Mersenne prime  $M_{127}$  characterizing electron [K46]. The codewords of this code could be represented as sequences of 21 DNA codons.

2. DNA as topological quantum computer model [K4] introduced a completely new level of information processing as counterpart of topological quantum computation made possible by magnetic flux tubes connecting DNA nucleotides and lipids of nuclear or cell membrane defining braiding. A realization of genetic code is involved. Perhaps the most convincing realization is in terms of 3+1 spin states of fermion pairs assignable to pairs of flux tubes. The realization using  $u$  quarks allows to stabilize DNA carrying 2 units of electric charge per nucleotide. The positive charge  $4/3$  at the end of flux tube pair serves as possibly testable experimental signature for the proposal. Introns would be optimal for the topological quantum computation and the increase of the intronic fraction of DNA with the increase of evolutionary level conforms with the idea that the evolution of magnetic bodies distinguishes between us and our cousins.

The notion of magnetic body inspires also the proposal that magnetic flux sheets traversing through DNA make possible integration of genomes to higher level structures: this leads to the notions of super genome and hypergenome. Could these higher level genomes manifest themselves as coherent gene expression in the scale of organism and even of population? The development of collective levels of consciousness and cultural evolution would reflect directly the presence of this level of information processing. One implication is the failure of genetic determinism. For this there already exists empirical support. Already the fact that the genomes of humans and of rather primitive life forms do not differ much (apart from intronic portion) suggests that an unidentified level of information processing is involved.

3. Dark DNA as sequences of dark nucleon strings is a fr completely unexpected twist in the development of ideas related to DNA and genetic code [K65, K48]. The theoretical challenge is to understand the relationship with ordinary DNA and its companion molecules. Is the transcription between dark nucleon counterpart of DNA, RNA, tRNA, amino-acids to their chemical variants possible? How could one make dark protons and nuclear strings “visible”. Scattering of photons from dark proton strings would involve transformation to dark photons and back. Also classical em fields created by the dark nuclei are in principle observable.

The presence of dark DNA could make possible active genetic engineering using the “virtual” world of dark DNA, and its companions and one can imagine that biology applies the analog of R&D in industry. This is obviously in conflict with the dogma that evolution is solely due to random change and selection.

4. What is amusing that the model for water memory and homeopathy led to this proposal [K48]. In the succession process water clusters would “steal” the magnetic bodies of dissolved polar ions and representations of the magnetic bodies as dark nucleon sequences would be generated. There could be also evolution driven by repeatedly occurring mechanical agitation implying increase of Planck constant associated with the magnetic bodies involved. All polar molecules have representation as a DNA sequence. The fundamental mechanism of immune system would be reconnection of magnetic flux tubes associated with the polar ions and the structures representing them so that the cyclotron radiation propagating along them could not interact with the biomolecules. Immunity would the outcome from this “stealing of attention”. If the transcription of dark nucleon sequences to the biochemical counterparts exist this could make possible to automatically generate genes coding for proteins which in turn “catch” the polar molecules that they represent.

A fascinating possibility is the transfer of genes homeopathically. Genes would be dissolved into water and succession process could be used to induce evolution of the magnetic bodies of the dark DNA associated with genes. These could be transferred to cells and germ cells and transcription to ordinary DNA would make possible genetic engineering.

#### 15.5.4 Model Of Cell Membrane As Almost Vacuum Extremal

The model for cell membrane as almost vacuum extremals brings in additional new physics predicted by TGD. Vacuum extremals are basic solutions of field equations and their small non-vacuum

deformations are expected to be important for quantum TGD. For instance, the long length scale limit of the theory in gravitational sector is expected to rely on almost vacuum extremals. 4-D spin glass degeneracy is also due to vacuum extremals and allows to have classical space-time correlates also for the non-deterministic aspects of quantum theory as a failure on standard form of classical determinism. Vacuum degeneracy also implies the realization for the hierarchy of Planck constants in terms of effective multiple coverings of the embedding space.

Since quantum criticality is expected to be key attribute of sensory receptor, one expects that cell membrane is almost vacuum extremal. This would also imply that large values of Planck constant and dark matter are involved.

The model for cell membrane as almost vacuum extremal involves an assumption that Weinberg angle in this phase differs from its value for elementary particles, which are in many respects diametrical opposite of almost vacuum extremals. The model makes precise predictions about preferred photon energies in visible and UV range and these photon energies correspond to peak frequencies for the photoreceptors.

## 15.6 General Model For Remote Mental Interactions

The assumption that the notion of magnetic body and hierarchy of Planck constants defines key element in remote mental interactions reduces the tests at the level of physics to tests for these notions.

### 15.6.1 Direct Metabolic Correlates For Remote Mental Interactions

The proposal is that ATP is the molecule of consciousness in the sense that its presence acts as relay in flux tube connection carrying negative entanglement entropy. ATP would be also the molecule of attention if negentropic flux tubes connecting perceiver and attended system serve as correlates of attention. There is complete symmetry between the two systems which conforms with the “Eastern” vision that there is no distinction between observer and observed during observation. The distinction emerges only after the observation is over and sensory percept has become a memory.

Also remote mental interactions should have ATP as a correlate of intentional action at the end of the operator and the rate of metabolism might be used as a correlate for the remote mental interaction such as psychokinesis or intentional imprinting or human-machine interactions.

### 15.6.2 How To Choose Senders And Receivers?

In the above discussion only the new physics phenomena suggested to be essential for both biology, neuroscience, and remote mental interactions are considered, and many experiments could be carried out without operator and target as they are used in remote mental interaction experiments. One might however hope that the model could give some idea about optimal planning of experiments related to remote mental interactions.

In these experiments an important aspect of testing is optimal choice of targets and the persons acting as sender.

1. Quite generally, the optimal target system for demonstrating these effects would be a critical system very sensitive to small perturbations. Any critical system would work, and one might even consider that the critical systems used to detect elementary particles might be used. Overcooled vapor or liquid or overheated liquid is one possibility. One could take register what happens in the system using same methods as in particle physics. Organic compounds might be by definition be this kind of systems.
2. One could also try to identify optimal “senders”. Persons with strong will power or with firm belief on the effect, or persons with lower level of inhibition (children, actors, artists, ...) could be considered as optimal “senders”. One could find whether some drugs which remove inhibition, could enhance telepathic and psycho-kinetic abilities. The “blessed are the meek since they quantum entangle” prediction could be also tested. Indeed, one of the most dramatic experiments supporting psychokinesis was done using chicken which imprinted

to a robot [J157]. The robot, whose behavior was programmed earlier by random number generator, tended to stay near the chicken, as if chicken had induced a quantum jumps changing the geometric past in macro-temporal time scales.

## 15.7 The Tip Of Iceberg: Placebo, Experimenter Expectation And Interference Phenomena In Subconscious Information Flow

The answers to the questions discussed below require a summary of the recent view about basic notions of TGD inspired theory of consciousness. The vision of Jeff Hawkins about neocortex led to a considerable updating of the vision about quantum jump as a moment of consciousness, and also about the notion of self allowing rather concrete connection with what happens in brain and the basic notions of Hawkins have quantum parts in TGD based vision. The question by Jean Burns inspired a model for how the memories and expectations of future are read without affecting the memories by using interaction free measurement. Remote mental interactions can be seen as special case of those occurring between magnetic body and biological body in TGD based view about living matter and brain and the answers to the questions rely on this vision.

### 15.7.1 The Vision Of Jeff Hawkins About Neo-Cortex

The progress in these aspects came from working out a general model for quantum jump in zero energy ontology (ZEO) with inspiration coming from the book of Jeff Hawkins (for book see <http://tinyurl.com/ybva3x1b>).

1. Hawkins suggests a general model for how neocortex constructs sensory representations and motor actions. One of his key observations is that these two basic operations look like time reversals of each other a model for sensory perception gives a model for motor action.
2. Hawkins emphasizes the role of time: not only spatial patterns but temporal sequences of them are stored in memory. Hawking introduces also the notions of invariant representation, association, abstraction and its reverse process, and hierarchy of abstraction levels having interpretation in terms of structure of neo-cortex and the basic question is what are the (possibly quantum) physical correlates of these notions.
3. Pattern recognition is the basic process and is carried out at various levels of hierarchy by comparing sensory input with standard patterns stored in memory. If the pattern fails to be recognized at given level it is sent to higher level where it is represented in lower resolution and might be recognized as a part of a larger pattern.

### 15.7.2 A Generalization To A Vision About The Anatomy Of Quantum Jump In Zero Energy Ontology

The vision seems to generalize to an interpretation of the anatomy of quantum jump by generalizing to various notions involved to quantum TGD context. This was to my a surprise. The basic observation and in zero energy ontology (ZEO) quantum jumps occur in two varieties: state function reduction to upper or lower boundary of causal diamond (CD). The interpretation for these two kinds of quantum jumps would be as generalizations for forming sensory representations and performing motor action. The processes would be carried out at various levels of the self hierarchy. Even at the level of elementary particles (see <http://tinyurl.com/yc46pq86>).

#### Sensory perception and motor action as time reversals of each other

In this framework sensory representations are not only (short term) memories but also predictions, symbolic representations for expectations and beliefs about future. Same applies to their p-adic counterparts defining cognitive representations in which sensory percept consists of objects. Motor actions correspond to sensory representations in reversed time direction and same statements apply to them as also their p-adic counterparts.

1. I assume the basic ideas about zero energy ontology (ZEO) and causal diamonds (CDs) known. Denote the light-like boundaries of causal diamond CD (cartesian product of the intersection of future and past directed light cones of  $M^4$  with  $CP_2$ ) by  $CD_{up}$  and  $CD_{low}$ . “Up” resp. “low” could be also taken to mean “future” resp. “past”. Let us use small letters  $a, b, ..$  for positive/negative energy states, which are state function reduced and thus look classical since particle numbers and quantum numbers are well-defined unless negentropic entanglement is present. Big letters are preserved for states which do not have this property. In any state of quantum jump sequence one has state of form  $(a, B)$  or  $(A, b)$  by the basic properties of state function reduction in ZEO. Note that state function reduction and state preparation are the same thing but occurring at opposite boundaries of CD in zero energy ontology.
2. Suppose first that  $CD_{low}$  is in a state function reduced state  $a$  with well defined single particle quantum numbers. State  $a$  could be regarded as an outcome of sensory perception process (top-down cascade of state function reductions with standard arrow of embedding space time) leading from perceptively fuzzy initial state to perceptively precise state. The state  $B$  at  $CD_{up}$  cannot be prepared/state function reduced if S-matrix is non-trivial and represents a superposition of states, something non-classical like qubit or Schrödinger’s cat. State  $B$  could be seen as a fuzzily defined goal, plan of future, or prediction resulting in sensory perception. This conforms with Hawking’s vision that sensory perception defines also a plan of future, expectation.

The p-adic variant of  $a \rightarrow B$  obtained by cognitive map mapping real space-time surfaces in the superposition to p-adic counterparts (these surfaces represent among other things nerve pulse patterns) would be cognitive representation, kind of symbolic representation describing the goal, expectation, or prediction, intention. Its fuzziness corresponds to the fact that we cannot predict future precisely.

3. Let us now make state function reduction at the opposite boundary  $CD_{up}$ , which after this is in perceptively precise state function reduced state  $b$ . The interaction is as motor action identified as time reversal of sensory perception.  $b$  represents now an achieved goal.  $b$  is of course not completely predictable and only the probability of particular  $b$  can be known.  $CD_{low}$  is state  $A$  which is not anymore state function reduced and classical looking. It can be interpreted the initial fuzzy motor plan represented as quantum superposition of options without fixing the details. The cascade of state function reductions proceeding from top to bottom for given CD and its sub-CDs only fixes the details.

The p-adic of this zero energy state would be cognitive representation for the realized motor action leading to final state  $b$ : a realized intention, cognitive representation for how intention was realized.

4. If this picture is correct, the outcomes of quantum jumps in ZEO would be universally organized into a sequence of pairs  $(a_n, B_n), (A_n, b_n)$  of zero energy states corresponding to sensory perception and motor action and the basic structure for the functioning of conscious brain would be part of quantum theory. This decomposition would take place in various scales of the scale hierarchy (sheets of many-sheeted space-time with various time scales and CDs containing sub-CDs containing...). This picture is consistent with the vision of Hawking at the structural level and if true, brain would not be so special system as neuroscientists tend to think but could be seen only as a highly specialized and highly developed instrument for producing sensory and cognitive mental images and controlling the external world. Also the localization of contents of consciousness to brain alone would be misleading in this framework.

### Quantum counterpart of association

Association is key concept of neuroscience and should have quantum counterpart.

1. To explain the idea one needs first some words about Negentropy Maximization Principle (NMP). NMP is analogous to second law. It states that the information gain in state function reduction is maximal. One can define information gain as difference between informations of initial and final zero energy states. NMP implies standard quantum measurement theory

for Shannon entropy as entanglement entropy. If entanglement probabilities are rational numbers or even algebraic numbers one can however define a hierarchy of number theoretic entanglement entropies corresponding to various p-adic numbers fields  $Q_p$ ,  $p$  prime and in this case the entropy can be negative and thus describes information interpreted as information carried by the entanglement. The pairs in quantum superposition would represent instances of a rule. Entropy would in turn characterize the loss of information about the state of either entanglement system.

NMP is analogous to second law and its natural to imagine the analogs of temperature and various other parameters as characteristics of “thermal equilibrium” under some constraints with respect to NMP instead of second law. These would be macroscopic parameters characterising the state of consciousness, and one can easily imagine psychological counterparts of thermodynamical notions. Psychological pressure would not be a mere metaphor!

2. Negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) provides a model for associations as rules in which superposition of tensor product states defines rule with entanglement pairs defining its various instances. This generalizes to N-fold tensor products. Associations would be realized as N-neuron negentropic entanglement stable against NMP. One could also think of realizing associative areas in terms of neurons whose inputs form entangled tensor product and when sensory inputs are received they form analogous tensor product in representative degrees of freedom.

Thus negentropic entanglement is necessary for mental images (having sub-CDs as correlates) to mental images representing spatial patterns. Negentropic entanglement in time direction for these patterns (zero energy states) is in turn necessary to bind them to sequences of mental images representing abstract memories as sequences of mental images. Negentropically entangled sequence would be a quantal counterpart for the original association sequence introduced as purely geometric concept.

3. Collective consciousness could involve formation of associative (tensor product) networks analogous to neuronal networks as this kind of negentropically entangled tensor products. They could be very relevant for remote mental interactions. Experimenter effect, effect of group to remote mental interactions such as healing, etc... They would form hierarchy and the communications between hierarchy levels would be important. The remote viewer or healer would be only part of a bigger structure.

### 15.7.3 Self Or Only A Model Of Self?

Negentropic entanglement provides a model for associations as rules in which superposition of tensor product states defines rule with entanglement pairs defining its various instances. This generalizes to N-fold tensor products. Associations would be realized as N-neuron negentropic entanglement stable against NMP. One could also think of realizing associative areas in terms of neurons whose inputs form entangled tensor product and when sensory inputs are received they form analogous tensor product in representative degrees of freedom.

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This picture however challenges the identification of self as quantum jump. Should the negentropically entangled sequences of mental images define selves so that self would be something characterizing zero energy state rather than something identified as quantum jump? Could they define a model of self to be distinguished from self identified as quantum jump? Or could one give up the notion of self altogether and be satisfied with model of self? At this moment it seems that nothing is lost by assuming only the model of self.

By definition negentropic entanglement tends to be preserved in quantum jumps so that it represents information as approximate invariant: this conforms with the idea of invariant repre-

sentation and quite generally with the idea that invariants represent the useful information. There is however a problem involved. This information would not be conscious if the original view about conscious information as a change of information is accepted.

The recent formulation of TGD inspired theory as quantum measurement theory in Zero Energy Ontology and assuming NMP requires that negentropic entanglement assignable to the passive boundary of causal diamond (CD) is directly experienced and defines what might be called unchanging self. The active boundary defines the changing part of self - the "Maya".

Sensory and memory representation based on bits assignable to the active boundary of CD are however possible. Could one imagine a reading mechanism in which this information is read without changing the representations at all? By non-cloning theorem this is too much to hope but one might achieve it with arbitrary accuracy. This reading process would be analogous to deducing the state of a two-state system in interaction free measurement to be discussed below in more detail. The interaction free measurement would thus allow to read memory representations constructed in terms of bits without changing them at all at the never-achievable idealized limit.

#### 15.7.4 Could Interaction Free Measurement Be Used To Read Memory Representations?

If memory representations are realized in terms of bits, there should exist a way to read them without changing them. No-cloning theorem prevents this but one can imagine a reading mechanism inducing no changes at idealized limit. The following proposal for non-destructive reading of memories and future plans allows to resolve this problem.

##### Bomb testing problem as a model for interaction free measurement

One can consider a generalization of so called interaction free measurement as a way to deduce information about self model realized in terms of bit representations. This information would be obtained as sequences of bits and might correspond to declarative, verbal memories rather than direct sensory experiences.

1. The bomb testing problem of Elitzur and Vaidman gives a nice concrete description of what happens in interaction free measurement, see <http://tinyurl.com/kx2jsyu> [B1] for an illustration of the system considered.

The challenge is to find whether the bomb is dud or not. Bomb explodes if it receives photon with given energy. The simplest test would explode all bombs. Interaction free measurement allows to make test by destroying only small number of bombs and at idealized limit no bombs are destroyed.

The system involves four lenses arranged in square and two detectors C and D at the upper right corner of the square. In the first lense at the lower left corner the incoming photon beam splits to reflected and transmitted beams: the path travelled by transmitted beam contains the bomb.

- (a) The bomb absorbs photon with a probability which tells the fraction of photon beam going to the path at which bomb is (is transmitted through the lense). The other possibility is that this measurement process creates a state in which photon travels along the other path (is reflected). This photon goes through a lense and ends up to detector C or D through lense.
  - (b) If the bomb is dud, the photon travels through both paths and interference at the lense leads the photon to detector D. If C detects photon we know that the bomb was not a dud without exploding it. If D detects the photon, it was either dud or not and we can repeat the experiment as long as bomb explodes, or C detects photon and stop if the detector continues to be D (dud). This arrangement can be refined so that at the ideal limit no explosions take place and all.
2. The measurement of bomb property is interaction free experiment in the sense that state function reduction performed by absorber/bomb can eliminate the interaction in the sense that photon travels along the path not containing the bomb. One might say that state

function reduction is an interaction which can eliminate the usual interaction with photon beam. State function reduction performed by bomb can change the history of photon so it travels along the path not containing the bomb.

This picture is only metaphorical representation of something much more general.

1. Bomb could be of course replaced with any two-state system absorbing photons in one state but not in the other state, say atom. Now one would test in which state the atom is gaining one bit of information in the optimal situation. Two-state atom could thus represent bit and one could in principle read the bit sequence formed by atoms (say in row) by this method without any photon absorption so that the row of atoms would remain in the original state.
2. Two-state system could be replaced with  $N$ -state system. In this case the testing selects at first step one state as analog of bomb intact and the remaining states as analogs of dud. If the answer was "dud" in the first step, the next step selects one preferred state from  $N - 1$  states and regards the remaining states as "dud". The process continues until the state of the system is measured.
3. In TGD framework the photon paths branching at lenses correspond to branching 3-surfaces analogous to branching strings in string model and photon wave splits to sum of waves travelling along the two paths.

### Memory recall as an interaction free measurement

One can imagine several applications if the information to be read in interaction free manner can be interpreted as bit sequences represented as states of two-state system. Lasers in ground states and its excited state would be analogous many particle quantum system. In TGD framework the analog of laser consisting of two space-time sheets with different sizes and different zero point kinetic energies would be the analogous system.

For instance, a model of memory recall with memories realized as negentropically entangled states such that each state represents a qubit can be considered.

1. Reading of a particular qubit of memory means sending of negative energy photon signal to the past, which can be absorbed in the reading process. The problem is however that the memory representation is changed in this process since two state system returns to the ground state. This could be seen as analog of no-cloning theorem (the read thoughts define the clone). Interaction free measurement could help to overcome the problem partially. Memory would not be affected at all at the limit so that no-cloning theorem would be circumvented at this limit.
2. A possible problem is that the analogs of detectors C and D for a given qubit are in geometric past and one must be able to decide whether it was C or D that absorbed the negative energy photon! Direct conscious experience should tell whether the detector C or D fired: could this experience correspond to visual quale black/white and more generally to a pair of complementary colors?
3. ZEO means that zero energy states appear have both embedding space arrows of time and these arrows appear alternately. This dichotomy would correspond to sensory representation-motor action dichotomy and would suggest that there is no fundamental difference between memory recall and future prediction by self model and they differ only the direction of the signal.
4. Since photon absorption is the basic process, the conscious experience about the qubit pattern could be visual sensation or even some other kind of sensory qualia induced by the absorption of photons. The model for the lipids of cell membrane as pixels of a sensory screen suggests that neuronal/cell membranes could serve defined digital self model at the length scale of neurons.
5. Active/passive dichotomy can be represented in very simple manner physically. One has two state system in which lower energy state can be excited to a long lived higher energy state by



photon absorption. System in higher energy state is passive and that in lower energy state active.

This model can be applied also to telepathy and maybe also to ESP since the basic mechanism are expected to be the same.

### What abstraction means in zero energy ontology?

A further central notion used by Hawkins is that of abstraction.

1. For sensory and cognitive representations abstraction means just a process of forgetting irrelevant details besides going to a longer time and length scales (example: sequences of music pieces in CD is the mental image instead of single piece).
2. The more abstract the representation the longer the corresponding time scale is. This suggests that the sequences of negentropically entangled mental images get longer as abstraction level increases. In state function reduction the quantum superposition of CDs with second boundary localized contains all scales for CDs and reduction localizes the opposite boundary but forces de-localization of the original boundary. This also means that the average size of the CDs increases and the sequences of negentropically entangled sub-CDs become longer as new sub-CDs (mental images) are created. These sequences of sub-CDs would give rise not only to self but also self-model
3. Getting rid of details is the second aspect of abstraction. In TGD framework measurement/ cognitive/ sensory resolution is a natural concept in this respect and emerge unavoidably if one interprets cognitive representations as maps of real space-time surfaces to their p-adic counterparts. Only discrete set of rational (or perhaps algebraic) points of space-time surface can be mapped to their p-adic counterparts as such. The p-adic space-time surface is a completion obtained as a preferred extremal containing these points. There are in general very many preferred extremals with this property and their quantum superposition represents the cognitive representation in finite measurement resolution. Quantum superposition in given resolution defines therefore abstraction and increasing the level of abstraction means reduction of the resolution. Note that also the reverse maps from p-adic preferred extremals to real ones define reversals of cognitive maps and have realization as a transformation of intention to action.

### Remote mental interactions as a special case

This general model applied also to remote viewing and psychokinesis assumed to be special cases of what happens when magnetic body interacts with biological body, could provide new insights.

1. The first conclusion would be that several levels (scales) are probably involved in both processes: not only various hierarchical levels of brain (various sensory and motor areas, and their 6-layered structure, various size scales in brain anatomy) but also the hierarchy of magnetic bodies would be present meaning that remote mental interactions involve collective levels of consciousness rather than only the operator and target. The presence of these collective levels suggests that the experimenter effect and many other analogous effects considered in the questions are real.
2. In the case of brain self hierarchy allows to understand various agnosias [J22] which look mysterious if one assumes only single level in the self hierarchy. One of the agnosias is blind sight: person sees but does not see consciously. The visual areas of the person are intact. Person indeed receives the visual information as but some other level of self level sees becomes clear from the fact that she can perform motor actions possible only if there is an access to the visual information generated in visual areas. Simplest explanation would be that the sub-selves representing mental images do not negentropically entangle with the other sensory mental images: associative areas would not work as they should. Agnosia would be disorder in tensor producting! They would entangle with unconscious-to-us motor mental images. The

explanation would be that some other self in hierarchy enjoys visual consciousness, perhaps above, at same level, or several level below in the hierarchy.

Could remote viewing be like blind sight: one sees but not consciously - some lower or upper level in the self hierarchy remote views consciously and the remote viewer manages to guess some of this information? The presence of self hierarchy extending even to the level of magnetic bodies and collective levels of course complicate the modelling attempts. For instance, one must ask how can one know that remote viewer does not read the thoughts of some person in the experimental group instead of remote viewing. In any case, the presence of the hierarchy and the crucial role of attention would also explain the difficulties related to the interpretation of experiments.

3. Ironically, various experimenter effects and placebo effect might provide the strongest support for remote mental interactions and the effect of intentions and expectations to the future history. In ZEO sensory perception produces not only summary of what happened but also an expectation what will happen and one could interpreted the expectation also as a quantum fuzzy goal. The next quantum jump realizes this motor plan. In ZEO we are really re-creating our reality repeatedly by just sensorily perceiving in the two different time directions. If one believes on hierarchy of Planck constants, and negentropic entanglement, the effects need not be minor anomalies masked by thermal fluctuations but can become manifest in everyday scales.

### 15.7.5 Possible Answers To The Questions

**Question 9:** Both Dr. Solfvin and Dr. Modell have conducted remote influence studies (on animal models, respectively random event generators; Solfvin, 1982; Modell, 2012) in which participants' expectation seemed to dominate the outcome. In the first case, animal handlers were told that half of their assigned mice were inoculated with babesia and half with sterile saline, and that half of each group would receive remote healing influence from an accomplished healer. In reality, all mice were inoculated with the same dose of babesia, and there was no remote healer. In spite of this, significant differences were recorded between "inoculated" and "control" groups, as well as between "healer" and "control" mice – which, the paper concluded, could only be attributable to handlers' expectations. In Modell's study, where a random event generator (REG) was set up to arbitrarily shut off the power to another, sequence-recording REG, eventual loss of interest by the experimenters invariably resulted in the initially spectacular PK effect size dropping to non-significance levels.

Are you aware of similar experiments corroborating these results? Can you think of a way to isolate the experimenter expectation effect from the overall outcome? How significant do you think experimenter expectations may be in mainstream clinical trials? Could a reduced level of emotional trepidation/ expectancy build-up on the part of principal investigators in post-marketing drug trials, when compared to pre-approval phase, mirror the steep decline noted with Modell's 2-REG experiments? What makes a system more susceptible to experimenter expectation?

**Answer:** One could understand these findings qualitatively in the proposed general vision. In particular, the loss of interest means that experimenter does not anymore direct attention to situation and there is no intention to achieve desired results. If emotions basically correspond to negentropy gradients then their lack means that attention is not directed to the target.

**Question 10:** Like the REG/DMILS studies above, the Schlitz/Wiseman experiments (Wiseman and Schlitz, 1998) suggest that the ganzfeld process is susceptible to experimenter expectation. However, these correlations are not consistent - successful remote viewing and PK have also been achieved in the presence of skeptics. Is there any supporting evidence for experimenter expectation in the GCP data or in other field-REG studies? Do you feel that some psi processes may be more robust in the face of experimenter expectation – for example, that the spontaneous mass emotional response typically associated with the major events registered by the Global Consciousness Project is more likely to dominate the outcome than the motivation of a typical operator trying to affect a bench top random event generator in the classical REG experiment?

**Answer:** Ganzfeld process would seem to be almost by definition a process involving several collective levels of consciousness so that if the vision discussed in the beginning makes sense, one could expect the susceptibility. What I fail to understand is how mass emotional response could lead to coherent effect on REG since the intention to obtain definite deviation from true randomness is obviously lacking.

Maybe one could think some kind of effect - via say periodic perturbation of magnetic fields of the collective magnetic body (Schumann resonances?) transferred also to the magnetic body assignable to the recording. William Tiller has reported this kind of effects due to intentional action in his books. I have proposed a rather crazy idea of demonstration of PK leaving no doubt about its reality by comparing records of RG with affected by PK able person with those not affected in this manner (see <http://tinyurl.com/yckq32pv>).

**Question 11:** In “The Possible Role Of Intention, Attention And Expectation In Remote Viewing” (see <http://tinyurl.com/yacazbus>) (May and McMoneagle, 2004) the authors argue that the sharply focused attention of all unit personnel on the one assigned task while doing operational remote viewing was likely responsible for the exceptional level of data produced. This seems to be corroborated by a series of experiments (Watt, 2003) in which subjects’ focus on a given task was shown to be significantly enhanced by a remote “assistant” concentrating their supportive attention on the operators. If these findings are correct, then it would seem that attention itself is a cumulative network phenomenon. Could that joint mass focus on the event being studied be a factor in the remarkable consistency of GCP results? **Answer:** To answer this question as

a physicists one should have a physical model for attention. My own model of attention relies on the identification of magnetic flux tube connections as a correlate of attention. Negentropic entanglement is present bringing in conscious information at this level of self hierarchy. Flux tubes create also quantum coherence in the sense that the systems connected by flux tubes form a single quantum coherent system in some degrees of freedom (dark matter with large value of  $\hbar_{eff}$  at connecting flux tubes and systems themselves).

Sharply focused attention of all unit personnel means that the level of consciousness of the collective mind created in this manner is high and one can expected that remote viewing is more effective. Note that remote viewing as analog of sensory perception would involve information transfer between different levels of this hierarchy in both directions: to abstraction and back to more detailed view.

**Question 12** (from B. Millar): Are there effects known in physics where three or more initially separate systems become quantum coupled or entangled? Do these have any consequences for remote mind-mind and mind-matter interactions?

**Answer:** There are. Quantum entanglement between electrons of atom and at molecular level are this kind of phenomena. Also quantum entanglement between valence quarks inside proton ( $N=3$ ). 2-particle entanglement is however special. So called monogamy theorem states that system can have maximally entropic entanglement with single system only. Therefore maximal entanglement between A and B, A and C, and B and C is not possible in 3-particle entanglement. The really happy couple must isolate themselves from the rest of the world!

**Question 13** (from J. Burns): We know through abundant evidence that ESP can travel without any physical signal to carry it. Up until recently the only way known, according to physical laws, to make a connection with no physical signal was through quantum entangled states. This possible method for the travel of ESP has the problem that quantum entanglement does not allow the transmission of information, but only correlations between certain events. However, it is thought that perhaps the extension of currently known quantum mechanics, which describes the interactions of matter, to incorporate interaction with consciousness might then provide an explanation.

However, recently a method has been proposed in which, according to the presently known laws of quantum mechanics, information can be transferred without a physical signal (see <http://tinyurl.com/cr5e6tzapr/16/alice-and-bob-communicate-without-transferring-a-single-photon>). It differs from the latter method in that it uses the Zeno effect, which is produced through multi-

ple instances of de-coherence, such as wave function collapse or interaction with the environment. Which method do you favor as a means by which ESP can travel? Why? If you favor a third method, please describe.

**Answer:** I already described the interaction free measurement realized in terms of lenses and photon beams. The bomb testing problem of Elitzur and Vaidman gives a nice concrete description of what happens (see <http://tinyurl.com/kx2jsyu>).

The basic idea of interaction free measurement and its possible application to memory recall allowing to avoid destruction of the memory represented in terms of bits (sub-selves, sub-CDs) was discussed in the first section ???. It was noticed that the absorption of photons could give rise to visual quale (black/white) as a representation for the bit that has been read and that the lipids of cell membrane could serve as pixels of sensory screen allowing to define mental images at neuronal level of self hierarchy.

One can imagine several applications if the information to be read in interaction free manner can be interpreted as bit sequences represented as states of two-state system. Lasers in ground states and its excited state would be analogous many particle quantum system. In TGD framework the analog of laser consisting of two space-time sheets with different sizes and different zero point kinetic energies would be the analogous system.

1. Mind reading - telepathy - might be possible using this mechanism if thoughts are expressible as qubit sequences or more general patterns. The mind reader sends a split beam of photons to the system which it wants to read. The target notices nothing at the idealized limit since no photons are absorbed by the target but a pair of systems analogous to detectors C and D: mind reader must of course be able to see whether either of these systems detects a photon.

This mechanism would differ from TGD inspired model of telepathy based on TGD inspired notion of sharing of mental images. Sharing of mental images requires that entanglement of mental images is possible although systems having those mental images as sub-selves (sub-systems) are not entangled. This is possible if one accepts TGD based view about space-time and corresponding view about hierarchy of subsystems. One can have two disjoint space-time sheets containing topologically condensed smaller space-time sheets which are connected by flux tubes. In the resolution of larger space-time sheets there is no entanglement. In the resolution of smaller space-time sheets there is entanglement and shared mental images.

2. Could this model apply to ESP?
  - (a) The recent TGD based model of ESP relies on much more classical picture. Magnetic flux tubes generated by remote viewer and serving as correlates of attention connect the remote viewer with the target (here macroscopic quantum coherence is required). Along the flux tubes travel the dark photon beams (photons with large  $\hbar_{eff}$  and thus scaled up wavelength for given energy) and are reflected at the second end and return back. This is very much like ordinary seeing using lamp but forcing the light beams to travel inside flux tubes so that the intensity of beam is not reduced with distance.
  - (b) There does not seem to be any compelling need for interaction free ESP as there is in the case of reading of negentropically entangled memories or future predictions.
  - (c) Furthermore, visual perception does not seem to be a process in which qubits are read. Note however that in the above described model reading of memories involves photon absorption by system C or D: these systems code for the values of bit and one could assign to this process a visual quale.

**Question 14:** If PK is goal-oriented, independent of an operator's understanding of the complex physical or biological mechanisms involved in achieving the desired effect, then should we assume that the operator is essentially interacting with the target at a future point in time, with causality apparently flowing backward to the present, to affect the target and all those connected to it ? Does the universe we share then find its probability course like a stream shaped by the resultant landscape of our collective intents, beliefs and expectations?

**Answer:** One could understand the possibility of PK without understanding how it is achieved, if the operator is only a part of collective mind. Although operator knows nothing about mechanisms, the higher or lower levels might know and could help to reach the desired effect. PK as any motor action would be a cascade proceeding from higher levels to lower ones with a lot of feedback if the lower level is not able to realize what higher level wants so that command is sent back for refinement.

In ZEO motor action can be indeed seen as a time reversal of sensory perception which also involves a lot of feedback between different abstraction levels (representations in given resolution with poorer resolution meaning higher abstraction resulting from forgetting the irrelevant details). Libet's findings support this picture in small time scales.

Also higher collective levels would be present (having magnetic bodies as correlates). This could mean that collective intents, beliefs, and expectations are indeed important and universe is reconstructed repeatedly even in macroscopic scales, as we indeed experience it to be.

**Question 15** (B. Millar): Eminent parapsychologists are almost unanimous that understanding experimenter effect is crucial for the field. All this lip service has resulted in remarkably little experimental action. Why is this and what can be done to improve matters? **Answer:** I

think that the problem is that precise enough theoretical frameworks are lacking. The situation is also circular. Experimenter effect is itself remote mental interaction and it is remote interactions we try to understand by doing experiments!

**Question 16:** We are currently operating under the working assumption that any such consciousness - related anomalies are peripheral to our routine activities and small enough to be absorbed by the tolerances built into our systems. Is that a correct assumption – and if not, which areas do you think are most susceptible to these poorly-understood effects? How critical could they become? **Answer:** If I take seriously the vision about quantum jump sequence as a

universal cognitive algorithm involving large number scales and self hierarchy, I must be also ready to consider the possibility that the effects are not always small. Understanding of anomalies of ordinary consciousness in terms of self hierarchy might help considerably also in this problem.

## Chapter 16

# Hypnosis as remote mental interaction

### 16.1 Introduction

In TGD framework one can argue that hypnosis represents an example about the fact that brain is not “private property”: hypnotist uses the biological body and brain of the subject as instrument. Therefore remote mental interaction is in question. This idea generalizes: if one accepts self hierarchy, one can assign to any kind of higher level structure - family, organization, species,... - a higher level self and magnetic body carrying dark matter, and these magnetic bodies can use lower level magnetic bodies as their instruments to realize their intentions. Biological bodies would be an important level in the hierarchy, which would continue down to cellular, molecular, and perhaps to even lower levels.

This view challenges the prevailing views about brain as a sole seat of consciousness and the assumption that conscious entities assigned with brains are completely isolated. Given magnetic body can use several biological bodies although one can assign to it the one providing the sensory input - at least during wake-up state. Note however that it is easy to produce illusion that some foreign object is part of biological body.

For more than decade ago I proposed a model for so called bicamerality based on the notion of semitrance [K95, K96]. In semitrance the brain of subject becomes partially entangled with a higher level self - in this case the self of family or more general social group uses the biological body of member for its purposes. Higher level self gives its commands and advice interpreted by the bicameral as “God’s voice”. The consciousness of schizophrenic might be basically bicameral. Also hypnotic state and dream consciousness are candidates for bicameral consciousness.

#### 16.1.1 Hypnosis As Hijacking Of Brain?

In TGD framework hypnotist and subject would partially share the biological body of the subject, and hypnotist could realize motor actions using the biological body of the subject and also induce sensory experiences by sending suggestions generating virtual sensory input to the sense organs of the subject (this if one accepts TGD view about the role of sensory organs).

One could see hypnosis as a kind of hijacking of some parts of the subject’s brain. Could one identify these parts? The general finding is that there is no universal neural or EEG signature of hypnotic state and possible changes in neural activity can be interpreted as neural correlates of imagination. Only in the case of persons highly susceptible to hypnotic induction one can identify a change of neural activity pattern identifiable as a correlate of hypnotic state.

“Hijacking” can be of course criticized for its negative tone. A more positive way to express the idea is to say that the subject is voluntarily provides part of her brain to the use of the hypnotist’s magnetic body. This conforms with the acronym “TEAM” symbolizing the subject’s orientation to hypnosis in terms of “trust”, “expectation”, “attitude”, and “motivation”.

The neurophysiological findings conform with the view that the really interesting phenomena take at the level of magnetic bodies. The changes - when they occur - take place in prefrontal cortex

(PFC) (see <http://tinyurl.com/642r4t>) [J16] and anterior cingulate cortex (ACC) (see <http://tinyurl.com/2yykqh>) [J4]: this together what is known about methods of hypnotic induction provides hints about what might occur in the hijacking process. The almost-prediction would be a correlation between EEGs of the hypnotist and subject person reflecting the sharing of parts of the subject's brain. It would be therefore highly interesting to study the correlations of the EEGs of subject and hypnotist.

Strongly focused attention to hypnotic suggestion is mentioned as a basic aspect of hypnosis and distinguishes it sharply from sleep. This feature brings in mind various altered states of consciousness reached in meditation and it has been suggested that meditation is one form of self-hypnosis. In TGD framework personal magnetic body has layered onion-like structure with layers characterized by p-adic length and time scales and the value of  $\hbar_{eff}$ . Therefore meditative state could be seen as a re-sharing of biological body and brain by these layers and even by foreign magnetic bodies.

### 16.1.2 Do Social Interactions Share Something With Hypnosis?

More generally, one can also ask whether the phenomena of collaboration and synergy on one hand, and influence, "power" and fight for power on the other hand, could be modelled in terms of the partial ownership of the biological bodies by magnetic bodies identified as intentional agents.

Social structures and organizations are complex networks in which the arrows characterizing relationships between individuals in the simplest situations are uni-directional and static. The person at either end of the arrow is in command. In more complex situations members are connected by several arrows of this kind, their directions can vary, and need not be static.

Should one therefore give up what physicist would call "single-particle" view and replace it with "many-particle" view by bringing in the notion of magnetic body attaching to several biological bodies and organizing them to loosely bound states of individuals? Under what conditions this kind of partial fusion of conscious entities can take place? Does it occur only when there is complete trust in either direction or can fear about consequences be enough? It would not be surprising if immune systems against hijacking of the biological body would have evolved: this would allow to understand why the reality of remote mental interactions is so difficult to demonstrate. They could however take place on daily basis in social interactions if the proposed picture makes sense.

The dynamical sharing of biological bodies can be seen also positively: this sharing would make possible collaboration and synergy at much deeper level than we have been used to think. This kind of shared use of biological bodies perhaps defines the direction to which human kind should proceed. Also the possibility to directly experience what it is to be "the other one" - something not allowed by the standard view about consciousness confined inside individual brain - is implicated.

The new view about influence and power might allow to understand better the often highly irrational looking behaviors of organizations and their members - in particular blind obedience of orders and fight for power. The hierarchy of magnetic bodies could serve as a physical correlate for the hierarchy of biological and social structures. In particular, the fight for power could be seen as fight between magnetic bodies for the ownership of biological bodies or lower level magnetic bodies. The dark matter realized as a hierarchy of phases with non-standard value of effective Planck constant would represent a new physics necessary for understanding the physical correlates of these phenomena.

In the sequel I will introduce some basic notions, ideas and theories about hypnosis (see <http://tinyurl.com/mgy2e>): the Wikipedia article [J9] gives a good overall view about the subject. The techniques of hypnotic induction provide valuable clues if one wants to imagine what hypnosis is. I will also describe the classical test for hypnotic susceptibility using Chevreul pendulum (to me it was quite a stunning experience to find that I am highly susceptible to hypnotic induction!), and propose an explanation in terms of hijacking of PFC and ACC by the magnetic body of hypnotist. The model makes an assumption about the logic of brain functions. Imagined motor action "Don't (really) do this" is realized as "Do this" followed by "Don't" stopping the imagined motor action proceeding otherwise from the magnetic body to PFC to motor regions of cortex via ACC to a real motor action.

In TGD framework sensory perception and motor action are related by time reversal and therefore an analogous mechanism applies to imagination realized as a genuine hallucination unless “Don’t” is realized. Hypnotist should therefore hijack the brain regions realizing “Don’t” by catching their attention so that they cannot perform their function. ACC is a good candidate for the region in which “Don’t” is realized under normal circumstances. This logic makes possible to induce motor actions and sensory hallucinations analogous to dreams. Dreams would be realized in terms of virtual sensory input to sensory organs (REM) rather than only to higher levels in hierarchy of sensory representations at cortex, which do not carry visual qualia conscious-to-us.

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> [L30].

## 16.2 Basic Facts About Hypnosis

The reader is recommended to read the Wikipedia article (see <http://tinyurl.com/mgy2e>) about hypnosis [J9] as a good introductory summary. The article begins by stating the basic big question about hypnosis: Can hypnosis be regarded either as a mental state (altered state of consciousness) or as an imaginative role-enactment? The first option conforms with the basic assumption of most existing theories of consciousness: consciousness is something completely private and in materialistic dogma reduces to the state of brain. Second option does not accept hypnosis as a genuine brain state and emphasizes the interaction between hypnotist and subject. Combined with standard neuroscience also this approach tries to understand hypnosis as single-brain phenomenon. In TGD view hypnosis is seen as a phenomenon involving two magnetic bodies interacting with single brain.

Also the heightened focus and concentration to a dominating idea (suggestion) blocking out sources of distraction is mentioned as characteristic of hypnosis and some theories emphasize this aspect instead of seeing hypnosis as a trance state.

The following discussion relies heavily on the Wikipedia article adding TGD inspired comments in the hope that they would help the reader to see the distinctions between TGD approach and more standard approaches.

### 16.2.1 Basic Definitions

In the following basic definitions of hypnosis are considered. The discussion follows the Wikipedia article with TGD inspired comments.

#### Definition of hypnosis

Braid’s original definition of hypnosis was following:

*[...] the real origin and essence of the hypnotic condition, is the induction of a habit of abstraction or mental concentration, in which, as in reverie or spontaneous abstraction, the powers of the mind are so much engrossed with a single idea or train of thought, as, for the nonce, to render the individual unconscious of, or indifferently conscious to, all other ideas, impressions, or trains of thought. The hypnotic sleep, therefore, is the very antithesis or opposite mental and physical condition to that which precedes and accompanies common sleep [...]*

Braid defined hypnotism as a state of mental concentration that often leads to a form of progressive relaxation, termed “nervous sleep”. Later, in his “The Physiology of Fascination” (1855), Braid concluded that his original terminology was misleading, and argued that the term “hypnotism” (“hypnos” refers to sleep) or “nervous sleep” should be reserved for the minority (10 %) of subjects who exhibit amnesia, substituting the term “monoideism”, meaning concentration upon a single idea, as a description for the more alert state experienced by the others.

The recent official definition of hypnosis is following:



*Hypnosis typically involves an introduction to the procedure during which the subject is told that suggestions for imaginative experiences will be presented. The hypnotic induction is an extended initial suggestion for using one's imagination, and may contain further elaborations of the introduction. A hypnotic procedure is used to encourage and evaluate responses to suggestions. When using hypnosis, one person (the subject) is guided by another (the hypnotist) to respond to suggestions for changes in subjective experience, alterations in perception, sensation, emotion, thought or behavior. Persons can also learn self-hypnosis, which is the act of administering hypnotic procedures on one's own. If the subject responds to hypnotic suggestions, it is generally inferred that hypnosis has been induced. Many believe that hypnotic responses and experiences are characteristic of a hypnotic state. While some think that it is not necessary to use the word "hypnosis" as part of the hypnotic induction, others view it as essential.*

### Induction

Hypnosis is preceded by induction phase, which according to state theorists leads into a "hypnotic trance" whereas "non-state" theorists view induction as "means of heightening client expectation, defining their role, focusing attention".

There exists a large number of induction techniques. The oldest and still dominant one is the eye fixation technique used by Braid and focusing the visual attention to some object - say oscillating pendulum. Ericksonian hypnotherapy relies on indirect techniques to induce trance states. Almost all methods used by Erickson - say handshake induction - rely on confusion as a way to induce hypnotic state. Erickson sees the resistance to direct suggestions as the basic challenge and used therefore indirect suggestions including so called double bind ("Shall we consider this problem now or perhaps later?" ) are used. Erickson saw hypnosis as a bi-directional process: also therapist can occasionally be in trance.

#### *Remarks:*

1. What notions like "role" and "client expectation" have as quantum physical correlates is of course unclear since even the notion of "consciousness" is poorly understood physically.
2. It has been proposed that all brain states are kind of hypnotic trance states: this extremist view brings in mind the view about magnetic body as a controller of brain and in this sense a hypnotist.
3. The unconscious-to-us fast visual pathway traverses through ACC, which suggests that the activation of ACC by visual attention to pendulum or some other object is involved in eye fixation technique. One can also ask whether flux tube connections retina - pendulum - retina are formed and whether the motion of pendulum promotes the their formation, perhaps in the same manner as "Mesmeric passes" might do.
4. ACC is the part of brain which seems to be involved with the treatment of conflicting situations and Francis Crick has identified it as a candidate for a locus of free will. This supports the view that ACC is indeed essential in the induction of hypnosis.

### Suggestion

Braid did not refer to suggestion in his definition of hypnotic state but saw it as focusing of the attention of subject upon a single idea. Later Braid however placed emphasis on using different verbal and non-verbal suggestions.

Bernheim shifted the emphasis from hypnosis as a physical state to the physical process of suggestion:

*I define hypnotism as the induction of a peculiar psychical [i.e., mental] condition which increases the susceptibility to suggestion. Often, it is true, the [hypnotic] sleep that may be induced facilitates suggestion, but it is not the necessary preliminary. It is suggestion that rules hypnotism.*

Suggestion can take place permissively or in authoritarian manner. One can distinguish between direct and indirect verbal suggestions such as insinuations, requests, metaphors, and stories. There are also nonverbal suggestions and both immediate and posthypnotic suggestions are used in hypnotherapy. Also subliminal suggestions involving visual inputs lasting so short time that there is no conscious experience: at least in this case the unconscious-to-us fast visual pathway through ACC would be naturally involved.

### 1. *Consciousness vs. subconsciousness*

One of the basic issues related to hypnosis whether the suggestion is communication to the conscious or unconscious mind of the subject. Braid and Bernheim believed on conscious mind whereas Freud, Janet, and Erickson believe that sub-conscious mind is essential.

There is also the question whether a person in deep hypnosis is conscious. It seems that this is the case: for instance, person can report about sensory experiences during hypnosis if the hypnotist requests this. The focused attention with the reduction of peripheral awareness and increased response to suggestions seem to characterize the hypnosis.

*Remark:* In TGD framework subconscious and unconscious translate to “not conscious-to-us” and - according to the theory to be discussed - the highest level of subject’s brain consciousness having FCC as brain correlate could fuse with that of hypnotist’s magnetic body.

### 2. *Ideodynamic reflex*

The first theory of hypnotic state was introduced by Braid, and was based on ideomotor reflex response (see <http://tinyurl.com/2cgs2am>) . The notion was originally introduced by William Carpenter, a friend of Braid. Carpenter observed that under certain circumstances the mere idea of muscular movement induce a small reflexive motor response.

Chevrel pendulum allows to demonstrate the ideomotor reflex response in the case of highly susceptible subjects. The mere imagination of motor action producing the motion of the pendulum induces its motion and it seems that the imagination of motion generates the neural activity leading to the motion which due to the hypnotic induction is not stopped so that it can develop to a real motor action.

*Remark:* One could interpret ideomotor reflex in TGD framework as imagined motor action identified as a genuine motor action which proceeds downwards from PFC but is stopped before reaching muscles. Sensory perception has an analogous interpretation as time reversal of motor action. During hypnosis this halting mechanism would be inhibited. This process would be one particular example of inhibition, which is basic mechanism of neural activity: in fact, the role of inhibition becomes more and more important during evolution.

## Susceptibility

Hypnotic suggestibility (see <http://tinyurl.com/3m93r5>) [J9] measures how easily the person can be hypnotized.

Braid distinguished between different stages of hypnotism: sub-hypnotic state, full hypnotic state, and hypnotic coma. Charcot made similar classification using the attributes lethargic, somnambulistic, and cataleptic. Liebeault and Bernheim introduced a more refined classification based on a combination of behavioral, physiological and subjective responses. At 20th century more refined scales were introduced. The most common scales are the Harvard Group Scale of Hypnotic Susceptibility and the Stanford Hypnotic Susceptibility Scales.

Most scales measure nowadays the degree of observed or self-evaluated responsiveness to specific suggestion tests. Normal (80 % of population), high (10 % of population), and low (10 % of population) is the simplest characterization of susceptibility. Highly susceptible subjects have been classified to fantasizers and dissociators. Fantasizers have often had parents who have encouraged imagination. Dissociators have typically a life history involving childhood abuse or some other trauma, and they have learned to escape into numbness and forget unpleasant events. The association to day-dreaming is “going blank” rather than fantasizing wildly.

### 16.2.2 A Brief History Of Hypnosis And Theories Of Hypnosis

Hypnosis has pre-cursors in yoga and meditation practices. Meditation could be seen as self-hypnosis (if hypnosis is “two-particle phenomenon”, one can wonder what this might mean!). The intense focusing of attention on single mental image can be seen as a common aspect of hypnosis and meditation practices.

Franz Mesmer (see <http://tinyurl.com/rs8qu>) [J7] was the pioneer of hypnosis. He used magnets to induce hypnotic state but later noticed that the same effects can be induced by passing the hands, at a distance from the subject’s body (“Mesmeric passes”). Mesmer believed on what he called “animal magnetism” according to which Universe was filled with some kind of magnetic fluid. At the request of King Louis XVI a Board of Inquiry having as members Antoine Lavoisier, Benjamin Franklin and an expert in pain control, Joseph-Ignace Guillotin (better known in somewhat different context), started to study whether animal magnetism is real. The effects were found to be real but placebo controlled experiments convinced the board that mesmerism was most likely due to belief and imagination rather than any sort of energy flowing from the hands of Mesmer.

*Remark:* In TGD approach to consciousness the flux quanta of magnetic bodies carrying dark matter become the key players of life and consciousness, and are also crucial for the understanding of hypnosis. Somewhat ironically, Mesmer might be making come-back. The effects would be mostly due to imagination but the hands of Mesmer might have induced magnetic flux tube connections making possible the hijacking of the brain of the subject!

James Braid (see <http://tinyurl.com/3s86z86>) [J10] revisited both the theory and practise of Mesmerism trying to reduce mesmerism to physiology and psychology. Braid emphasized the differences between sleep and hypnosis. He did not believe in any kind of magnetism or supernatural occult influence.

Besides Mesmer and Braid, Bernheim, Janet, Freud, Coue, Hull, Elman, Erickson (see <http://tinyurl.com/y4cp73r>) [J6] are pioneers of hypnosis. Bernheim was a follower of Braid and emphasized suggestion as an essential element of hypnosis instead of viewing hypnosis as a trance state possessed by Braid.

Freud was highly enthusiastic about hypnosis and even wrote a book about hypnotherapy. After the advent of psychoanalysis he started to emphasize the role of free association as a road to unconscious mind. Freud however saw hypnosis as a fast alternative to time taking psychoanalytic therapy. As already described, Erickson developed his own hypno-therapy based on the use of confusion as a manner to achieve hypnotic induction. Erickson also realized that the hypnotic induction can work in both directions.

#### The notion of dissociation

Janet (see <http://tinyurl.com/g55mo>) introduced the notion of dissociation of the control of behavior from ordinary consciousness [J9]. Hilgard introduced later the notion of neo-dissociation: the subject divides her mind voluntarily so that the other part responds to the hypnotist and the other part corresponds to the awareness of the subject. Hilgard made subjects take an ice water bath. They said nothing about the water being cold or feeling pain. Hilgard then asked the subjects to lift their index finger if they felt pain and 70 % of the subjects lifted their index finger. This showed that even though the subjects were listening to the suggestive hypnotist they still sensed the water’s temperature.

Mind-dissociation theory of Tsai generalizes the notion of dissociation so that any function of mind can be dissociated. For instance, imagination can be dissociated leading to dreams, some sense can be dissociated leading to hypnotic anesthesia, motor function can be dissociated leading to immobility, “reason” (volition) can be dissociated so that the subject obeys the hypnotist’s orders, ...

#### Hypnotism as imagination becoming reality

A complementary view about hypnosis is as imagination, which becomes reality. Persons highly susceptible to hypnosis have been classified as either dissociators and fantasizers. Hence it seems that both views contain a germ of truth.

*Remarks:*

1. In TGD approach dissociation of the control of behavior from conscious mind has a concrete interpretation. The magnetic body of the hypnotist hijacks the prefrontal cortex responsible for the control of behavior. The division of the subject's mind claimed by the neo-dissociation theory conforms with this notion. Also braid regions responsible for other brain functions can be hijacked in this manner so that a picture analogous to that of Tsai emerges.
2. Also the role of imagination can be understood. Hypnotist can prevent the halting of the neural process behind motor imagination so that it transforms to genuine motor action. This hijacking and transformation of imagination to a real action applies also to sensory perception, which in TGD framework is time reversal for motor action and behavior and allows to understand sensory hallucinations induced by hypnotist.

**Two key questions**

In the following the history of hypnosis is discussed with emphasis on two questions.

1. Is hypnosis a genuine (altered) state of consciousness or is it a kind of role taking (partially unconscious) and learned social behavior possibly motivated by the need to appeal to the hypnotist?
2. Is hypnotic induction a message to conscious mind or subconscious/unconscious mind. Braid saw hypnotic suggestions as messages to the conscious mind whereas both Janet, Freud, and Erickson believed that hypnotic induction is communication with unconscious mind.

*Remark:* Self hierarchy implies that “unconscious” translates to “unconscious-to-us” in TGD framework. In TGD framework hypnotic induction would be a message to both conscious and unconscious-to-us levels of self hierarchy. The first guess would be that PFC serves as the neuro-anatomical correlate for conscious mind and ACC to that for unconscious mind. Fractality understood as abstraction hierarchy inspires the question whether PFC is same for cognition about cognition as ACC is for cognition.

**State or no-state?**

Braid saw hypnosis as a sequence of trance states whereas Bernheim did not believe hypnosis as state and saw suggestion as a key element of hypnosis and thus the interaction between hypnotist and subject. Erickson believed that trance states occur continually in everyday life (day-dreaming and situations in confusing situations) and that also hypnotist can fall in trance state.

Social role taking theory of Sarbin [J169] and cognitive-behavioral theory of Barber, Spanos, and Chaves [J33] took the latter view to extreme. According to social role taking theory hypnotic behaviour would be meaningful, goal-directed striving, its most general goal being to behave like a hypnotised person as this is continuously defined by the operator and understood by the client. Obviously this definition does not apply to self-hypnosis nor allows the interpretation of meditative states as self-hypnosis.

Pavlov could be seen a predecessor of cognitive-behavioral approach. Pavlov saw hypnosis as learned associations and conditioned inhibition. The argument was that the words used by hypnotist reach the whole cortex and can replace all signals reaching cortex and can therefore induce also behavioral reflexes.

The cognitive-behavioural theory of hypnosis is in some respects similar to Sarbin's social role-taking theory. In particular, Barber argued that responses to hypnotic suggestions were mediated by a “positive cognitive set” consisting of positive expectations, attitudes, and motivation. Daniel Araoz subsequently coined the acronym “TEAM” to symbolize the subject's orientation to hypnosis in terms of “trust”, “expectation”, “attitude”, and “motivation”.

*Remarks:*

1. No clear neuro-physiological correlates for a unique hypnotic state have been found except some signatures in the case of highly susceptible subjects. This does not support the interpretation of hypnosis as an altered state of consciousness if hypnosis is interpreted as “single-brain” phenomenon. In TGD framework hypnosis would involve the magnetic body of hypnotist and even altered states of consciousness achieved in meditation could be seen as analogs of hypnotic states (self-hypnosis). Hence the two views about hypnosis would be consistent in TGD framework.
2. Although the approach of Pavlov (see <http://tinyurl.com/z3vms>) looks like exaggeration it might make sense in TGD framework if reflex action is seen as standardized mental image accompanied by a pattern of neural activity. If patterns of neural activity define representations of imagined motor actions and sensory percepts and if also speech reduces to this kind of patterns, one can imagine that the mechanism inhibiting the inhibition of imagination from proceeding to real motor action or sensory percept can produce motor actions and sensory percepts. The acronym TEAM could be interpreted as listing the prerequisites for the readiness of subject to allow hypnotist to use the brain of subject.

### 16.2.3 Neuropsychology And Hypnosis

One can find in Wikipedia article a short summary about neuropsychology of hypnosis.

*Neurological imaging techniques provide no evidence for a neurological pattern that could be equated with a “hypnotic trance”. Changes in brain activity have been found in some studies of highly responsive hypnotic subjects. These changes vary depending upon the type of suggestions being given. However, what these results indicate is unclear. They might indicate that suggestions genuinely produce changes in perception or experience that are not simply a result of imagination. However, in normal circumstances without hypnosis, the brain regions associated with motion detection are activated both when motion is seen and when motion is imagined, without any changes in the subjects perception or experience. This may therefore indicate that highly suggestible hypnotic subjects are simply activating to a greater extent the areas of the brain used in imagination, without real perceptual changes. It is, however, premature to claim that hypnosis and meditation are mediated by similar brain systems and neural mechanisms.*

According to Wikipedia article another study has demonstrated that a color hallucination suggestion given to subjects in hypnosis activated color-processing regions of the occipital cortex. A 2004 review of research examining the EEG laboratory work in this area concludes:

*Hypnosis is not a unitary state and therefore should show different patterns of EEG activity depending upon the task being experienced. In our evaluation of the literature, enhanced theta is observed during hypnosis when there is task performance or concentrative hypnosis, but not when the highly hypnotizable individuals are passively relaxed, somewhat sleepy and/or more diffuse in their attention.*

Hypnotic suggestion seems to enhance imagination: this conforms with the basic vision that hypnosis involves strong concentration on suggestion defining what is imagined.

The induction phase of hypnosis may also affect the activity in brain regions that control intention and process conflict. According to Anna Gosline:

*Gruzelier and his colleagues studied brain activity using an fMRI while subjects completed a standard cognitive exercise, called the Stroop task. The team screened subjects before the study and chose 12 that were highly susceptible to hypnosis and 12 with low susceptibility. They all completed the task in the fMRI under normal conditions and then again under hypnosis. Throughout the study, both groups were consistent in their task results, achieving similar scores regardless of their mental state. During their first task session, before hypnosis, there were no significant differences in brain activity between the groups. But under hypnosis, Gruzelier found that the highly susceptible subjects showed significantly more brain activity in the anterior cingulate gyrus than the weakly susceptible subjects. This area of the brain has been shown to respond to errors and evaluate emotional outcomes. The highly susceptible group also showed much greater brain activity on the left side of the prefrontal cortex than the weakly susceptible group. This is an area involved with higher level cognitive processing and behaviour.*

Stroop task involves two conflicting cues and one might expect that ACC is involved with the solution of this kind of task. The similar performance before hypnosis and during hypnosis suggests that the changes in activity did not improve the task performance but were somehow due to hypnotic induction.

*Remark:* Concerning TGD approach to hypnosis, the findings about PFC and ACC give important clues concerning the possible mechanism of hypnotic induction. The absence of specific neurological pattern reflecting “hypnotic trance” conforms with the idea that hypnosis involves something more than just brain. Instead of presence of specific EEG patterns one can expect the synchrony of EEGs of hypnotist and subject.

## 16.3 TGD View About Hypnosis

In the following TGD inspired ideas about hypnosis are discussed. The basic guideline is the observation that PFC and ACC seems to be the brain regions activated in Stroop task under hypnosis in the case of highly susceptible subjects. A more detailed view about functions of these brain areas suggests a picture about hypnosis as a kind of hijacking of the subject’s FCC and ACC by the magnetic body of the hypnotist so that the biological body and brain of the subject become to some extent part of the hypnotist. One could say that hypnosis represents one particular example of remote mental interactions in which remote control of personal biological body by magnetic body is extended to that of the foreign biological body.

Second key assumption is that imagined motor action is a halted motor action. This applies also to sensory imagination, which however involve a virtual sensory input from magnetic body to the primary sensory organs. In hypnosis hypnotist can prevent this halting action. A plausible candidate for the seat of the halting action is ACC which also is in some respects analogous to a lower level variant of PFC. This kind of analogy makes sense if brain is fractal like structure.

### 16.3.1 Chevreul Pendulum As a way To End Up With The Model Of Hypnosis

My personal interest on hypnosis as a possible application of TGD inspired theory of consciousness was re-stimulated by an experience testing my susceptibility to hypnotic induction. My own expectation was that I would not be “an easy case”. The test was done by using improvised Chevreul pendulum. I held the pendulum at the height of my eyes. I received two kinds of suggestions. The first suggestion was a prediction that the pendulum will move. Second direct suggestion was “Don’t move the pendulum”. To my surprise the pendulum started to move and its amplitude grew gradually. I must admit that this looked like magic.

The first TGD inspired interpretation to come in mind was that the magnetic body of hypnotist hijacked some parts of my brain and used it to realize the suggestions given also verbally to increase their effectiveness. The discussion about the paradoxical outcome of “Don’t move the pendulum” led to the key ideas of the model.

1. Imagined motor action is realized as halted motor action - the negation of motor action: somehow this halting action should fail for hypnotic suggestions. In other words, the imagined motor action starts at high level, most naturally PFC and then proceeds downwards until it is halted in normal circumstance. By the duality relating motor action and sensory perception by time reversal (predicted by zero energy ontology [K24] ) similar mechanism should work at the level of sensory perception. Halting would involve inhibition of the neural signals otherwise propagating to muscles. The same failure of the halting mechanism would be behind dreams and hallucinations and automatisms as their motor counterparts.
2. Since ACC serves as a central station for top-down and bottom-up signals, ACC might be the place, where the halting signals are sent to various parts of motor cortex. Hence the catching of the attention of ACC so that it fails to perform its ordinary job would be the natural thing to do. This is achieved by generating flux tube connection binding ACC and some part of hypnotizers magnetic body to single quantum coherent system. ACC has also connections to PFC so that also PFC could be hijacked via ACC - at least in deep hypnosis.
3. ACC takes care of conflict situations and confusion as an effective method to induce hypnosis could be alternative to the eye fixation method. Confusion would induce distress inducing a contact with some magnetic body possibly providing help. This could be a basic mechanism in bicameral and schizophrenic consciousness in which “God’s voice” provides commands and advices. In the case of hypnotic induction the magnetic body of hypnotist would come in rescue. The activity of ACC would be a signature of conflict situation and could help in generating the connection.
4. The formation of flux tube connections could make the pendulum effectively a part of the biological body of the subject. This is nothing new: almost anyone knows that we feel bicycle or car effectively as our body part. Also illusions in which subject person identifies an external object as part of the biological body are created routinely. The command “Don’t move the pendulum” would be realized as a *motor command* “Move the pendulum” which would be usually halted but hypnotic induction would prevent this.

Some remarks about the relation to more general TGD based ideas about quantum biology and consciousness are in order.

1. The basic distinction between hijacking model and more standard models is that hypnosis is not single-brain phenomenon anymore. It would be interesting to see whether there is synchrony between the EEGs of hypnotists and subject in PFC and ACC and whether the synchronies between various brain regions could correlate with the nature of suggestions.
2. In this framework self-hypnosis would represent a situation in which some external magnetic body hijacks the brain of the person. This magnetic body could correspond to a layer of personal magnetic body or perhaps a magnetic body assignable to some collective level of consciousness as the model of bicameral and schizophrenic consciousness suggest.
3. Hypnosis can induce regression to childhood and is claimed to induce even memories about earlier lives. For instance, subjects manner to speak becomes childlike in this kind of state. Standard neuroscience does not allow beyond life memories but in TGD framework the situation remains open (for “Akashic records” view about memories see [K24] ). One can argue that a strong concentration to the suggestion might allow to become conscious about memories of childhood and even of previous lives.
4. Reconnection of flux tubes and phase transitions changing the effective value of Planck constant and therefore the length of flux tubes are basic mechanisms of TGD inspired quantum biology. Catching the attention of ACC would be as a mechanism very similar to its molecular counterpart in the TGD inspired model of homeopathic healing [K48]. In the latter case the attention of receptors at cell membrane is caught by an entity mimicking the invader molecule binding otherwise to the receptor. Hence most receptors bind to entities which do not cause the damaging effects produced by the invader molecules. Mimicry would be mimicry of cyclotron frequencies achieved by tuning the magnetic field strengths associated with the mimicking entity and at the same time making possible reconnection inducing flux tube connections and conscious attention at molecular level.

### 16.3.2 Hypnosis As Hijacking Of Foreign Biological Body

In the following I use hijacking as a metaphor for what could happen in hypnotic induction. A more positive manner to see the process would be as a voluntary sharing of brain with hypnotist's magnetic body. If one accepts TGD based view about remote mental interactions implying that personal magnetic body controls biological body by remote mental interactions, hypnosis represents a genuine example of remote mental interaction.

The model to be discussed assumes that hypnotist's magnetic body hijacks some parts of the subject's brain. The mind-dissociation model encourages to think that almost any brain region/function can be hijacked. One can however expect that there are some preferred brain regions: kind of central stations especially favorable and sensitive targets for high-jacking. In this respect important hints come from what are believed to be basic facts about functions of prefrontal cortex (see <http://tinyurl.com/642r4t>) (PFC) [J16] and anterior cingulate cortex (see <http://tinyurl.com/2yykqh>) (ACC) [J4], and from the observation that for highly susceptible subjects these regions demonstrate heightened activity during hypnosis during the performance of so called Stroop test.

#### Prefrontal cortex as target of hijacking

The general ideas of the hijacking model were already described. The following provides a more detailed discussion of the model (anyone with better background in neuroscience could probably add interesting details). The best strategy is to hijack the highest brain regions responsible for volition and control of motor and sensory imagination. Prefrontal cortex (PFC) is certainly an excellent candidate in this respect but it is not of course clear whether the direct hijacking of PFC is easy.

Prefrontal cortex (see <http://tinyurl.com/642r4t>) is the anterior part of frontal lobes lying in front of the motor and premotor areas. This brain region has been implicated in the planning complex cognitive behavior, personality expression, decision making, and moderating social behavior. One can also say that PFC carries executive function. This means cognition relating to control of cognition meaning thoughts/decisions about thoughts - imagination. Executive function relates to abilities to differentiate among conflicting thoughts, determine good and bad, better and best, same and different, future consequences of current activities, working toward a defined goal, prediction of outcomes, expectation based on actions, and social "control" (the ability to suppress urges that, if not suppressed, could lead to socially unacceptable outcomes). Clearly, PFC, the size of which also distinguishes between us and other primates, represents a very high if not the highest level of cognitive hierarchy unless one includes also the hierarchy of layers of the magnetic body.

A damage to frontal lobes can lead to loss of some of the listed functions, in particular to inability to make decisions so that also the patient has not lost his intellectual abilities and skills, he cannot do anything spontaneously but outsider must make the initiatives: this state brings in mind hypnotic state.

#### Anterior cingulate cortex as second target of hijacking

ACC (see <http://tinyurl.com/2yykqh>) is second brain area of primary interest. According to Wikipedia:



*ACC is the frontal part of the cingulate cortex, which resembles a “collar” surrounding the frontal part of the corpus callosum. It consists of Brodmann areas 24, 32, and 33. It appears to play a role in a wide variety of autonomic functions, such as regulating blood pressure and heart rate, as well as rational cognitive functions, such as reward anticipation, decision-making, empathy, impulse control, and emotion.*

*The anterior cingulate cortex can be divided anatomically based on cognitive (dorsal), and emotional (ventral) components. The dorsal part of the ACC is connected with the prefrontal cortex and parietal cortex as well as the motor system and the frontal eye fields making it a central station for processing top-down and bottom-up stimuli and assigning appropriate control to other areas in the brain. By contrast, the ventral part of the ACC is connected with amygdala, nucleus accumbens, hypothalamus, and anterior insula, and is involved in assessing the salience of emotion and motivational information. The ACC seems to be especially involved when effort is needed to carry out a task such as in early learning and problem-solving.*

*On a cellular level, the ACC is unique in its abundance of specialized neurons called spindle cells (see <http://tinyurl.com/yamxmwej>) [J18]. These cells are a relatively recent occurrence in evolutionary terms (found only in humans and other great apes, cetaceans, and elephants) and contribute to this brain region’s emphasis on addressing difficult problems, as well as the pathologies related to the ACC.*

A typical task that activates the ACC involves induction of some form of conflict within the subject that can potentially result in an error. Stroop task represents one such task and activates the ACC of highly susceptible subjects more strongly during hypnosis. In Stroop task the person must name the color of the ink of words that are either congruent or in-congruent (the color of the word RED is red or blue). The conflict occurs since the color or the written word is in conflict with the meaning of the word. Erickson’s methods use confusion as a means of inducing hypnosis. This suggests that the activation of ACC by confusion is essential for hypnotic induction.

Error detection, anticipation of tasks, attention, motivation, and modulation of emotional responses are functions assigned with the ACC. Deep focusing of attention is indeed essential for hypnosis. The fact that frontal eye fields representing unconscious-to-us fast visual pathway initiating of eye movements such as voluntary saccades, pursuit eye movements and its connection to ACC suggests that the pendulum catches the attention of ACC in the Chevreul test. The fact that prefrontal lobes are connected to ACC suggests that hijacking of PFC could take place via ACC.

Francis Crick identifies ACC as a possible locus free will. In TGD framework this kind of identification is too strong. One might however consider the possibility that ACC is the part of brain halting the motor imagination proceeding as cortical activity downwards and prevents it from transforming to a genuine motor action. Volition might be quite generally halting or non-halting of imagined motor action. By the time reversal symmetry relating motor action and sensory perception in TGD framework, ACC would play similar role for sensory perception. Note that the selection between sensory percepts associated with bin-ocular rivalry could be understood in terms of time reversed volition. The role of ACC as central station for bottom-up and top-down stimuli would conform with this view.

*Remarks:*

1. One can imagine two kinds of stimuli: the motor stimuli initiated at frontal lobes originally as imagination and possibly halted by ACC and simple motor stimuli initiated by ACC respectively proceeding directly to motor organs via premotor cortex. In the similar manner one can image sensory stimuli received by ACC and not proceeding to upper levels and those proceeding to higher levels and sensory stimuli proceeding up to PFC.
2. This division could roughly correspond to “slow” and “fast” (unconscious-to-us) sensory and motor pathways. Freud’s super-ego-ego-Id hierarchy might in turn relate to magnetic body-PFC-ACC division. The interpretation of ACC as a primitive analog of PFC would also conform with the role of ACC in early learning. Hijacking of ACC first by redirecting its attention - to say pendulum - so that it cannot take care of some of its basic functions, could be part of hypnotic induction.

Why the activation of ACC should promote the hypnotic induction? The activation could be a neural correlate for confusion, which puts the person to the same position in which bicameral according to Jaynes was and schizophrenic is often. In this kind of situation some higher layer of the personal magnetic body could come in rescue. The generation of reconnections requires that ACC performs “magnetic motor activity” modulating the thickness of the flux tubes of its magnetic body (tuning the value of magnetic field to be the same as that of the hoped for helper) and perhaps also moving the flux tubes to achieve the desired reconnection. In the case of hypnosis the reconnection of between the magnetic bodies of ACC and hypnotist would take place. If ACC is responsible for “Don’t” function then catching the ACC’s attention by hypnotic induction or confusing it would allow the imagined motor actions and sensory perceptions to become real and hypnotic suggestions could be realized.

### 16.3.3 Preconscious Mechanism Of Hypnotically Altered Colors

I learned recently about very interesting work on hypnosis by finnish researchers Mika Koivisto, Svetlana Kirjanen, Antti Revonsuo and Sakari Kallio. The article “A Preconscious Neural Mechanism of Hypnotically Altered Colors: A Double Case Study” is published in journal Plos ONE [J101] and is available at <http://tinyurl.com/ydzbc43q>.

Here is the abstract of the article:

*Hypnotic suggestions may change the perceived color of objects. Given that chromatic stimulus information is processed rapidly and automatically by the visual system, how can hypnotic suggestions affect perceived colors in a seemingly immediate fashion? We studied the mechanisms of such color alterations by measuring electroencephalography in two highly suggestible participants as they perceived briefly presented visual shapes under posthypnotic color alternation suggestions such as “all the squares are blue”. One participant consistently reported seeing the suggested colors. Her reports correlated with enhanced evoked upper beta-band activity (22 Hz) 70–120 ms after stimulus in response to the shapes mentioned in the suggestion. This effect was not observed in a control condition where the participants merely tried to simulate the effects of the suggestion on behavior. The second participant neither reported color alterations nor showed the evoked beta activity, although her subjective experience and event-related potentials were changed by the suggestions. The results indicate a preconscious mechanism that first compares early visual input with a memory representation of the suggestion and consequently triggers the color alteration process in response to the objects specified by the suggestion. Conscious color experience is not purely the result of bottom-up processing but it can be modulated, at least in some individuals, by top-down factors such as hypnotic suggestions.*

According to the announcement of finnish academy, the results challenge the existing theories of hypnosis. This work represents a model of hypnosis as one particular instance of remote mental interactions on basis of TGD inspired quantum theory of consciousness. Quantum entanglement between parts of separate brains, the notion of magnetic body, and TGD based view about sensory organs play key roles in the model. In TGD framework the primary qualia are at the level of sensory organs and sensory representations involve a feedback from magnetic body via brain to sensory organs in terms of dark photons so that the sensory percepts consist of standardized mental images - being more like an artworks emphasizing important features rather than a faithful representation of reality.

The findings of about hypnosis can be used also to test the proposed view about hypnosis. As the abstract concludes, color experience is not purely the result of bottom-up processing but can be modulated by top-down factors. In TGD framework this reflects the basic difference between standard neuroscience and TGD deriving from two assumptions.

- Sensory organs are carriers of primary qualia - the phenomenal experience.
- Brain is manufacturer of sensory and memory representations decomposing perceptive field to standardized mental images representing objects and naming them. Virtual sensory input is used to achieve this.

In the experiments the form-color correlation created by hypnotic suggestion could be in conflict with the real visual input. The other subject person sensitive to hypnosis managed to transform the real color percept to a percept consistent with the suggestion. The other subject person also sensitive to hypnotic suggestions reported that his/her eyes and brain “saw” different colors.

In TGD Universe the interpretation would be that magnetic body and brain below it in the self hierarchy imagined the correlation consistent with the suggested one in both case. The imagined color was produced by a virtual sensory input realized as dark photons propagating down from magnetic body to cortex and to the lower levels of brain. This applies to imagination in general. For the sensory imagination the propagation halts before reaching sensory organ - now retina. For hallucinations this halting does not happen. Hypnotic suggestion can prevent this halting so that imagined color transforms to a hallucinated color. This happened for the first subject in the experiments. The second subject experienced both the real color and possibly conflicting imagined color associated with the virtual sensory input halting to some higher level in brain between visual cortex and retina. Note that this serves as evidence for the notion of self hierarchy, which is a basic prediction of TGD inspired theory of consciousness.

Also a comment about time scales involved is in order. The peak in the EEG of the person, who experienced the suggested color-shape correlation appeared after an average time of  $T = .1$  seconds from the visual input.  $T$  corresponds to 10 Hz fundamental bio-rhythm and the chronon of sensory experience. In TGD framework  $T$  characterizes the scale of causal diamond (CD) defining the spotlight of consciousness assignable also to sensory percepts. That  $T$  is also the secondary p-adic length scale assigned with electron in TGD conforms with the proposal that electron Cooper pairs play a central role in sensory perception. Primary and secondary p-adic length and time scales (the latter are macroscopic) characterizing elementary particles represents new physics predicted by TGD.  $R = .05$  seconds corresponds to distance  $R = cT = 15$  Mm, which is more than twice the radius of Earth equal to 6.4 Mm. Hence a signal propagating with velocity of light could travel to a layer of magnetic body with this size and back during time .1 seconds.

After having received the announcement of Finnish academy and before seeing the abstract of the article, my own guess was that the high-frequency EEG refers to 40 Hz thalamo-cortical resonance studied by Antti Revonsuo - one of the authors of the recent work. I was wrong. What Revonsuo found was that 40 Hz resonance does *not* serve as a correlate of mental image as conjectured by Crick and Koch but for the emergence of a new mental image. What was studied was a situation in which the subject person experienced the emergence of 3-D geometric pattern from a chaotic set of dots and lines. 40 Hz activity accompanied only the eureka period: a possible TGD inspired interpretation is that the direct eureka experience was transformed to a memory, which did not generate 40 Hz activity. The 20 Hz activity involved with the change of the perceived color to the suggested color would also correspond to similar re-organization of the perceptive field induced by virtual sensory input masking the real one. What is interesting is that 10, 20, 40, 80 Hz frequencies appear as resonances in EEG (see <http://tinyurl.com/yaa5xyo5>) and that they are octaves of 10 Hz. TGD indeed strongly suggests that preferred CD scales come as octaves. Primary p-adic length scales in turn would come as half octaves.

#### 16.3.4 Chi Energy - master gets animals to sleep

In Facebook I encountered an interesting video with the title “Chi Energy - master gets animals to sleep” (see <http://tinyurl.com/hvfk4nv>). The video was very impressive and I recommend seeing it. Below I propose an explanation for the feats of the master.

I have constructed a theory of remote mental interactions but always said that I do not believe in them - I just take their possibility very seriously. To be honest, the only reason for this attitude is that they emerge naturally from TGD inspired theory of consciousness. This video made me a believer. I know that skeptic “knows” that the video is hoax and demands 10 sigma statistical proof that every chi master in every corner of the Universe can put animals to sleep under controlled laboratory conditions by weaving his hands. It does not matter: we can laugh together to my gullibility if this helps skeptic to avoid despair in his intellectual isolation.

We had a long discussion about the video and Ulla noticed the similarity with hypnosis: even the word “hypnosis” originally means some kind of sleep like state. In TGD framework hypnosis could be seen as a particular example of remote mental interactions. Simplifying: hypnotizer would

in some sense hijack some part of brain of the subject by quantum entangling with it so that it becomes part of hypnotizer and obeys his commands. Note that the social explanation of hypnosis as the desire of subject to please the hypnotiser does not explain what happens to the animals.

In the discussion consciousness was of course mentioned and consciousness was compared to field. As a philosophically oriented physicist I get worried when one says "consciousness is a field" or something like that. I would prefer to speak about field patterns as correlates for contents of consciousness. To me consciousness itself is an independent form of existence not reducing to a property of physical system as materialist believes. This looks like pedantry but becomes absolutely crucial if one really wants to understand consciousness. Real progress in science is mostly getting rid of sloppy language implying sloppy thinking.

I have explained so many times the basic ideas of TGD inspired theory of consciousness (call it TTC for short) and I am afraid that most readers have not got the message. I think that independently rediscovering TTC is the only manner to realize what I am trying to say. Therefore only few paragraphs.

One needs a new ontology - a vision about what exists. This ontology is neither materialistic nor dualistic and in which consciousness is not a property of physical state as "-ness" would suggest but resides in the nowhere-nowhen-land between two quantum states replaced with analogs of quantum evolutions of Schrödinger equation. I call the new ontology Zero Energy Ontology (ZEO) and it leads to a new view about quantum measurement theory and state function reduction giving theory of consciousness as by-product by transforming observer from an outsider to the Universe a part of quantum physics. Conscious entity is the outcome of Zeno effect - a sequence of state function reductions which would not change the state in standard ontology at all but gives rise to the experienced flow of time in ZEO.

A lot of unexpected predictions follow. Mention only the possibility of exotic unexpected phenomena such as time reversed consciousness, the re-incarnation of conscious entity in different time after biological death, and the predicted hierarchy of conscious entities with mental images identifiable as sub-selves - conscious entities. Also a detailed view about quantum biology and about remote mental interactions emerges.

Quantum biology involves a generalization of both classical physics and quantum physics.

1. Classical physics is generalized by replacing space-time with space-time surfaces bringing in notions like many-sheeted space-time, magnetic flux quanta/tubes, field body and topological light rays essential for understanding living matter. Magnetic body (MB) becomes what might be called intentional agent. Our MB is the "real us" using our biological body (BB) as a motor instrument and sensory receptor. EEG and its scaled variants mediate sensory information from neuronal/cell membranes to parts of magnetic body having onion-like structure and control commands from MB to genome initiating gene expressions and possible other hitherto unknown genome related functions such as topological quantum computation and communications with dark photons which then decay to bio-photons.

Magnetic flux tubes accompany and are space-time correlates of entanglement: note that also superstringers have ended up with this idea but talk about wormholes instead of flux tubes.

Concerning remote mental interactions, the crucial difference from Maxwell's linear and relatively simple theory is that flux tubes make possible precisely targeted communications such that the signal does not weaken with distance. This is like replacing radio station with something sending laser signals along cable: replacing mass communication like radio broadcast with email. The signals - I call them topological light rays - are analogous to laser light beams travelling along flux tubes: also their existence distinguishes TGD from Maxwell's theory where light signals travel in all directions and weaken like  $1/r^2$ .

2. The generalization of quantum physics involves the hierarchy of Planck constants coming as multiples of ordinary Planck constants and identified in terms of dark matter which becomes a key player in living systems. Scaling of Planck constant scales up quantum lengths and gives rise to macroscopic quantum coherence, which is the key property of living matter. p-Adic physics and fusion of real physics (correlates of sensory experience) and various p-adic physics (correlates of cognition and imagination) is an essential element of the theory too.

Consider now what remote mental interactions might be.

1. Attention is obviously an essential element. This master intensively attends. Magnetic flux tubes are correlates for attention. When I attend something the flux tubes connecting some part of me to this something are formed. This something could be mental image perhaps localizable to my brain or an object of external world - say my cat. Or the animals in the amazing video, which motivated the writing of this posting. Magnetic flux tubes are like tentacles studying the environment and when they find tentacle of another BB, reconnection to a bridge connecting the biological bodies can happen if the magnetic field strengths are nearly the same. This implies that cyclotron frequencies are same so that the reconnection involves resonance.

This is a good reason to identify the prerequisites/correlates for remote mental interactions as magnetic flux tubes, which are TGD counterparts of Maxwellian magnetic fields but differ from them since they are topologically quantized.

2. Remote mental interactions are not anything exotic in this world view: the communications from BB and control of my BB by my MB rely on remote mental interactions. What we are used to call remote mental interactions is the same phenomenon except that the target is not my BB but something else: say patient in remote healing or computer in experiments testing whether intention can affect random number generator.

What might happen in the video?

1. What could happen as the master in the video weaves his hands? Same as in hypnosis, which is also a remote mental interactions. The magnetic flux tubes for a part of hypnotizer's MB reconnect with those for a part of subject's MB fusing two conscious entities single one with chi master serving as boss for the unit formed in this manner. Both supra currents and analogs of laser light signals can proceed along these bridges thus formed. This is the same effect as the fusion of mental images - subselves - producing stereo vision. Fusion can occur also for mental images in different brains: our consciousness is not so private as we think - be cautious with your thoughts;-). Your brain children are not always only your brain children!
2. What makes a fellow who just weaves his hands "superhuman" - as the video says? How the movement of his hands can have so magic effect? It cannot. MB acting as an intentional agent is needed. The skills of the master in using his MB give him his magic looking powers - he is a master in magnetic gymnastics;-). Yoga trains your BB, meditation trains your MB. Using the tentacles emanating from his hands the master can get a contact even to the MBs of members of different species and make them part of this own MB and give commands to them. As the master weaves his hands he helps the flux tubes to form reconnections with the MBs of the subject animals. I wonder whether the master can "see" the flux tubes of foreign magnetic bodies (not necessarily consciously at his level of self hierarchy). This would make his task much easier.

## Chapter 17

# Meditation, Mind-Body Medicine and Placebo: TGD point of view

### 17.1 Introduction

The chapter represents TGD inspired answers to Lian Sidorov's questions concerning meditation, mind-body medicine and placebo in quantum biology framework. To help the reader, some aspects of TGD inspired theory of consciousness and quantum biology are summarized since several new insights inspired by the notions of magnetic body and dark matter have emerged lately. This includes improved views about quantum metabolism and prebiotic life: the basic input comes from the claimed free energy phenomena interpreted in TGD framework. Water structures representing simplified analogs of basic biomolecules suggested by water splitting producing so called Brown's gas might be highly relevant also for the ordinary metabolism. The main new input concerning remote mental interactions comes from a possible answer to the question whether TGD based ontology of physics could allow the "shamanistic" view that the experiences (say encounters with strange life forms assigned with distant civilizations) induced by various psychedelics used in the spiritual practices of indigenous people could be genuine remote sensory perceptions rather than hallucinations. Affirmative answer would mean a direct and testable connection between neuropharmacology and remote sensory perception with serotonin defining the crucial neurotransmitter and pineal gland ("third eye") serving as a candidate for the brain area of special importance in this respect.

Concerning the questions about meditation, mind-body medicine and placebo, the key concept is that of magnetic body. Usually organism and environment are seen as members of an interacting pair: organism receives sensory data from environment and controls it. Now magnetic body appears as a third party, "intentional agent" using biological body as a kind of interface between magnetic body and environment. Various "motor actions" of the magnetic body are highly relevant for both consciousness and biochemistry. The pairs formed by various information molecules and corresponding receptors could define plug-ins to the Indra's net (or Internet) defined by the magnetic bodies and Josephson radiation emitted by Josephson currents assignable to receptors would propagate along flux tubes. Meditation can be seen as "bodily exercise" of the magnetic body and a method to improve the communications between magnetic body and biological body. In healing magnetic body would be the active participant and healing would be also the healing of magnetic body. The placebo effect could be seen as an outcome of intentions of magnetic body affecting biological body.

The change of gene expression in meditation could be understood in terms of magnetic body. Genetic expression would be naturally determined by the permanent flux tube connections from the magnetic body to the promoter portions of DNA. Differentiation would select the promoters to which the magnetic body has permanent connections. The change of gene expression could be due to a change of these connections. Both meditation, placebo effect, and healing could induce changes in gene expression in this way.

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 [L30].

## 17.2 Brief Summary About TGD Based Vision About Life And Consciousness

### 17.2.1 Magnetic And Electric Bodies

The notion of “magnetic body” has become more and more central concept in TGD inspired theory of quantum biology. Also electric fields are fundamental in living matter consisting of electrets and one could speak about electric bodies too. The notion of field body is possible only in TGD framework where space-times are 4-surfaces of 8-dimensional space  $M^4 \times CP_2$  and various classical fields are geometrized in terms of geometry and spinor structure induced from those of embedding space.

One can assign to any physical system magnetic body (or more generally field body), which consists of space-time sheets representing field quanta of magnetic and electric fields geometrically: typically they have the shape of flux tube or flux sheets. Of special importance are flux tubes carrying monopole Kähler magnetic flux - as if there would be magnetic monopole serving as the source of the magnetic field. There are however known magnetic monopoles in TGD Universe. These flux tubes are in fundamental role in the description of elementary particles and very probably also the magnetic flux tubes relevant for living matter carry monopole fluxes: even magnetic field associated with permanent magnets could involve monopole flux tubes, whose characteristic property is that there is no current creating the field. In cosmology this kind of fields are present in all scales and the mystery in the standard physics framework is caused by the fact that permanent currents in this scales are not possible.

The topological dynamics of magnetic flux tubes is based on reconnection process creating and modifying the topology of the web of magnetic flux tubes. In living matter this web is assumed to be responsible for the coherent behavior of living organisms. The reconnection building a double flux tube bridge between two systems is assumed to define the space-time correlate for the generation of directed attention. Second important piece of dynamics is the change of the length of the magnetic flux tube induced by the change of  $h_{eff}/h$ . The shortening of flux tubes connecting distant biomolecules would force them near each other and make possible selective bio-catalysis. This mechanism should be crucial for DNA replication and transcription, and mRNA translation.

Also the dark matter at magnetic flux tubes is assumed to be essential element of what it is to be living. Dark matter hierarchy corresponds to a hierarchy of effective values of Planck constant given by  $h_{eff}/h = n$ . Cyclotron frequencies for charged bosons and Cooper pairs of charged fermions could be carriers of metabolic energy realized as cyclotron energy which is large for large values of  $n$ .

One can of course also speak about electric bodies - living matter is full of electrets and already Fröhlich realized the importance of electric fields - and cell membrane would define a fundamental system of this kind. The flux tubes connecting the interior and exterior of membrane would carry electric voltage in the stationary case and in super-conducting situation oscillating Josephson currents generating dark Josephson radiation at frequency  $f_J = ZeV/h_{eff}$  are present. EEG - or rather hierarchy of dark EEGs at various frequency scales but with same energies actually assignable to bio-photons - could correspond to this radiation and dark cyclotron radiation. They would mediate communication of sensory data to the magnetic body and control commands from the magnetic body.

### 17.2.2 Frequency Coding And Targeted Attention

Dark photons are also an important piece of the bio-puzzle. Microscopically they correspond worm-hole contact pairs connecting to “massless extremals” (MEs) (as a matter of fact, all elementary particle have this kind of identification). Dark photons would be generated as Josephson photons and cyclotron photons. The simplest assumption is that standard mechanisms of biochemistry generate only ordinary photons. The basic property of dark photons is that the energy for a given frequency is scaled up by factor  $h_{eff}/h$  so that ELF radiation can correspond to energies of even

visible photons as would indeed do if EEG corresponds to dark photons having energies if visible and perhaps even UV photons.

1. If the photons are absorbed resonantly, photons frequencies serve as analogs of passwords so that living matter would apply the analog of radio communications for dark photons. Given part of living system in given scale would be characterized by photon frequency which by p-adic length scale hypothesis would correspond to a power of two. A collection of these frequencies coming as powers of two would effectively define a sequence of binary digits specifying the p-adic space-time sheet of the receiver. This coding mechanism could be at work not only inside organism but also between different organisms. The magnetic bodies have astrophysical dimensions and in principle there is no limit for the scales involved. Directed attention would correspond to reconnection of magnetic flux tubes implying common cyclotron frequency spectrum plus cyclotron transitions induced by the radiation transferred between the participants.

Frequencies serving as passwords would make possible precisely targeted communications if receiver frequencies vary as a function of position. Cyclotron radiation along massless extremals parallel to magnetic flux tubes serving as kind of waveguides achieves the same. These two mechanisms could be actually one and same.

2. Zero energy ontology in turn strongly suggests communications based on reflections in time direction at the opposite boundaries of causal diamonds (CDs) having interpretation in terms of state function reductions. This allows to speculate about communications in cosmic scales taking place instantaneously with respect to subjective time. It is not clear whether the standard view about causality based on unique direction of geometric time denies this possibility.
3. Very probably frequency alone is not all that is involved. Just as in the ordinary radio communications, the signal itself could be coded by amplitude or frequency modulation of the carrier frequency. One of the possible mechanisms generating dark photons would be amplitude modulation. Frequency modulation could be realized as variation of Josephson frequency induced by that of membrane potential and cell membranes indeed carry membrane potential waves besides nerve pulses. Cyclotron frequency could be modulated by oscillations of the flux tube thickness induced the variation of magnetic field strength forced by the flux conservation.

There is evidence that a process interpreted as a propagation of bio-photons along neural fibers takes place. In TGD framework this would correspond to the propagation of dark photons along magnetic flux tubes parallel to the fibers. I have proposed that magnetic flux tubes assignable to neural pathways (and also meridians of acupuncture system) serve as analogs wave guides for dark photons. If sensory organs are really the seats of the fundamental sensory experiences and brain builds cognitive representations by analyzing the sensory input and decomposing it to objects with names as TGD suggests [K44], then the feedback from brain and even magnetic body is needed in order to build the sensory representations as kind of art works. This would explain dreams (REM) and hallucinations as being caused by virtual sensory input from the magnetic body (maybe induced by sensory input to magnetic body even from some other magnetic body as in case of remote mental interactions).

### 17.2.3 Meditation And Magnetic Body

One manner to see meditation is as a method to develop ability to precisely targeted attention by getting rid of all perturbing mental images. If one accepts that reconnections for the flux tubes of the magnetic body are crucial for the targeted attention and that the  $h_{eff}$  serves as a kind of universal quotient of spiritual intelligence, the conclusion would be that meditation means practices for developing maximally flexible magnetic body able to build rapidly contacts with higher levels of the personal magnetic body and also with other magnetic bodies. Meditator would be a master of magnetic motor actions whereas yogi would be a master of motor actions of biological body. If healing involves connection between magnetic bodies or magnetic body and biological body of healee, meditation should help also to achieve healing abilities.



In biology everything seems to obey engineering standards and the build-up of connections to other magnetic bodies need not be an exception to the rule. Various information molecules and corresponding receptors would indeed define natural candidates for the plugs connecting brain and body to the magnetic Indra's net. Therefore meditative practices should develop the ability to control the levels of various information molecules and receptors in body.

## 17.3 NMP, Hierarchy Of Planck Constants, P-Adic Length Scale Hypothesis And Negentropic Entanglement

Around the year 2003 a number of new ideas emerged simultaneously. Learning about hyperfinite factors of type  $II_1$  and their inclusions [K124] lead to a proposal for the mathematical description of finite measurement resolution and cognitive resolution. Also the idea about hierarchy of Planck constants allowing to identify dark matter as phases of ordinary matter, and the notion of negentropic entanglement emerged and led to a lot of speculation. Over the years connections between these notions and vision about their more detailed realization have emerged. One can say that NMP, hierarchy of Planck constants, p-adic length scale hypothesis, negentropic entanglement, and even inclusions of hyperfinite factors are very intimately related. Of course, all of this is just a highly entertaining intellectual game - very much like solving a crossword puzzle - and only time and experiment will show whether it has anything to with reality.

### 17.3.1 Negentropic Entanglement And Hierarchy Of Planck Constants

The hierarchy of Planck constants makes possible negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) and genuine information represented as negentropic entanglement in which superposed state pairs have interpretation as incidences  $a_i \leftrightarrow b_i$  of a rule  $A \leftrightarrow B$ : apart from possible phase the entanglement coefficients have same value  $1/\sqrt{n}$ , where  $n = h_{eff}/h$  define the value of effective Planck constant and dimension for the effective covering of embedding space. This picture generalizes also to the case of multipartite entanglement but predicts similar maximal entanglement for all divisions of the system to two parts. There are however still some questions which are not completely settled and leave some room for imagination.

1. Negentropic entanglement is possible in the discrete degrees of freedom assignable to the  $n$ -fold covering of embedding space allowing to describe situation formally. For  $h_{eff}/h = n$  one can introduce  $SU(n)$  as dynamical symmetry group and require that  $n$ -particle states are singlets under  $SU(n)$ .  $SU(n)$  brings in mind the dynamical gauge symmetry group introduced earlier for inclusions of hyper-finite factors of type  $II_1$  [K124] to which one can assign simply laced Lie groups such as  $SU(n)$  by Mac Kay correspondence [A9]. I proposed these groups as effective gauge group making possible emulation of all possible gauge group dynamics so that TGD Universe would be like Turing machine able to mimic any mathematically consistent dynamics. The inclusions would also characterize the finite measurement resolution: the states created by the included algebra would create states not distinguishable from each other in the resolution used.

This gives rise to  $n$ -particle states constructed by contracting product of some number  $k$  of  $n$ -dimensional permutation symbols contracted with many particle states assignable to  $m$  factors. These states would generalize  $k$ -particle states. For  $k = 1$  and  $m > 1$  one would have single particle state in "schizophrenic state" consisting of  $m$  particles with fractional quantum numbers  $n_i/n$  times the usual quantum numbers. Spin-statistics connection might produce problems - at least it is non-trivial - since one possible interpretation is that the states carry fractional quantum numbers - in particular fractional fermion number and charges.

These strange states with completely unique form would generalize the notion of N-atom proposed for decade ago as giving emergence of symbols and "sex" at molecular level [K32]. The status of this idea has remained very uncertain but I have not been able to throw it to paper basked. The second quantization associated with the finite coverings of embedding space would give rise to the negentropic entanglement, symbolic dynamics, and also to "Akashic

records” as almost invariants of the quantum jump sequence (thanks to their negentropic resources respected by NMP). “Molecular sex” means that all states can be seen as composites of two states with opposite fractional  $SU(n)$  quantum numbers (this decomposition need not be unique!). This brings in mind the monogamy theorem for ordinary entanglement stating that maximal entanglement means this kind of decomposition to two parts.

2. While writing this I realized that the question whether negentropic entanglement is possible only in the new covering degrees of freedom or also in more familiar angular momentum, electroweak, and color degrees of freedom, remains open [K61]. The latter states are especially interesting biologically and from the point of view of photosynthesis and navigation of birds if one believes on the proposed explanations: long-lived negentropically entangled spin singlet electron-hole pairs and electron pairs are proposed as explanation of the experimental findings. If only the covering degrees of freedom are involved the entanglement stable against thermal perturbations is in these degrees of freedom.

### 17.3.2 NMP And Evolution Of Intelligence

Alexander Wissner-Gross, a physicist at Harvard University and the Massachusetts Institute of Technology, and Cameron Freer, a mathematician at the University of Hawaii at Manoa, have developed a theory that they say describes many intelligent or cognitive behaviors, such as upright walking and tool use [J42, J181]. The basic idea of the theory is that intelligent system collects information about large number of histories and preserves it. Thermodynamically this means large entropy so that the evolution of intelligence would be rather paradoxically evolution of highly entropic systems. According to standard view about Shannon entropy transformation of entropy to information (or the reduction of entropy to zero) requires a process selecting one of instances of thermal ensemble with a large number of degenerate states and one can wonder what is this selection process. This sounds almost like a paradox unless one accepts the existence of this process. I have considered the core of this almost paradox in TGD framework already earlier.

According to the popular article (<http://tinyurl.com/cb9p8we>) the model does not require explicit specification of intelligent behavior and the intelligent behavior relies on “causal entropic forces” (here one can counter argue that the selection process is necessary if one wants information gain). The theory requires that the system is able to collect information and predict future histories very quickly.

The prediction of future histories is one of the basic characters of life in TGD Universe made possible by zero energy ontology (ZEO) predicting that the thermodynamical arrow of geometric time is opposite for the quantum jumps reducing the zero energy state at upper and lower boundaries of causal diamond (CD) respectively. This prediction means quite a dramatic deviation from standard thermodynamics but is consistent with the notion of syntropy introduced by Italian theoretical physicist Fantappie already for more than half a century ago as well as with the reversed time arrow of dissipation appearing often in living matter.

Negentropy Maximization Principle (NMP) resolves also the above mentioned almost paradox (at least). I have proposed analogous principle but relying on generation of negentropic entanglement and replacing entropy with number theoretic negentropy obeying modification of Shannon formula involving p-adic norm in the logarithm  $\log(p)$  of probability. The formula makes sense for probabilities, which are rational or in algebraic extension of rational numbers and requires that the system is in the intersection of real and p-adic worlds. The dark matter matter with integer value of Planck constant and  $h_{eff} = nh$  predicts rational entanglement probabilities: their values are simply  $p_i = 1/n$  since the entanglement coefficients define a diagonal matrix proportional to unit matrix. Negentropic entanglement makes sense also for n-particle systems as found and the form of the states is essentially unique.

Negentropic entanglement corresponds therefore always to  $n \times n$  density matrix proportional to unit matrix: this means maximal entanglement and maximal number theoretic entanglement negentropy for two entangled systems with number  $n$  of entangled states.  $n$  corresponds to Planck constant  $h_{eff} = n \times h$  so that a connection with hierarchy of Planck constants is also obtained. Power of the p-adic prime by definition defines largest prime power divisor of  $n$ . Individually negentropically entangled systems would be very entropic since there would be  $n$  energy degenerate states with same Boltzmann weight. Negentropic entanglement changes the situation: thermodynamics

of course does not apply anymore. Hence TGD produces same prediction as thermodynamical model but avoids paradox.

### 17.3.3 How To Produce Dark Matter

If one wants to test the vision about dark matter, one must be able to manipulate and even produce it. I have considered several mechanisms for producing dark matter. It must be emphasized that the ideas are yet at rather heuristic level.

1. Modulation of high frequency radiation by low frequency radiation such that the ratio of the frequencies is integer, call it  $n$ , characterizing the effective Planck constant  $h_{eff}/h = n$  is one proposal inspired by experimental findings of Cyril Smith related to water memory [J43]. Smith suggests that one particular ratio  $n \simeq 2 \times 10^{11}$  is of special importance. Number theoretical simplicity and p-adic length scale hypothesis suggest Fermat integers - are products of distinct Fermat primes and powers of two - as good candidates for  $n$ . One could perhaps say that ordinary higher frequency photons is replaced with a bundles of  $n$  fractional photons with energy and frequency divided by  $n$ . At the level of space-time and embedding space geometry this means the emergence of effective  $n$ -fold covering. The extreme non-linearity of Kähler action could give rise to these  $n$ -furcations.
2. The presence of strong electric fields and voltages and plasma phase seem to generate effects having explanation in terms of the hierarchy of Planck constants. In particular, di-electric breakdown seems to be involved. For instance, cell membrane characterized by the presence of extremely strong electric field. Plasmoids as lifeforms would also involve strong electric fields. Also magnetic fields seem to be essential. Splitting of water in electrolysis using strong electric fields ("peaky" electrodes) involves also strong electric fields and generates Brown's gas having anomalous properties. One could argue that the presence of strong electric fields is what leads to the generation of  $n$ -furcations at the level of space-time dynamics.
3. The latest proposal is based on some input from observations related to free energy leading to the observation that the quantum mechanical description of a system to which constant torque is applied leads to mathematical problems in the framework of standard quantum theory solved by introducing  $n$ -fold covering space of circle, hierarchy of Planck constants, and zero energy ontology [K52]. The value of  $n$  is at least the number of turns made by the rotating system during the time the torque is applied. This mechanism would explain why the values of  $n$  are so large. Constant torque represents an example of an open system driven by external generalized forces and living systems are systems of this kind. Formally the system is conservative but the potential function is either many-valued or discontinuous at  $2\pi$  and this forces to introduce the covering space if one wants to describe rotating and accelerating wave packets. Note also that the force can be arbitrarily small so that there is instability against generation of higher values of  $h_{eff}$ . What is of special interest is that ATP synthase (<http://tinyurl.com/y8xu5nto>) involves generator with a rotating shaft (just like an electric power plant) and therefore also a torque to compensate for dissipative losses. Is its purpose to generate large  $h_{eff}$  phase?

Note that cavitation is one manner to generate water splitting and associated charged water clusters and plasmoids: it is typically produced by a rotating shaft. Does this mean that turbulent water could have served as a seat for primordial life forms? Note that in homeopathy mechanical agitation is applied to the diluted sample: the proposed interpretation has been that this drives the replication and evolution of dark life forms defined by dark nucleon sequences [K48].

### 17.3.4 Dark Proton Sequences, Genetic Code, And Primordial Life Forms

The general strategy should be simple. One starts from experimental facts and explains them in terms of TGD allowing free imagination and trying to achieve internal consistency between different ideas [K52].

1. The old result is that I cannot avoid mentioning again and again is that in atto-second scale water obeys stoichiometry  $H_{1.5}O$  as if 1/4: th of hydrogens were dark and thus not visible in electron scattering and neutron diffraction. This fact can be found from Chaplin's homepage (<http://tinyurl.com/ye77f7d>) devoted to water and containing impressive list of anomalies related to the physics of water. This finding was one of the original motivations for introducing hierarchy of Planck constants.

I introduced dark nuclei identified as sequences of dark hydrogens/protons as explanation of the strange stoichiometry and also for the anomalies: there would be two phases (at least, not the  $h_{eff}$  can have several values) present and this makes the behavior of water more complex. Dark nuclei are strings of dark protons connected by color bonds. The size scale of nucleus is scaled up by  $h_{eff}$  and would be about atomic scale: atto-second multiplied by  $c$  gives this scale.

The really big surprise was that the model for dark proton led directly to the realisation of vertebrate genetic code [K65, K48]: the states of dark proton can be naturally arranged to groups corresponding to DNA, RNA, amino acids, and remaining states whose number is smaller than 64 which I tentatively identify in terms of tRNA. Genetic code is obtained if states in different groups are identified by requiring that states corresponding to each other have same total quark spin and same spin assignable with the flux tube (two colour bonds connecting quarks).

In TGD framework this relates also to the understanding of water memory and homeopathy [K48] and to the evolution of immune system as well.

2. The field of free energy (presumably possessing somewhat similar academic status as the research of remote mental interactions) represents second source of experimental input. Quite lately I have been reconsidering what is believed to be known about the splitting of water - for instance using strong electric fields or cavitation. This is a rich store of anomalies. In particular although the splitting of water molecules requires energy, more energy is claimed to emerge from the process in some situations. Also cold fusion is reported to occur in this kind of system and liberates energy as heat. Nuclear transmutations in living matter have been reported much before the cold fusion was claimed for the first time [C1, C3].

Already more than century ago it was reported that the resulting vapor - christened as Brown's gas according to its discoverer - behaved strangely. For instance, its temperature was 130 C but it melted metal as if it had stored a lot of energy which was liberated and was heating the metal about thousand of degrees of Celsius. These results do not of course fit standard physics and have been actively forgotten and denied by the academic environment (for an authoritative skeptic explanation see Wikipedia article <http://tinyurl.com/y7a8swzg>). I know personally some people in the field of free energy and I am not able to see them as "fringe scientists" as opposed to "real scientists". It is a pity that this kind of schizophrenic splitting prevents the study of the free energy claims using the resources provided by the academic environment.

Free energy enthusiasts have been studying this process and a lot is believed to be known about it. According to Moray B. King [H2, H1] Brown's gas can be separated from water vapor and hydrogen and is weightier than air. It is believed that charged plasma clusters resulting in the "electric expansion" of water are involved with electrons and protons separated. Torus shaped plasmoids are introduced also. In TGD framework plasmoids, which involve magnetic body carrying electron Cooper pairs at least, are identified as primordial life forms.

3. The question is how many properties assigned with chemical life are shared by plasmoids. Could linear biomolecules, storage and liberation of metabolic energy, and even genetic code have plasmoidal analogs?
  - (a) Circular sequences of OH: s has been proposed by King [H2] as basic building bricks of plasmoids. To my best understanding this does not fit with the ordinary chemistry (covalent bond between OHs cannot be realized). TGD inspired proposal consistent with King's proposal is that actually  $OHH_{dark}$  sequences are in question.

Covalent bonds are replaced with color bonds between dark nuclei, which are scaled up variants of ordinary nuclear modelled as highly entangled nucleon strings in TGD framework. Already this represents a new view about nuclear physics (it is ironic that string like appear at practically all levels in TGD Universe but that string theorists desperately try to understand physics by putting them to Planck scale).

As a matter fact, learning about the work of Gerald Pollack *et al* [L34] led to a simpler model in which dark proton sequences at magnetic flux tubes replace  $\text{OHH}_{\text{dark}}$  sequences. Predictions are almost the same except for charge separation having neat explanation in the simpler model which is actually the original model for water as partially dark phase of matter.

- (b) Free energy phenomena involve the splitting of water. Water splitting is also the first step in the storage of energy to biomolecules in photosynthesis. Could  $\text{OHH}_{\text{dark}}$  or dark proton sequences define simplified counterparts of basic biomolecules, and could they carry metabolic energy in colour bonds between dark protons replacing “high energy covalent bonds” ?
- (c) This metabolic energy would be liberated as metal melts in the presence of Brown’s gas. This is completely analogous to the splitting of biopolymers in catabolism leading to liberation of metabolic energy. This liberation does not take place in the interaction with living matter: why the conductor property of metals leads to the burning? Why the presence of conduction electrons induced the phase transition reducing  $h_{\text{eff}}$  and scaling up p-adic prime  $p$  correspondingly so that energy is liberated. Do conduction electrons perhaps serve as a seed like in ordinary phase transitions forcing the dark Cooper pairs to decay to ordinary electrons?
- (d) This framework inspires the conjecture that chemical life has preceded by plasmoids consisting of these ultra-simplified versions of basic biomolecules. “Ontogeny recapitulates phylogeny” forces to ask whether this primordial life form could be still in key role living matter meaning that the role of water would be much more than serving as a passive solvent of biomolecules. The phase of water known as ordered water and having ice as the closest analog is believed to be crucial for the stability of DNA against hydrolysis, and one can wonder whether the dark DNA defined by half dark water molecule sequences could be the basic building brick of the ordered water and accompany the ordinary DNA. This would make also highly probable the analogs of transcription and translation between ordinary and dark variants of basic biopolymers. Note that Brown’s gas would be ideal fuel since it would “burn” to water: no  $\text{CO}_2$  would be produced as in case of biofuels. Again the problem is that academic community how refuses to take free energy people seriously enough to try to demonstrate that they are wrong. Free energy enthusiasts in turn seem to concentrate too much to their dream and fail to realize that Brown’s gas could carry the usable energy and the amount of this energy liberated as heat need not measure the actual success of the experiment.

### 17.3.5 Pollack’s Findings About Fourth Phase Of Water

What is described above was the view about Brown’s gas before I received a link to a Youtube lecture by Gerald Pollack about fourth gel like phase of water (see <http://tinyurl.com/oyhstc2>) [L34]. Listening this lecture provided considerable support for this picture and led to a much more detailed and also simplified view.

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. Below I discuss this notion from TGD point of view.

The proposal will be 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  $\text{H}_{1.5}\text{O}$  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 [K48, K65]. 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.

### The findings

One can find a biographical sketch [I9] (<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. I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [L34].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term “exclusion zone”. The layer consists of layers of molecular thickness and in these layers the stoichiometry is  $H_{1.5}O$ . The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown’s gas negatively charged regions are reported to emerge [H2, H1].
2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.
3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by  $H_{1.5}O$ .
4. In the splitting of water producing Brown’s gas [H2, H1] having a natural identification as Pollack’s fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

### Dark nuclei and Pollack’s findings

While listening the lecture of Pollack I realized that a model for dark water in term of dark proton sequences is enough to explain the properties of the exotic water according to experiments done in the laboratory of Pollack. There is no need to assume sequences of half-dark water molecules containing one dark proton each.

1. The dark proton sequences with dark proton having size of order atomic nucleus would reside at the flux tubes of dark magnetic field which is dipole like field in the first approximation and defines the magnetic body of the negatively charged water blob. This explains the charge separation if the flux tubes have length considerably longer than the size scale of the blob which is given by size of small cell. In the model inspired by Moray B. King’s lectures charge separation is poorly understood.
2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of  $CP_2$ .
3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the  $H_{1.5}O$  blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized.

These primitive forms of photosynthesis and metabolism form could be key parts of their higher level chemical variants. Photosynthesis by irradiation would induce a phase transition

generating dark magnetic flux tubes (or transforming ordinary flux tubes to dark ones) and the dark proton sequences at them. Metabolism would mean burning of the resulting blobs of dark water to ordinary water leading to the loss of charge separation. This process would be analogous to the catabolism of organic polymers liberating energy. Also organic polymers in living matter carry their metabolic energy as dark proton sequences: the layer could also prevent their hydration. That these molecules are typically negatively charged would conform with the idea that dark protons at magnetic flux tubes carry the metabolic energy.

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiples of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J47].

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.

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of  $ZeV$ , where  $V$  is membrane potential about .06 V and  $Z = 2$  is the charge of electron Cooper pair. This gives  $E = .12$  eV.
2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function  $x^3/(e^x - 1)$ ,  $x = E/T$  given by  $e^{-x} + x/3 - 1 = 0$ . The maximum is given approximately by  $x = 3$  and thus  $E_{max} \simeq 3T$  (in units  $c = 1, k_B = 1$ ). At physiological temperature  $T = 310$  K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at  $E \simeq 5T$  corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.
3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

“Electric expansion” of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H2, H1].

- (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with  $f$  degrees of freedom for particle ( $f = 3$  if there are no other than translational degrees of freedom) is  $(T/T_0) = (V/V_0)^{-\gamma}$ ,  $\gamma = (f + 2)/f$ . This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.
- (c) The electric expansion of water need not however involve the increase of Planck constant for water volume. Only the Planck constant for flux tubes must increase and would allow the formation of dark proton sequences and the generation of cyclotron Bose-Einstein condensates or their dark analog in which fermions (electrons in particular) effectively behave as bosons (the anti-symmetrization of wave function would occur in dark degrees of freedom corresponding to multi-sheeted covering formed in the process).

#### Fourth phase of water and pre-biotic life in TGD Universe

If the fourth phase of water defines pre-biotic life form then the phase transition generating fourth phase of water and its reversal are expected to be fundamental elements of the ordinary metabolism, which would have developed from the pre-biotic metabolism. The following argument conforms with this expectation.

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (<http://tinyurl.com/y8ubjgnc>), which forms the basic element of both photosynthesis (<http://tinyurl.com/yauwzkho>) and cellular respiration (<http://tinyurl.com/ybeefxmb>), involves electron transport chain (<http://tinyurl.com/yat3m4vk>) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.
2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (<http://tinyurl.com/yd5ndcyk>) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.
3. ATP is generated also in glycolysis (<http://tinyurl.com/ybzgdgve>), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (<http://tinyurl.com/y8v7aq9s>)).
4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (<http://tinyurl.com/ybzgdgve>) the net reaction  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l) + \text{heat}$  takes place. The Gibbs free energy change is  $\Delta G = -2880$  kJ per mole of  $C_6H_{12}O_6$  and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce  $N = 38$  ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From  $Joule = 6.84 \times 10^{18}$  eV and  $mol = 6.02 \times 10^{23}$  and for  $N = 38$  one would obtain the energy yield .86 eV per single ATP. The nominal value that I have used .5 eV. This is roughly 5 to 8 times higher than  $E = ZeV, Z = 2$ , which varies in the range .1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

In the thermodynamical approach to metabolism the additional contribution would be due to the difference of the chemical potential  $\mu$  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  $\mu_i$  at the two sides of the membrane. Chemical potentials for the ions parametrize the properties of the cell membrane reducing basically to the properties of the channels and pumps (free diffusion and membrane potential do not entirely determine the outcome).

If the transfer of ions - now protons - through cell membrane is quantal process and through Josephson junctions defined by transmembrane proteins, then the thermodynamical model can at best be a phenomenological parameterization of the situation. One should find the quantum counterpart of thermodynamical description, and here the identification of quantum TGD as square root of thermodynamics in Zero Energy Ontology (ZEO) suggests itself. In this approach thermodynamical distributions are replaced by probability amplitudes at single particle level such that their moduli squared give Boltzmann weights.

#### 1. Simplest Josephson junction model for cell membrane

The first guess is that quantum description is achieved by a generalization of the Josephson junction model allowing different values of Planck constant at magnetic flux tubes carrying dark matter.

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.
2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of  $h_{eff}$  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.

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system  $(\Psi_1, \Psi_2)$  obeying Schrödinger equation.

$$i\hbar_1 \frac{\partial \Psi_1}{\partial t} = ZeV\Psi_1 + k_1\Psi_2 \ ,$$

$$i\hbar_2 \frac{\partial \Psi_2}{\partial t} = k_2\Psi_1 \ .$$

One can use the decomposition  $\Psi_i = R_i \exp(i\Phi(t))$  to express the equations in a more concrete form. The basic condition is that the total probability defined as sum of moduli squared equals to one:  $R_1^2 + R_2^2 = 1$ . This is guaranteed if the hermiticity condition  $k_1/\hbar_1 = k_2/\hbar_2$  holds true. Equations reduce to those for an ordinary Josephson junction except that the frequency for the oscillating Josephson current is scaled down by  $1/h_{eff}$ .

2. One can solve for  $R_2$  assuming  $\Phi_1 = eVt/\hbar_{eff}$ . This gives

$$R_2(t) = \sin(\Phi_0) + \frac{k_1}{\hbar_1} \sin\left(\frac{eVt}{\hbar_1}\right) \ .$$

$R_2$  oscillates around  $\sin(\Phi_0)$  and the concentration difference is coded by  $\Phi_0$  taking the role of chemical potential as a phenomenological parameter.

3. The counterparts of Boltzmann weights would be apart from a phase factor square roots of ordinary Boltzmann weights defined by the exponent of Coulomb energy:

$$R = \sin(\phi_0) = \exp\left(\frac{ZeV(t)}{2T}\right) .$$

Temperature would appear as a parameter in single particle wave function and the interpretation would be that thermodynamical distribution is replaced by its square root in quantum theory. In ZEO density matrix is replaced by its hermitian square root multiplied by density matrix.

### 2. The counterpart of chemical potential in TGD description

This model is not as such physically realistic since the counterpart of chemical potential is lacking. The most straightforward generalization of the thermodynamical model is obtained by the addition of an ion dependent chemical potential term to the membrane potential:  $ZeV \rightarrow ZeV + \mu_I$ . This would however require a concrete physical interpretation.

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy  $E_c = \hbar_{eff} ZeB_{end}/m$  of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to  $\hbar_{eff}$  and can be rather large as assumed in the model for the effects of ELF em fields on brain.
2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of  $\hbar_{eff}$  and  $B_{end}$ . The scales of ionic chemical potential and ion concentrations would also depend on value of  $\hbar_{eff}$ .
3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

The earlier proposal [K44] 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. Furthermore, for proton the  $Z^0$  contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

4. The simplest model the communications to magnetic body rely on Josephson radiation whose fundamental frequency  $f_J$  is at resonance identical with the cyclotron frequency  $f_c(MB)$  at particular part of the flux tube of the magnetic body:  $(f_c(MB) = f_J)$ .  $f_c(MB)$  corresponds to EEG frequency in the case of brain and biophotons are produced from dark EEG photons as ordinary photons in phase transition reducing  $\hbar_{eff} = n \times h$  to  $h$ .

In the modified model the sum  $f_c + f_{J,n}$  ( $f_{J,n} = E_J/n \times h$ ) of  $\hbar_{eff}$ -independent cyclotron frequency and Josephson frequency proportional to  $1/\hbar_{eff}$  equals to cyclotron frequency  $f_c(MB)$  at “personal” magnetic body varying slowly along the flux tube:  $f_c + f_{J,n} = f_c(MB)$ . If also the variation of  $f_J$  assignable to the action potential is included, the total variation of membrane potential gives rise to a frequency band with width roughly

$$\frac{\Delta f}{f} \simeq \frac{2f_{J,n}}{f_c + f_{J,n}} = \frac{2f_{J,1}}{nf_c + f_{J,1}} .$$

If dark photons correspond to biophotons the energy of cyclotron photon is in visible and UV range one has  $nf_c = E_{bio}$  and

$$\frac{\Delta f}{f} \simeq \frac{2ZeV}{E_{bio} + ZeV} .$$

The prediction is scale invariant and same for all ions and also electron unless  $E_{bio}$  depends on ion. For  $eV = .05$  eV,  $Z = 1$ , and  $E_{bio} = 2$  eV ( $f \simeq 5 \times 10^{14}$  Hz) one has  $\Delta f/f \sim .1$  giving 10 per cent width for EEG bands assumed in the simpler model.

If this vision is on the correct track, the fundamental description of osmosis would be in terms of a phase transition to the fourth phase of water involving generation of dark matter transferred to the magnetic flux tubes. For instance, the swelling of cell by an in-flow of water in presence of higher concentration inside cell could be interpreted as a phase transition extending exclusion zone as a process accompanied by a phase transition increasing the value of  $h_{eff}$  so that the lengths of the flux tube portions inside the cell increase and the size of the exclusion zone increases. In general case the phase transitions changing  $h_{eff}$  and  $B_{end}$  by power of two factor are possible. This description should bring magnetic body as part of bio-chemistry and allow understanding of both equilibrium distributions, generation of nerve pulse, and basic metabolic processes leading to the generation of ATP.

### 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 [K104] explaining anomalously large gravimagnetic effect claimed by Tajmar *et al* [E5, E10] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order  $10^{-4}$  and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional  $h_{eff}^2$  in TGD and if one uses  $h_{gr}$  for electron-Earth system one obtains correct order of magnitude.

Nottale's finding that planetary orbits seem to correspond to Bohr orbits in gravitational potential with gigantic value of gravitational Planck constant is the basic input leading to the model of gravimagnetic anomaly.

1. By Equivalence Principle  $h_{gr}$  has the general form  $h_{gr} = GMm/v_0$ , where  $M$  and  $m$  are the interacting masses and  $v_0$  is a parameter with dimensions of velocity. For 4 inner planets one has  $v_0/c \simeq 2^{-11}$ .
2. The notion of  $h_{gr}$  generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which  $h_{em} = Z_1 Z_2 e^2 / v_0$  is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.
3. Since the natural expansion parameter of perturbative expansion is the  $g^2/4\pi\hbar$ , one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

$h_{em}$  might be large in the exclusion zones (EZ) appearing in the water bounded by gel and their variants could play central role in living matter.

1. EZ carries very large negative charge with positive charge outside the exclusion zone.
2. TGD interpretation is in terms of  $H_{1.5}O$  phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of  $h_{eff}$ . The proposal is that primitive life form is in question.
3. The pair formed by EZ and its complement could have large value of  $h_{eff} = h_{em} = Z^2 e^2 / v_0$ .
4. The velocity parameter  $v_0$  should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and  $v_0$  is the rotation velocity at the surface of Earth. The prediction for  $h_{eff}$  would be of order  $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$ .
5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large  $h_{em}$  or  $h_{gr}$  could be formed.

I have proposed that metabolic machinery generates large  $h_{eff}$  phase somehow.  $h_{eff} = h_{em}$  hypothesis allows to develop this hypothesis in more detail.

1. I have speculated earlier [K52] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity  $v_0$  of the shaft appears in the formula for  $h_{em}$ . Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge  $Z$  associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving  $h_{em} = 2e \times Z/v_0$ .
2. The value of  $v_0/c$  is expected to be of order  $10^{-14}$  from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for  $h_{em}$  could be same as for  $h_{gr}$  associated with Earth-particle system.

$h_{eff}(ATPsynthase) = h_{gr}(2e, Earth)$  would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K84].

### Is time reversal involved with Pollack effect?

EZs have the very strange property that the impurities are spontaneously removed from them. This seems to be in conflict with the second law of thermodynamics according to which both temperature and concentration gradients should tend to disappear. Could one understand this as being due to a reversal of the arrow of time?

Indeed, TGD inspired theory of consciousness relying on zero energy ontology (ZEO) predicts the possibility of time reversed selves [L100]. When conscious entity - self - dies, it reincarnates as a self with opposite arrow of geometric time.

1. In ZEO zero energy states replace ordinary quantum states assigned with time=constant snapshots of time evolution in space-time. Zero energy states are pairs of ordinary quantum states at opposite light-like boundaries of causal diamond (CD) identifiable as counterparts of initial and finals states of a physical event. Conservation quantum numbers translates to a mathematical statement that the quantum numbers associated with the members of pairs are opposite. One can also say that zero energy state is analogous to a deterministic computer program or a behavioral mode. The act of free will replaces this program/behavior with a new one so that one avoids the paradox between the non-determinism of free will and determinism of physics.
2. Causal diamond (CD) defines the embedding space correlate of self. One can assign to the opposite light-like boundaries the attributes active and passive. During the sequence of analogs of "small" state function reductions analogous to weak quantum measurements (resembling classical measurements) the passive boundary remains unaffected as also the members of state pairs defining zero energy states associated with it. Active boundary recedes farther away from the passive boundary and the members of state pairs at it change. The size of CD thus increases and gives rise flow of geometric time as an increase of the temporal distance between the tips of CD.
3. Eventually the first state function reduction to the opposite boundary of CD must occur, and active and passive boundary change their roles. Self dies and re-incarnates as a self with opposite arrow of geometric time: the formerly passive boundary of CD becomes now active and moves in opposite time direction reduction by reduction. In the next re-incarnation self continues almost from the moment of geometric time at which it died. It might be that we die repeatedly without noticing it at all!
4. The many-sheeted space-time approximated with slightly curved regions of Minkowski space would certainly tend to mask the time reversals in given length scale. In elementary particle

length scales the state function reductions would indeed change the arrow of time but this would occur so often that there would be no arrow of time in statistical sense: one would speak of microscopic reversibility. In time scales considerably longer than those of human consciousness the observed arrow of time would correspond to that associated with selves with very large CDs and with lifetime much longer than ours. The change of the arrow of time could be detectable in time scales relevant to living matter and human consciousness and just these scales are the scales where the anomalies occur!

Could the ghostly space-time regions - time reversed selves - have some physical signatures making possible to prove their existence empirically?

1. Second law would still hold true but in opposite direction of geometric time for the space-time sheets with non-standard arrow of time. The effects implied by second law would be present as their reversals. The observer with standard direction of geometric time would see temperature and density gradients to develop spontaneously. Also parameters describing dissipation rates such as Ohmic resistance and viscosity could have in some situations negative values.

This indeed seems to take place in living matter. For instance, the building bricks of molecules spontaneously arrange to molecules: DNA replication, transcription and translation of RNA to proteins are basic examples about this. The development of concentration gradients is also clear in the strange ability of EZs to get rid of impurities. Also the charge separation creating EZs could be seen as disappearance of charged separation in reversed direction of time. Healing of living organism could be a basic example of the process in which the arrow of time changes temporarily at some level of hierarchy of space-time sheets.

2. The generation of temperature gradients would be a clear signature for the reversal of the arrow of time. Water is the basic stuff of life, and the thermodynamics of water involves numerous anomalies summarized at Martin Chaplin's homepage "Water structure and science" (see <http://tinyurl.com/ye77f7d>). TGD based explanation could be naturally in terms of dark variants of protons at magnetic flux tubes and possible change of the arrow of geometric time.
3. There is a lot of anecdotal evidence for the effects challenging our beliefs about standard arrow of time. A spontaneous generation of temperature differences is basic example. There is a nice popular document about this boundary region of science by Phie Ambo (see <http://tinyurl.com/yaog8h39>), which even skeptic might enjoy as art experience.

It was a great surprise for me that one of the key personalities in the document is Holger B Nielsen, one of the pioneers of string models. I have had the honor to have intense discussions with him in past: he is one of the very few colleagues who has shown keen interest on the basic ideas of TGD. The document discusses strange phenomena associated with the physics of water possibly having interpretation in terms of time reversal and formation of EZs. From the document one also learns that in Denmark physics professionals are beginning to take these anomalies seriously.

Unfortunately, the people who claim having discovered this kind of effects - often not science professionals - are labelled as crackpots. The laws of science also tell what we are allowed to observe (and think), at least if we want to be called scientists!

4. The ghost stories might also reflect something real - this real need of course not be ghost but something deep about consciousness. Could it be that it is sometimes possible to consciously experience the presence of a space-time region - self - with an opposite arrow of geometric time? Ghost stories typically involve a claim about the reduction of temperature of environment in presence of ghost: could this be something real and a signature for the reversal of time at some level of dark matter hierarchy affecting also dark matter? As a matter of fact, in TGD Universe our conscious experience could involve routinely sub-selves (mental images) with non-standard arrow of time [L100]: motor actions could be identified as sensory mental images with opposite arrow of time.

### Which came first: metabolism or cell membrane?

One of the basic questions of biology is whether metabolism preceded basic biopolymers or vice versa. RNA world scenario assumes that RNA and perhaps also genetic code was first.

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.
2. There is very interesting article (see <http://tinyurl.com/ycdhd4fd>) [I10] reporting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.
3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K48, K65] 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.

## 17.4 TGD View About Metabolism

The general strategy in TGD based attempts to understand metabolism [K52] is based on the assumption that a very large class of anomalous phenomena rely on same basic mechanism. This includes life as a gigantic collection of anomalies, water memory and homeopathy, free energy phenomena involving over-unity energy production related to the dissociation of water, lightning and ball lightning, anomalous effects associated with rotating magnetic systems, phenomena related to UFOs (light balls), and remote mental interactions. One must have a unified explanation for all these phenomena based on a real theory.

Plasmoid as primitive life form would be the underlying connecting thread between these phenomena so that all the listed phenomena would involve life and prebiotic (or/and possibly post-biotic!) life. This gives very strong constraints on the model. Plasmoid should consist of the analogs of linear biomolecules, it should metabolize and communicate, in TGD Universe it should have magnetic body, and even genetic code might be realized. In particular, the simplified analog of biological metabolism would be at work. In living matter photosynthesis relies on the splitting of water whereas cell respiration relies on the reversal of this process producing carbon di-oxide and water. Something very similar should happen in free energy systems involving electrolysis, and the fact that water splitting occurs also in several free energy phenomena suggests that these processes are analogous to photosynthesis and store energy to “molecules” analogous to various linear biomolecules, in particular sugars. Even the simplified version of ADP-ATP process might be realized.

TGD suggests a very general model for the metabolism of pre-biotic systems identified as plasmoids consisting of cyclic linear structures formed by exotic water molecules. For a dark water molecule one proton would be dark and dark protons of the neighboring exotic water molecules would bind to form a linear structure identifiable as dark nucleus: this picture is a direct generalization of nuclear string model [K37, K34, K65]. These linear structures would define the analogs of linear biomolecules. This metabolism would be more fundamental than ordinary biochemical metabolism and form a yet unknown part of the latter. One cannot exclude the possibility that

also other than water molecules contain dark protons: the signature would be the presence of apparently non-allowed covalent bonds due to the fact the dark proton is not visible. In the following I will discuss the basic principles involved.

The older view about the metabolic energy quanta as energies liberated as particle “drops” to a larger space-time sheet is modified (an objection against this mechanism is that its coherence for many particles is far from obvious). Metabolic energy quanta are liberated when the space-time sheet at which the particles reside expands in a phase transition increasing its p-adic prime and reducing the value of Planck constant correspondingly so that the net result is that the size of the space-time sheet remains the same. This condition implies a close relationship between p-adic and dark matter hierarchies. This process is automatically coherent since all particles suffer the change simultaneously. It applies also to a situation in which particles are in magnetic field: in this case the scale of cyclotron energies changes since the strength of the magnetic field is scaled down to guarantee the conservation of magnetic flux. This transition is not cyclotron transition but liberates essentially the same energy as coherent cyclotron transition so that magnetic fields (their “motor actions”) become essential players also in metabolic activities.

### 17.4.1 Three Possible Models For Liberation Of Metabolic Energy

One can imagine three different models for the liberation of metabolic energy.

1. The simplest TGD based model is as a phase transition increasing the value of p-adic prime  $p$  assignable to the space-time sheet at which particle is topologically condensed:
  - (a) Particle drops to a larger space-time sheet with larger p-adic prime  $p_1$  with  $p_1/p \simeq 2^k$ . The problem is that different particles need not drop simultaneously so that coherent liberation of energy is not automatic consequence of the assumption.
  - (b) The space-time sheet itself suffers a phase transition increasing its p-adic length scale. In absence of interactions (particles in box) the energies are scaled down by factor  $2^{-k}$  and the difference is liberated as usable energy. Coherent liberation of energy is achieved automatically. If the particle inside the space-time sheet is free in good approximation a model as particle in box applies, and if the expansion of the space-time sheet takes place adiabatically, the quantum numbers characterizing the state of the particle do not change in the transition. As a consequence, the energy  $E_{\{n_i\}} = k \sum_i n_i^2 \hbar^2 / 2mL_p^2$  is reduced as  $L_p \propto \sqrt{p}$  increases to  $L_{p_1}$ , where  $p_1/p \simeq 2^k$  holds true. The difference of vacuum energies is liberated as usable energy in coherent manner: this is of special significance in living systems. This has led to the identification of p-adic length scales that would correspond to fundamental metabolic quantum with value about .5 eV. Entire hierarchy of metabolic quanta is predicted.
2. The space-time sheet could also carry magnetic energy and particles are expected to be in cyclotron states and perhaps form a cyclotron Bose-Einstein condensate. In this case the phase transition reduces the value of  $B$  but preserves the magnetic flux so that  $B \rightarrow B/2^k$ ,  $p_1/p \simeq 2^k$ , takes place. This scales down the energies of cyclotron states by the same scaling factor  $2^{-k}$  as in the case of free particle. The liberated energy is in good approximation just the cyclotron energy for large enough values of  $k$ . Coherence is achieved automatically. The value of the fundamental metabolic energy quantum and the value of endogenous magnetic field of about  $B_{end} = .2$  Gauss deduced from the experiments of Blackman and others [J71] fix the value of  $\hbar_{eff}$ . It would be proportional to particle mass number  $A$ .
3. The earlier model for the liberation of cyclotron energy was based on the assumption that the value of  $B$  is not changed but that the value of magnetic quantum number  $n$  changed. If  $n$  is reduced one achieves liberation of energy. Coherence of the transition might produce problems now. Both models can explain the observations of Blackman and others concerning the effects of ELF radiation on vertebrate brain since the spectrum of photon energies inducing effects correspond to cyclotron energies for the latter option and in excellent approximation to it for the previous model. The mechanism is however quite different.

This phase transition for the larger space-time sheet can take place in two steps.

1. First a phase transition increasing  $\hbar_{eff}$  of the background space-time sheet by  $n = 2^k$  occurs. This leaves ZPKE invariant but scales up the size of the space-time sheet by  $2^{k/2}$ . The interpretation would be as “electric expansion” of Brown’s gas. No energy transfer takes place since both kinetic and magnetic energies are invariant under the scaling of  $\hbar$ . Note however than in the original situation the magnetic field can be very strong so that zooming up from microscopic scales can happen.
2. After this a phase transition reducing Planck constant back to  $\hbar$  but increasing p-adic length scale by  $2^k$  occurs. The size scale of the background space-time sheet is not affected but the zero point kinetic energy is reduced by factor  $2^{-k}$  and liberated as usable energy. This phase transition would take place for the dark component of Brown’s gas in the melting of the metal and other similar phenomena. Also the liberation of metabolic energy in living matter could correspond to this phase transition.

This model for electric expansion, implosion, and energy liberation assumes nothing about the particles involved since dark particle means ordinary particle topologically condensed on dark space-time sheet and having wave function de-localized in the n-sheeted structure. For instance, water can be dark in this sense. One could indeed consider the possibility that the vapor phase identified as charged water cluster is just water containing positive ions  $H_+^3$  or protons and electrons and that phase transition to large  $\hbar$  phase expands the space-time sheet at which water is topologically condensed at evaporates the water. Ordinary liquid to gas transition could proceed in the same manner and involve liberation of ZPKE at the second step of the process. In the general case the binding energy involved with the formation of the denser phase could compensate for the energy gain in the increase of the p-adic prime so that the melting would require energy feed.

#### 17.4.2 Where The Metabolic Energy Is Stored?

High energy phosphate bond is one of the problematic notions of standard biology, and has served as inspiration in attempts to understand metabolism in TGD framework. The ideas have evolved gradually and the only defense for those which have survived is that they are inspired by a rather wide spectrum of anomalies including biology, neuroscience, and free energy phenomena so that the constraint of internal consistency eliminates many options.

1. The notion of negentropic entanglement allows to consider the possibility of bound states which have wrong sign of binding energy. Entanglement would be stable because it is negentropic rather than being characterized by binding energy. This led to the idea that high energy phosphate bond as a carrier of negentropic entanglement. The milder assumption is that ATP has the ability to generate it. The problem is that one can imagine endless variety of mechanisms without further conditions.
2. A highly attractive idea is that magnetic body could serve as the fundamental storage of metabolic energy with negative energy photons serving as a way to extract energy from the personal magnetic body or even other magnetic bodies. This would locate higher energy phosphate bond to magnetic flux tube and suggests that the energy is assignable to an analog of Cooper pair. This vision inspires also speculations about future energy technologies.
3. The generalization of the simple picture about liberation of metabolic energy as associated with the dropping of particle to a larger space-time sheet to a phase transition liberating cyclotron energy of charged particles led to the realization that also the phase transitions in which p-adic length scale increases by  $2^{k/2}$  factor and  $\hbar_{eff}$  decreases by factor  $2^{-k}$  so that the size of space-time sheet remains the same, liberate kinetic energy or magnetic energy and this happens coherently and simultaneously for all particles involved. This mechanism makes essentially the same predictions about effects of ELF em fields at multiplet of cyclotron frequencies (in good approximation).

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to



the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant  $h_{eff}$  so that cyclotron energy would be liberated.

4. The negentropic states with wrong sign of binding energy could also correspond to cyclotron states with large  $h_{eff}$  (equally well to the states of a free particle in box, now space-time sheet). Magnetic body could carry metabolic energy and negentropic entanglement as that associated with dark pairs of charged particles. Because of their small mass electrons carry highest energy for given value of  $h_{eff}$  and magnetic field  $B$ . The deep irony is that one cannot automatically exclude even the elusive neutrinos as key players of metabolism: neutrinos have even smaller masses than electron and would carry even more energy in classical  $Z^0$  magnetic fields possible in cell scales for large enough values of  $h_{eff}$  [K81] !
5. Also ordinary biomolecules can be said to carry metabolic energy in covalent bonds: one could therefore assign the attribute “high energy” also the them. Do we really understand these bonds or do we just accept and forget? Do we really understand what the valence electron pairs associated with covalent bonds are? Is this really nothing but standard chemistry understood for long time ago? To my best knowledge we cannot deduce the existence of chemical bonds from Schrödinger equation because the numerics gets too intensive and choose to believe on reductionistic dogma. Hence there is some room for imagination.

- (a) Concerning covalent bond, the first option is conservative and based on the free energy inspired idea that the orderer water stabilizing DNA corresponds to dark DNA sequences. If this situation prevails also for RNA and proteins known to be surrounded by order water, one can wonder whether the covalent bonds are indeed more or less standard chemistry but that it is dark DNA parallel to the ordinary DNA that carries the metabolic energy as cyclotron energy liberated as the biopolymer and its dark variant image is catabolized. The metabolic energy would be carried by the same structures as in the case of plasmoids which would be therefore be a key element of also life as we know it!

For this option the long color flux tubes carrying quark or electron pairs would give rise to the flux tubes needed for reconnections. The transfer of metabolic energy would rely on reconnection mechanism transferring also electron Cooper pairs. Dark and thus scaled-up variant of strong interactions would become perhaps the most essential part of biophysics! Chirality selection suggests strongly that also dark variant of weak physics is in a central role in living matter.

- (b) Second option suggests a radically new view about covalent bond itself. Could valence bonds corresponds to Kähler magnetic flux loops carrying this kind of dark electron pair? Could they define the loops by which biomolecules could touch each other and reconnect to form dynamical webs. Could the fundamental energy transfer process be the transfer of electron pair between molecules involving two reconnections so that piece of magnetic loop would be exchanged? Could ATP could simply give piece of flux loop containing dark electron pair to the biomolecule as it is constructed?
6. Both options would unify also biochemistry with DNA as topological quantum computer vision. DNA sequences accompanied by magnetic flux loops would make possible DNA-cell membrane flux tube connections and topological quantum computer. Also for DNA as topological quantum computer I have considered two options: one for which quarks and antiquarks are associated with the ends of flux tubes and second one in which only electron pairs are involved [K4].

These ideas are of course speculative and time will probably show that Nature has not chosen them. What I see as the beauty of the general picture is that all relevant elements of biology at molecular level would reduce to the basic “motor actions” for magnetic body and their effects on cyclotron Bose-Einstein condensates. Same can be said about basic elements of consciousness: directed attention and sensing the presence of other molecule relying on the use of cyclotron frequencies as passwords and reconnection of flux tubes.

### 17.4.3 Dark Photon-Bio-Photon Connection

TGD inspired model for bio-photons is as ordinary photons resulting as decay products of dark photons in energy-momentum conserving decay. I have discussed this model [K23] [K14] using the input from the findings of Persinger *et al* [J94, J95, J96].

1. In the first article (see <http://tinyurl.com/y7nbr496>) [J94] entitled *Congruence of Energies for Cerebral Photon Emissions, Quantitative EEG Activities and  $\sim 5$  nT Changes in the Proximal Geomagnetic Field Support Spin-based Hypothesis of Consciousness* correlations between cerebral photons emissions, EEG, and changes of the proximal geomagnetic field are reported. The findings provide support for the proposal of Hu and Wu [J120] that nerve pulse activity could induce spin flips of spin networks assignable to cell membrane motivated by the observation that the magnetic spin-spin interaction between protons at a distance of 10 nm (cell membrane thickness) corresponds to energies for which frequency is in EEG range.
2. In the second article (see <http://tinyurl.com/ycv53lye>) [J95] entitled *Demonstration of Entanglement of "Pure" Photon Emissions at Two Locations That Share Specific Configurations of Magnetic Fields: Implications for Translocation of Consciousness* the group reports an excess correlation between "pure" photon emissions at two locations separated by few meters that share specific correlations of frequency modulated magnetic fields. The photon emissions were from LEDs in the experiment consider. In an earlier similar experiment, which is also discussed, they were from chemical reactions occurring in solutions contained by cell cultures.
3. In the third article (see <http://tinyurl.com/ya4yb6bc>) [J96] entitled *Experimental Demonstration of Potential Entanglement of Brain Activity over 300 Km for Pairs of Subjects Sharing the Same Circular Rotating, Angular Accelerating Magnetic Fields: Verification by s\_LORETA, QEEG Measurements* an excess correlation of brain activity of subject persons separated by 300 km and sharing the same circular rotating, angular accelerating magnetic fields is reported.

The frequencies of the ordinary and dark photon are predicted to be in integer ratio  $f_h/f_l = h_{eff}/h = n$  and I have already considered amplitude modulation as a way to produce dark photons and mentioned Cyril Smith's experiments which can be interpreted in terms of this transformation.

1. The bio-photon emissions at two ends should be compared. The correlations between temporal patterns would be one basic signature. Temporal correlations are extremely important and should be studied further: otherwise the findings are taken as mere claims by mainstream.
2. Collection of frequencies as a password is the rather strongly TGD based prediction. Common frequencies at both ends define second signature. Phase transitions changing frequencies but preserving photon energies are of course possible so that also sub-harmonics must be considered. More specific predictions lead soon to bio-electromagnetism. I do not know whether bio-electromagnetists have continued the work of pioneers or whether anything is done nowadays.

This picture raises an interesting question: suppose that one has identified a collection of frequencies responsible for a biological password. Could one produce these effects artificially using these frequencies to modulate a carrier wave corresponding to some bio-photon frequency?

3. Time delay is one signature and would give idea about how long distance the radiation travels and at the same time can give additional support for magnetic bodies of astrophysical size, which is certainly the most astral looking feature of TGD model for biologist.

Delayed luminescence is also a phenomenon related to bio-photons. Delayed luminescence has been produced as a model of visual after images: this could apply to all mental after images. TGD enthusiast could see after images as a indirect support for the idea that communications to and from the layers of magnetic body take place and require definite time measuring directly the size scale of the layer. The time delay is rather long in the model of after images so that the magnetic bodies in question would be rather large involving photon

travels over cosmic distances! Mainstream thinking suggests that some other mechanism is in question and the complexity of nervous system certainly allows to invent alternative mechanisms.

4. The ability to tune the cyclotron and Josephson frequencies by varying magnetic field would be basic magnetic motor skill of the meditator besides ability to move magnetic body parts to make reconnections more probable. For Josephson frequencies this skill would mean the ability to tune the value of the membrane voltage and Josephson frequency characterized by the associated value of  $h_{eff}$ . If given receptor-information molecule pair corresponds to a particular value of  $h_{eff}$  defining a connection to a particular magnetic body part as will be suggested below, an advanced meditator would have developed the ability to control the density of the receptor-information molecule pairs.
5. How to detect changes of cyclotron frequencies? In Persinger's experiments, magnetic field identified as that of Earth, was slightly reduced and therefore also the frequency. Could one learn to detect the tuning of the value of magnetic field? Can one demonstrate the ability of meditator to modify these frequencies? Can one try to identify the place where the radiation with these frequencies originates. Can one characterise body parts by slightly differing frequencies and build a kind of frequency map about body? Do deviations from standard values characterize unhealthy state?

## 17.5 Questions

The following represents answers to the 3<sup>rd</sup> JNL Panel on meditation, mind-body medicine and placebo based on the previous summary of TGD perspectives on consciousness and quantum biology. The introduction of the article should help to obtain a very short overview about the background.

### 17.5.1 I: Long Term Meditation Remodelling And Its Effects On Bio-Photon Emissions

Q1: Is the plasticity restricted to brain? Could meditation/visualization trigger BPE/redox-regulated changes in body wide microtubule arrays increasing coherence and synchronization?

A: I see no deep reason why plasticity would be restricted to brain alone. Brain might have however achieved highest level of plasticity because it represents a kind of "postmodern" layer in the evolution of cell cultures allowing cellular individualism. An interesting question in TGD framework is also the plasticity of magnetic body. Is meditation reshaping the magnetic body, making it more plastic so that it can build reconnections and in this manner direct attention more sharply and more stably?

Q4. Would the increased alpha power, brain connectivity and synchronization translate into greater amplitudes and bio-photon field coherence throughout the organism? And is there any mechanism through which BPE's could be reflected within the body's various conduction matrices (neural system, the mitochondria-microtubule reticulum – see Rahnema *et al*, 2011) acting like a resonant cavity for laser-like amplification of EEG-pumped BPEs, in order to reach the requisite thresholds for biological action?

If there is a common mechanism of action between LLLT and mind-body healing, as suggested by the parallels reviewed in the discussion above, then of particular interest is the fact that proficient qigong meditators appear capable of directing bio-photon emissions to specific areas of the body [see "Intent-directed localization" section in bibliography]. Given that LLLT is limited in the depth of effective tissue irradiation, the prospect of targeted delivery of specific frequencies is quite intriguing. On the other hand, the actual intensity of bio-photon fields inside the cells and the robustness of quantum coherence at physiological temperatures remain controversial issues (Tafur *et al*, 2010; Rahnema *et al*, 2011).

A: If bio-photons are what results from dark photons in phase transition, the increase in alpha power and more generally in EEG power should increase bio-photon yield: BPE pumped by EEG corresponds to BPE as leakage from EEG. That there is decrease for meditators might be

related to the absence of sensory and motor mental images: if there are no mental images, there is nothing to be communicated by dark EEG photons to the personal magnetic body.

Q5. There is evidence for the conduction of bio-photons along neural fibers. Do you think it's possible that the localization of BPE during such visualization exercises is due to the photons' transmission from the brain to that affected area along efferent neurons, in the same way motor commands would be locally transmitted? Is it technically possible to measure such neural photon conduction in meditating human subjects? And should localization of action, such as targeted BPE, be part of patient training in mind-body interventions?

A: That LLLT is limited by tissue depth, ceases to be a problem if dark photons propagate along magnetic flux tubes. Darkness would provide also shield against de-coherence. One can imagine two ways to achieve targeting.

1. Password mechanism for which parts of body correspond to characteristic resonances so that dark photons with particular frequency determined by energy and value of  $\hbar_{eff}$  are received only by that body part.
2. Second mechanism is propagation along magnetic flux tubes directed to that body part. If dark photons have cyclotron frequencies in the magnetic field of a flux tube, these mechanisms are more or less equivalent. Frequency corresponds to magnetic field strength and this in turn to thickness of magnetic flux tube. Microtubular matrix could be accompanied by magnetic flux tubes perhaps serving as a template for it. Biological effects at specific frequencies at the other end of the pathway would be the basic signature.

Q6. What do you think of target specificity in mind-matter interactions – based on your understanding of the literature, how narrowly are we able to target a particular area of the body or a particular effect? Could the differential sensitivity to LLLT on the basis of redox status or proliferation rate account for the fact that qigong-based therapies show apoptosis of tumor cells but not normal cells? What do you think is the physical basis of such differential effects, or their localization to particular areas of the body?

A: The different sensitivity of tumor cells and normal cells would be explained by different cyclotron frequencies for their magnetic bodies. The unhealthy state would be also unhealthy state of magnetic body: maybe some parts of collective magnetic body of tumor cell complex with rather large value of  $\hbar_{eff}$  are just missing and this translates to selfish behavior of tumor cells. The claim of inventor Royal Rife (see <http://tinyurl.com/yo5yfx>) regarded as pseudoscience by the mainstream is that tumor cells can be destroyed using irradiation with specific resonance frequencies. This method must be distinguished from radiation therapy based on ionization of DNA. Rife's claim would be roughly consistent with TGD inspired proposal. Basically the challenge would be to find the frequency serving as the password to the cancer cell's magnetic body.

Q7. In your opinion what is the most likely mechanism underlying the connection between long term meditation practice and the development of healing/ psi abilities?

A: I see meditation and visualization as practices for making magnetic body more flexible. This process modifies also biological body since genetic expression is changed as magnetic body controlling the expression of genes modifies it. Also build-up of connections to the larger layers of magnetic body with large value of  $\hbar_{eff}$  would be in question as well as developing the ability to reconnect to other magnetic bodies. The travels of meditators/shamans/etc. to other realities could involve real sensory perceptions in TGD based ontology based on same mechanisms as remote sensory experiences. In any case, the communications in shorter length scales, say inside body and to lower layers of personal magnetic body, would rely on this mechanism.

The modification of the gene expression in meditation could be interpreted as being due to the changes of the connections between magnetic body and biological body. Genetic expression could be determined by the permanent flux tube connections from the magnetic body to the promoter portions of DNA. Differentiation would select the promoters to which the magnetic body has permanent connections. The role of transmitter-receptor complex could be taken by the complex formed by the promoter and RNA polymerase making possible to receive the cyclotron radiation from the magnetic body. The model for motor action and sensory perception assumes that they are time reversals of each other so that the cyclotron radiation to genome and Josephson radiation from the cell membrane would travel in opposite time directions. In the most general case both radiations can travel in either time directions so that also cell membrane could receive control

commands (possibly interpreted as virtual sensory input giving rise to what is usually regarded as hallucinations).

The change of the gene expression would be due to a change of these connections. Both meditation, placebo effect, and healing could induce changes in gene expression in this manner. One can wonder whether this change of connections to the magnetic body can be heritable so that it would provide a new mechanism of epigenetics (examples of which are histone modification and DNA methylation). If dark photons are involved with the communications to and from the magnetic body then also BPEs as dark photon leakages would reflect the change of genetic expression.

### 17.5.2 Ii: Healing Input Parameters, Dosimetry, Research Technology

Q8. What other approaches and technologies could be used to quantify healing intent? Is there a place for operator EEG, heart rate variability, skin conductance and operator bio-photon measurements on the input side of mind-body research protocols? Should we find a correlation between healing effects and BPE intensity/frequencies, would this provide a more useful, quantitative assessment of “healer input” in mind-body methodologies than the years of meditation practice?

A: If information molecule-receptor complexes serve as bridges to magnetic body parts, the technology quantifying healing intent would involve also correlates at neuro-pharmacological level. Neuroscience and study of remote mental interactions would fuse together. Elaborate maps about the information molecule connections to magnetic body would be constructed.

Q9. Since we know the action spectra required for specific LLLT effects, would it be useful to compare these LLLT spectra to the BPE wavelengths measured outside the heads of qigong healers attempting to produce the same effects through visualization? Could we feedback-train patients to reproduce such circumcerebral frequencies through meditation?

A: The comparison of peaks of LLLT and bio-photon spectra would be very interesting. This idea can be expanded if one accepts interpretation of EEG as dark photons. The naïve prediction would be that the ratios of peak frequencies for EEG for given value of  $h_{eff}$  and for bio-photons are same. In principle (I do not know about practice) this could be tested by looking at action spectra for LLT and bio-photons!

Q10. What do you think is the mechanism through which sender-receiver bonding facilitates DMILS effects? Specifically, could we test whether healing-specific EEG frequencies and the intensity of BPE at the sender are greater when the sender has a shared history with the receiver (due to cognitive/emotional memory activation and increased neural recruitment)? Could then “pre-bonding” with a targeted tissue, such as detailed visualization of a tumor, be used to enhance the effect of a patient’s healing meditation on his own body?

A: Pre-trial bonding would translate to permanent flux tube connections between magnetic bodies due to the reconnections. This would facilitate DMILS effects: the two magnetic bodies would receive some input from each others biological bodies by dark photons, say EEG. The correlations between EEG spectra and also spectra at other frequencies could serve as a signature for this.

Q11: Could endogenous, EEG generated bio-photons be trapped and utilized as such a source of energy? And could specific forms of meditation trigger new, low-dissipation physiological configurations and metabolic pathways which would allow the capture and high-efficiency utilization of surrounding environmental photons, such as light absorbed through the eyes? How could we test for such epigenetic and molecular configuration changes?

A: The trapping of dark photons to flux tubes would look more natural than trapping of bio-photons in TGD framework. The utilization of environmental photons in Bigu does not look to me an attractive option: dark photons from magnetic body would look more natural if TGD ontology is accepted. I have considered a model for Bigu assuming that magnetic bodies serve as fundamental storages of metabolic energy. What this really means is far from obvious and several options can be imagined. The metabolic energy assigned with the covalent bonds of biopolymers could be actually cyclotron energy assignable with large  $h_{eff}$  magnetic flux tubes. Metabolism could be basically transfer or generation of negentropic entanglement assignable most plausibly to electron Cooper pairs. Bigu might reduce to sending of negative energy dark photons to some magnetic body with same cyclotron frequency (but does this generate negentropic entanglement by generating negentropic entanglement, say between electrons of Cooper pair?). This would involve

formation of reconnection to this magnetic body (same field strength, same cyclotron frequency). Negative energy photons make sense only if the arrow of geometric time (thermodynamical time) can vary, and this quite generally would make possible also instantaneous communications as reflections of signals in time direction making possible remote mental interactions with arbitrarily distant targets. Zero energy ontology guarantees this.

### 17.5.3 III: Is Placebo A Form Of Healing Intent? Placebo Genotype Vs. Phenotype

Q12: How do you physiologically interpret the recent finding that patients with a met/met COMT variant are more prone to placebo effects?

A: That persons with met/met COMT would be more prone to placebo effects than normal variant, looks at first rather weird. From Wikipedia (<http://tinyurl.com/yc5ps8pg>) one learns about the claim that people with this variant tend to feel themselves happier than those with normal variant.

If one believes that neural transmitter-receptor complex establishes a plug-in from neuron to relevant part of the magnetic body, then this does not look so weird. Methylation of DNA and proteins is a universal manner to modify the functioning of reaction pathways and appears also in epigenetics. Met/met COMT instead of Met/Val COMT could favor the generation of this kind of bridges to some parts of magnetic body with higher value of  $h_{eff}$ : if larger negentropy is responsible for feeling happiness, then the finding could be understood. The parts of the magnetic body are in one-to-one correspondence with those of brain areas and might have similar specialization to feel happy or unhappy as limbic brain is claimed to have (right limbic brain seems to be specialized in suffering!). These bridges or “plug-ins” would most naturally correspond to post-synaptic receptors for some neural transmitters - perhaps one could localize them to limbic brain.

Placebo would be self-healing based on building this kind of contacts. Healing could be seen as healing of the communications between biological and magnetic body (or bodies, say magnetic bodies of collectives).

Q13. Given the evidence that meditation produces different effects on plasma catecholamines according to BDNF or COMT polymorphisms, do you think there is there a common genetic/CNS/therapeutic pathway between placebo and healing qi ability? Could subjects' placebo and healing effectiveness be correlated with an ability to entrain massive CNS domains through both activation of broad cognitive basins (multi-sensory visualization) and emotional modules? Would certain genetic variants be more conducive to this type of CNS activation?

A: I tend to think that many pathways are involved. The pathway in question need not be the same for placebo and healing qi ability. For psychedelics and perhaps also for remote perception the pathways affecting serotonin accumulation to postsynaptic receptors seem to be important and pineal gland might be the seat of action. The general mechanism could be similar to that conjectured for the action of psychedelics/hallucinogens. The interpretation would be that connections to some parts of magnetic body or even other magnetic bodies become more stable. If information molecules and receptor proteins are crucial for building connections to the magnetic body, gene dependence is implied: biochemist could probably easily tell whether methylation is a universal mechanism for modifying these molecules.

Q14. Could certain types of meditation training replicate this effect even in subjects who do not carry the COMT met/met variant – i.e. could we train patients to “compensate” for placebo effects by long term physiological remodelling?

A: It is hard to believe that meditation would not work at all for those without met/met variant. It would only make things easier.

Q15. Would it be useful to compare the remote bio-PK ability of the two populations studied for placebo in the COMT experiment, to see if that same genetic variant may translate in a different in vitro effect size?

A: Both PK ability and placebo would involve “motor actions” of magnetic body. I however believe that the structure of hierarchy of magnetic bodies is as rich as the spectrum of neurotransmitters and other information molecules. Therefore I prefer to not answer the question!

#### 17.5.4 IV: Biophotons In Long Range Effects: DMILS From Life Precursors To Biosphere; Morphogenetic Fields, GCP, TGD

Q16. There is some evidence for remote viewing by healer and healee. Could this be due to bio-photon emissions induced through external qi?

A: The TGD expectation differs from the usual view. Dark photons is what is relevant for remote mental interactions and sending and receiving of dark photons involves leakage as bio-photons, which are ordinary photons. Various correlations between bio-photon emissions at sending and receiving ends could serve as signature for the presence of remote mental interactions, say remote viewing and healing, say correlations of temporal patterns, correlations between energies of bio-photons, and the frequencies of dark photons manifesting as EEG frequencies. Optimistically one could even expect that the ratios of peak EEG frequencies are same as those of peak bio-photon frequencies. Healing involves visualization and this might imply that also remote viewing is induced as a side product. If pineal gland functions like a “third eye” able to remote view by using dark photons instead of ordinary ones as for lower animals, its role in all remote mental actions could be important. Could this be tested by looking at what happens in pineal gland or some other brain region during remote mental interactions? Could the ability of birds and fishes to migrate to the birth places be one spectacular example of remote mental interaction? This is discussed in more detail in Appendix.

Q18. Can one imagine any technology differentiating between memory/imagination and remote perception using bio-photon profiles.

A: In TGD framework it is surprisingly difficult to distinguish between these two since also memories and vision about future can be also seen as examples of remote viewing. If fishes and birds are able to find their birth places in the manner discussed in Appendix, one would have a rather dramatic example about remote sensory perception. Hypnosis could be seen as second dramatic example of remote mental interaction.

Q19. Is the increased photon emission at living recipients due to a change in physiology? Or of energy/signature of entanglement. Stress related clinical research of meditation or research with focus on quantum non-locality?

A: TGD expectation would be that the emission would be basically due to leakage during communications to some parts of magnetic bodies involved. If one is ready to believe in dark photons and magnetic body, neuropharmacology of conscious experience and quantum non-locality inspired approach could be combined together. Questions to be asked would such as “What what bio-photon energy and what ELF frequency (that is  $h_{eff}$ ) does a particular information molecule/neurotransmitter correspond to?” The hierarchy of Planck constants and the hierarchical anatomy of magnetic body would correlate with analogous hierarchy of information molecules and their receptors with neurotransmitters at top: this would mean also hierarchy at the level of cells with neurons at the top.

## Chapter 18

# Non-locality in quantum theory, in biology and neuroscience, and in remote mental interactions: TGD perspective

### 18.1 Introduction

Non-locality seems to be a basic aspect of what it is to be living. Living system is elementary particle like coherent unit. The phenomenon of memory suggests temporal non-locality. Also remote mental interactions - if real - suggest non-locality. In fact, non-locality - both spatial and temporal - is the basic element of entire quantum TGD, and in particular, of its applications to quantum biology, neuroscience, theory of consciousness, and also of remote mental interactions.

In the following I make kind of pseudo deduction of the picture provided by Topological Geometrodynamics (TGD) by starting from empirical findings loosely related to non-locality rather than problems of General Relativity or of particle physics. The hope is that this could make the basic ideas of TGD easier to grasp.

#### 18.1.1 What does non-locality mean physically?

Both spatial and temporal non-locality are possible and manifested as spatio-temporal coherence not expected on basis of classical and standard QM considerations.

There are many hints about the nature of non-locality.

1. Spatial non-locality manifest itself as a coherent behavior: organisms behave like independent coherent units. The idea about sacks of water containing some chemicals able to climb in trees and write poems does not look plausible. At the level of brain spatial coherence manifests itself as synchronous behavior of brain regions.
2. Temporal non-locality manifests itself as temporal synchrony, especially so in the dynamics of brain. Also memories suggest temporal non-locality. Also various functions/behavioral patterns meaning intentional goal-directed action reflect temporal non-locality. In EEG quasi-stationary segments separated by rapid transients appear [J79].
3. Libet's findings [J31] about anomalous time ordering of conscious decision and neural correlates of associated action suggest that signals can propagate backwards in time. Motor actions would involve signals propagating backwards in time and sensory-motor dichotomy could correspond to two arrows of time.
4. Fantappie [J133] suggested long time ago that the arrow of time is not always the same in living matter and christened the entropy increasing in reverse direction of time syntropy. Spontaneous self assembly could be example of process taking place in reverse direction of



time as a decay process. This would however imply that experienced time having always the same direction cannot be equated with the geometric time. There are also other reasons for distinguishing between these two times.

**Questions:** Do we really understand the notion of time, in particular the relationship between geometric time and the experienced time? What experienced time is? Is the arrow of time always the standard one?

Temporal non-locality is very difficult if not impossible to understand in the standard physics framework, where 3-D snapshot of reality together with initial values for generalized positions and velocities determine everything. Are the basic objects 4-dimensional? Should one consider generalized positions at two values of time as basic data. Could kind of generalized Bohr orbits be in question. Could the basic entities be events - pairs of 3-D snapshot at different values of geometric time?

Should ordinary positive energy ontology (PEO) be replaced with something different, in which pairs of states - physical events - or equivalently the 4-dimensional space-time evolutions connecting them, are basic entities. One can think that these pairs of initial and final states are zero energy states in the sense that the values of various conserved quantum numbers for the positive and negative energy parts sum up to zero. This would allow to have deterministic dynamics for connecting time evolutions without loss of laws of physics. I call this ontology Zero Energy Ontology (ZEO). ZEO would be much more general than PEO but consistent with conservation laws and solve the to-be-or-not-to-be question of theoretician: why to see the pains of constructing a theory if only one particular solution of equations is realized in Nature: one cannot test the theory without additional assumptions. In ZEO based quantum theory any zero energy state could be created from vacuum.

### 18.1.2 Living systems have shape

Living organisms have shape, which is non-local property. All physical systems have shape. These shapes appear in all scales and in the case of fundamental biomolecules the shapes have crucial significance for the functioning of living matter. For instance, the dynamical folding of DNA double strand is essential for transcription.

In standard physics the shape is described in terms of densities of particles as something phenomenological. In the modelling the shape is fed in as a phenomenological geometric input and there is no attempt to really deduce the shape from microscopic physics as reductionism would demand. It is highly questionable whether this attempt could be even successful.

Could shape as something non-local be something real?

1. Geometry and topology provide two definitions of shape. Could the space-time topology and geometry - its shape - be non-trivial in even macroscopic scales? This idea does not conform with the general relativistic view according to which space-time would be topologically rather uninteresting above Planck scale. One would lose the energy momentum conservation as consequence of lost space-time symmetries (translations and Lorentz transformations). Also topology change for 3-space, which takes place routinely in living matter systems, is impossible in this framework.
2. How could one modify the general relativistic view? The hint comes from superstring models in which string world sheets are 2-D space-times represented as 2-D surfaces - sub-manifolds - in 10-D space-time. String models fail but one could perhaps modify them. The basic problem of string models is how to get the 4-D space-time from string models. Why not replace 2-D surfaces with 4-D ones in some higher-D space-time, which could be taken to be fixed because the dynamics of space-time would be coded by its geometric shape. One would avoid the notorious landscape problem and loss of predictivity.

The identification of space-time as 4-surface would change completely the view about what space-time is. The good news is that one does not lose classical conservation laws if the higher-dimensional space-time is chosen properly. Space-time surfaces can contain even Euclidian regions (time and space in the same role) without loss of basic conservation laws. This means huge flexibility.

3. The visible world is also hierarchical: shapes within shapes. Biological body consists of organs consists of cells consists of biomolecules consists of ... . This fractal like structure should have counterpart as the structure of space-time surface. Space-time surface indeed turn out to have this kind of structure: ... space-time sheets glued to larger space-time sheets glued to.... I refer to this structure as many-sheeted space-time and we indeed see it directly!

**Question:** Could space-time be 4-D surface in some higher-D space-time - many-sheeted space-time. The shape of spacetime would have meaning also as shape in this higher-D space-time.

### 18.1.3 Does coherence in long spatial and temporal scales reduce to macroscopic quantum coherence?

Coherence could be understood as macroscopic quantum coherence if living systems are macroscopic quantum systems. But how?: Planck constant is too small? There are several hints suggesting that Planck constant could have actually a spectrum.

#### Effects of ELF em fields on living matter, macroscopic quantum coherence, and dark matter and energy

The effects of ELF em fields on vertebrate brain involving both physiology and behavior look like quantal appearing at multiples of basic frequency assignable to cyclotron transitions of biologically important ions such as  $\text{Ca}^{++}$  ion in endogenous magnetic field of  $B_{\text{end}} = 2B_E/5 = .2$  Gauss, where  $B_E = .5$  is the nominal value of Earth's magnetic field [J47] The problem is that cyclotron energies are extremely low: more than ten orders of magnitude below thermal energies.

**Question:** Could Planck constant have nonstandard values: say  $h_{\text{eff}} = n \times h$ .

If this were the case, quantum scales would be scaled up. Energy  $E = h_{\text{eff}} f$  associated with given frequency is scaled up. Could EEG consist of photons with  $h_{\text{eff}} = n \times h$  such that the energies of dark EEG photons are above thermal energies. These photons can transform to ordinary photons perhaps identifiable as bio-photons in the energy range of visible and UV photons.

What these phases of matter with non-standard Planck constants could be? Why we have not observed them? We know that dark energy and dark matter exist. Could they correspond to  $h_{\text{eff}} = n \times h$  phases? If so, dark matter could be in key role in living matter. Two mysteries would find a common explanation.

**Question:** Should one generalize quantum theory so that dark matter/energy would be assignable to hierarchy of  $h_{\text{eff}} = n \times h$  phases?

#### Where could the dark matter reside?

Where could the dark matter reside?

1. The first hint comes from quite recent finding that the brain hemispheres of persons having no corpus callosum are in synchrony (see <http://tinyurl.com/3gjhtgb>). What synchronizes the brain hemispheres in this kind of situation? The hint comes from spontaneous synchronization of clocks (penduli) involving generation of very weak periodic perturbation - "boss" - forcing the clocks in same phase. Is there a kind of "boss", which forces neurons to march in synchrony [K81]?
2. Second hint comes from the observation that EEG correlates strongly with the contents of consciousness. Why? Information costs energy. Why to construct information not used for any purpose? Could it be that EEG communicates information about brain state to some entity? Could this entity be the "boss" in turn using EEG to control the brain. The wavelength associated with EEG frequency 7.8 Hz is circumference of Earth. Could this entity be of this size or even larger?
3. There is a further hint: the effects of ELF radiation were at cyclotron frequencies in endogenous magnetic field with strength of .2 Gauss. For iron it corresponds to 10 Hz frequency for which wavelength is slightly larger than circumference of Earth. Could the "boss" be a magnetic field structure - magnetic body (MB) - assignable to the organism?

4. There is an objection against this idea. In Maxwell's electrodynamics magnetic fields of different organisms interfere to a random background so that the informations from separate organisms would be lost. Standard space-time concept is not enough. Should the very notion of space-time be such that the magnetic field structures of different organisms behave like separate entities without interference between them. The phases of matter with different values of  $h_{eff}$  would in some sense live in different worlds - they would be dark relative to each other - but also interact with matter visible to us. Generalization of space-time concept seems to be necessary. The guess is many-sheeted space.

**Question:** Do magnetic bodies carrying dark matter characterized by non-standard value of Planck constant carry serve as "bosses"? They should also effectively correspond to separate space-times.

### How to create dark matter?

One eventually encounters the question how to test the theory. To achieve this one should be able to create dark matter by inducing phase transition of ordinary matter to dark matter or to do the opposite: ordinary matter would mysteriously disappear somewhere or pop up somewhere. This would serve as a signature for the dark matter. There are some hints.

1. Biosystems look like critical systems. Sensory systems have optimal sensitivity to small changes in environment. There is analogy with fundamental physics: in particle accelerators measurement instruments are critical systems to maximize the sensitivity and transform microscopic effects to macroscopic ones. Neural system is an excellent example of a control system in which small control signals give rise to large effects. Homeostasis can be understood in terms of positive and negative feedback keeping the system near criticality. Living systems are functional in rather narrow temperature range. There is also evidence for quantum criticality (QC) at molecular level [I78].
2. The appearance of  $h_{eff} = n \times h$  dark matter should lead to a generation of long range coherence and non-locality. On the other hand, long range fluctuations are the tell-tale signature of criticality. Could dark phases with  $h_{eff} = n \times h$  be created at quantum criticality (QC)?

**Question:** Is QC essential for having non-locality manifesting itself as long range correlations, dark matter, and  $h_{eff} = n \times h$  phases.

### 18.1.4 Summing up

To sum up: these propagandistic arguments suggest the following picture.

1. Temporal non-locality requires that PEO is replaced ZEO. The arrow of time is not always the same. The relationship between experienced and geometric time must be understood: they are not same although they are strongly correlated.
2. The importance of shape - a non-local concept - in biology suggests identification of space-time as 4-D surface in some higher-D space-time.
3. EEG contains information about the contents of consciousness: EEG communicates information to some entity identified as magnetic body serving as intentional agent receiving sensory input and controlling biological body. The organism-environment duality would be replaced with trinity involving also MB.
4. Coherence in long scales reduces to quantum coherence for  $\rightarrow h_{eff} = n \times h$  dark matter hierarchy and dark matter at magnetic bodies is the quintessence of living matter.
5. Criticality of living matter reduces to long range correlations implied by QC. Dark matter is created at QC and implies also non-locality.

The challenge is to realize this picture mathematically. TGD does this although I ended up with it with motivations coming from General Relativity and particle physics. In the sequel I discuss the mathematical formulation and its physical interpretation. I also discuss briefly various applications of this picture.

## 18.2 TGD

General theory of relativity (GRT) plagued by the problem that the notions of energy and momentum are not well-defined for curved space-time. The proposal for overcoming the energy problem (made 1977, thesis came 1982) was that space-times are not abstract 4-D manifolds but representable as 4-D surfaces in certain 8-dimensional space-time  $H = M^4 \times CP_2$ , which is empty Minkowski space  $M^4$  with points replaced with certain very small 4-D space  $CP_2$  fixed uniquely from the condition that standard model symmetries and standard model fields can be geometrized. This choice of  $H$  is uniquely fixed both by twistorial considerations [K114, L59] or by the condition that theory is consistent with standard model symmetries.

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

TGD Universe is predicted to be fractal: this replaces the naïve Planck length scale reductionism with fractality for which the simplest realization would be p-adic length scale hypothesis emerging from p-adic thermodynamics and dark matter hierarchy. Non-trivial predictions emerge in all scales from Planck length to cosmology and this makes it very difficult to communicate TGD for colleagues believing firmly on naïve length scales reductionism.

In what follows I will proceed from quantum TGD to classical TGD without starting from particle physics observations - it would be extremely boring to repeat same old arguments again and again and reader can find these arguments from [K127].

### 18.2.1 Quantum TGD

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

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

The condition that the entire quantum theory is geometrized requires infinite-dimensional geometric structure instead of space-time and the “world of classical worlds” (WCW) identified roughly as the space of space-time surfaces is the natural identification [K28, K50].

1. The construction of quantum TGD leads to a generalization of the notion of super-space of Wheeler and to construction of infinite-dimensional geometry that I call “World of Classical Worlds” (WCW) having rough mathematical identification as space of 3-surfaces in  $H$  (ZEO dictates the identification in more detail). The mere mathematical existence of WCW geometry fixes it essentially uniquely - this is true already for the loop spaces of string model [A26] - and therefore physics. A huge generalization of the symmetries of super-string models emerges giving hopes of understanding the theory.

The geometrization of hermitian conjugation of quantum theory requires that WCW allows complex structure its metric is Kähler metric [K50] and coded by Kähler function identified in terms of Kähler action for a preferred extremal: this gives direct connection with classical physics since induced Kähler form define classical U(1) field, for the U(1) factor of electroweak gauge group assignable with weak hyper-charge. twistor lift implies the presence of a volume term identifiable in terms of cosmological constant. It would bring also Planck length into the theory as the radius of twistor sphere [K114].

2. Quantum states are identified as classical WCW spinor fields so that there is no need to perform quantization and state function reduction is the only genuinely quantal aspect of TGD [K125, K93]. Spinor structure requires identification of gamma matrices anticommuting to WCW metric and if the metric is Kähler metric, the anti-commutation relations are

completely analogous to those of fermionic oscillator operators and one can indeed express the gamma matrices as linear superpositions of fermionic oscillator operators at space-time surface. Second quantization at space-time level is a purely classical notion at WCW level and becomes geometrized in WCW context.

3. ZEO (Zero Energy Ontology) is an essential element of theory. Usually one assumes that in classical physics generalized positions and their time derivatives (generalized velocities) giving at given moment of time in 3-D snapshot of space-time dictated the time evolution. This has generalization to Schrödinger equation. One has initial value problem.

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

ZEO is much more flexible than ordinary ontology since any zero energy state can be created from vacuum whereas in standard classical ontology only one solution of field equations is realized and in principle it is not possible to test the theory without additional assumptions. ZEO is especially natural in biology and neuroscience: the notions like function, behavioral pattern, and habit are not easy to describe in terms of the state of organism as 3-D snapshot of time evolution.

The two time=constant snapshots are actually replaced with past and future boundaries of CD, which is the intersection of future and past directed light-cones of Minkowski space with each point replaced with  $CP_2$ . The ends of space-time surfaces are at these boundaries. Zero energy states have opposite conserved quantum numbers at the opposite boundaries of CD: this guarantees that conservation laws are satisfied and the system is consistent with standard laws of physics. CDs form a fractal hierarchy. There are CDs within CDs and CDs can also overlap.

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

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

This eventually led to the realization that partonic 2-surfaces and string world sheets should be enough for the formulation of WCW geometry and quantum TGD [K27]. Classical fields in the interior of space-time surface would be needed only in quantum measurement theory, which demands classical physics in order to interpret the experiments. The outcome is SH stating that quantum physics should be coded by string world sheets and partonic 2-surfaces inside given CD. SH is very much analogous to the AdS/CFT correspondence but is much simpler: the simplicity is made possible by much larger group of conformal symmetries. 2-dimensionality of space-time regions carrying fermion field can be deduced also from the condition that electromagnetic charge is well-defined for spinor modes: this requires that W boson fields vanish and this implies in the generic case 2-D string world sheets. Number theoretic vision suggests the interpretation of string world sheets and partonic 2-surfaces as commutative or co-commutative sub-manifolds of the space-time having quaternionic (associative) tangent space as a 4-surface in the embedding space with octonionic (non-associative) tangent space [K107, K123].

If these 2-surfaces satisfy some consistency conditions one can continue them to 4-D space-time surface inside CD such that string world sheets are surfaces inside them satisfying

the condition that charged (possibly all) weak gauge potentials identified as components of the induced spinor connection vanish at the string world sheets and also that energy momentum currents flow along these surfaces. String world sheets carry second quantized free induced spinor fields and fermionic oscillator operator basis is used to construct WCW gamma matrices.

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

### Quantum Criticality and hierarchy of Planck constants as dark matter hierarchy

The Kähler coupling strength  $\alpha_K$  appearing in Kähler action is analogous to temperature. In its original form [K50] QC stated that this coupling strength is analogous to critical temperature and therefore has discrete spectrum. This idea makes sense even if Kähler action is generalized to contain additional terms: all coupling constants would be analogous to critical thermodynamical parameters.

Indeed, the twistor lift of TGD [K114, L59] replacing space-time surfaces with their twistor spaces in 12-dimensional product of twistor spaces of  $M^4$  and  $CP_2$  indeed brings in cosmological constant  $\Lambda$  and Planck length as radius of the sphere  $S^2$  serving as the fiber of twistor space. This lift makes sense only for  $M^4 \times CP_2$  making this choice unique. If Planck length and cosmological constant emerge in this manner their spectrum would be fixed by QC condition. The negative pressure implying accelerated cosmic expansion can be also assigned to magnetic flux tubes with monopole flux so that the situation remains open.

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

1. The hierarchy of Planck constants labelling a hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of the super-symplectic algebra assignable to the boundary of CD with points replaced with  $CP_2$ . The conformal weights are  $n$ -ples of those for the entire algebra. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question. For  $n > 1$  the hierarchy levels are interpreted in terms of dark matter. What is highly non-trivial that the conformal weights itself need not be integers or half integers as usually. The generators of algebra could have conformal weights which are proportional to zeros of zeta and poles of zeta so that the number of generating elements (finite for ordinary super-conformal algebras) would be infinite [L43]. Physical states would however have real conformal weights which would be half integers (conformal confinement).

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

2. QC in turn reduces to the number theoretic vision about SH. String world sheets carrying fermions and partonic 2-surfaces are the basic objects as far as pure quantum description is considered. Also space-time picture is needed in order to test the theory since quantum

measurements always involve also the classical physics, which in TGD is an exact part of quantum theory.

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

3. The hierarchy of algebraic extensions of rationals defines the values of the parameters characterizing the 2-surfaces, and one obtains a number theoretical realization of an evolutionary hierarchy. One can also algebraically continue the space-time surfaces to various number fields - reals and the algebraic extensions of p-adic number fields. Physics becomes adelic [K123].

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

4. The assignment of the hierarchy of Planck constant to a hierarchies of inclusions of hyperfinite factors of type  $II_1$  is natural. Also the interpretation in terms of finite measurement resolution makes sense. As  $n$  increases the sub-algebra acting as conformal gauge symmetries is reduced so that some gauge degrees of freedom are transformed to physical ones. The transitions increasing  $n$  occur spontaneously since criticality is reduced. A good metaphor for TGD Universe is as a hill at the top of a hill at the top.... In biology this interpretation is especially interesting since living systems can be seen as systems doing their best to stay at criticality using metabolic energy feed as a tool to achieve this. Ironically, the increase of  $\hbar$  would mean increase of measurement resolution and evolution!
5. If twistor lift is not performed, the only coupling constant of the theory is Kähler coupling constant  $\alpha_K = g_K^2/4\pi\hbar$ , which appears in the definition of the Kähler function  $K$  characterizing the geometry of WCW. In the most general case  $\alpha_K$  has a spectrum of critical values and this conjecture seems at this moment the most reasonable one. It has indeed turned out that the discrete spectrum could have interpretation in terms of discretized coupling constant evolution for U(1) coupling constant of standard model. The identification of the spectrum in terms of zeros of so called fermionic zeta function expressible in terms of Riemann zeta is attractive [L43]. The exponent of  $K$  defines vacuum functional analogous to the exponent of Hamiltonian in thermodynamics. The allowed values of  $\alpha_K = g_K^2/4\pi\hbar_{eff}$  should be analogous to critical temperatures and determined by QC requirement.

### 18.2.2 Classical TGD

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

### Space-time surfaces as preferred extremals of Kähler action

Preferred extremal of Kähler action have remained for a long time one of the basic poorly defined notions of TGD. There are pressing motivations for understanding what “preferred” really means. For instance, the conformal invariance of string models naturally generalizes to 4-D invariance defined by quantum Yangian of quantum affine algebra (Kac-Moody type algebra) characterized by two complex coordinates and therefore explaining naturally the effective 2-dimensionality [K114].

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

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

### Many-sheeted space-time and topological field quantization

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

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

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

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

The notion of magnetic body carrying dark matter identified as macroscopically quantum coherent  $h_{eff} = n \times h$  phases has become central in TGD inspired quantum biology [K82, K81]. Magnetic body becomes intentional agent using biological body as a sensory receptor and motor instrument. Communication and control would be based EEG and its fractally scaled variants consisting of dark photons. The size of magnetic body is rather large, at EEG frequency range the size scale is defined by the wave length of photons involved and is of the order of the size scale of Earth. The proposal is that bio-photons are created in a phase transition transforming dark photons to ordinary photons [K14]: since bio-photons have energies are in the range of visible and UV photons, this requires that the value of  $h_{eff}/h$  is roughly the ratio of the frequency of EEG photon with the frequency of visible photon and rather large.

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



### New ontology

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

1. At space-time level many-sheeted space-time represents new piece of ontology. Single space-time sheet is extremely simple objects and the information needed to construct it is by SH 2-dimensional. Complexity emerges at quantum field theory limit when the sheets of the many-sheeted space-time are replaced with single slightly curved region of  $M^4$ .
2. The hierarchy of Planck constants identified in terms of dark matter as phases of ordinary matter represents second new ontological element. Dark matter is assumed to reside at magnetic body which also represents a new ontological element.
3. A further modification of ontology is the replacement of the usual positive energy ontology (PEO) with what I call ZEO already described. In ZEO quantum states are superpositions of quantum evolutions connecting the positive and negative energy parts of the states. Zero energy states are essentially 4-D and only the positive and negative energy parts are 3-D. Quantum jumps/state function reductions re-create the zero energy states with new ones and this allows to solve the basic paradox of ordinary quantum measurement theory due to the fact that non-determinism of state function reduction is in conflict with the determinism of unitary time evolution. One also ends up with identification of "self" as conscious entity: self corresponds to generalized Zeno effect: to a sequence of state function reduction to say positive (positive) energy part of zero energy state [K9] [L70]. Self dies when the first reduction to negative (positive) part occurs. Also the origin for the flow of experienced time can be understood.

### Hierarchies

TGD Universe is characterized by various hierarchies. At space-time level there is a hierarchy of space-time sheets labelled by a hierarchy of p-adic length scales coming as primes near powers of two and probably generalizing to primes near powers of prime [K67, K123]. In ZEO and at embedding space level there is a hierarchy of CDs labelled by their size scales coming as integer multiples of  $CP_2$  scales. The fractal hierarchy of symplectic sub-algebras leads to a generalization of quantum theory based on a hierarchy of Planck constants characterizing hierarchy of dark matters [K37, ?], hierarchies of inclusions of hyper-finite factors [K124], hierarchies of breakings of super-symplectic gauge symmetry [K125, K93] associated with a hierarchy of quantum criticalities [?]. There is also a number theoretic hierarchy of algebraic extensions of rationals accompanied by those of p-adic number fields [K123] allowing to see evolution as a gradual increase of the complexity for extensions of rationals assignable to the parameters characterizing string world sheets and partonic 2-surfaces. In TGD inspired theory of consciousness [K59] self hierarchy emerges.

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

By SH implied by the SGCI the core of the mathematical description of quantum TGD reduces to that for 2-D systems associated with partonic 2-surfaces and string world sheets. Although space-time is 4-D, all that can be said mathematically about quantum physics can be reduced to these 2-D "space-time genes". 4-D space-time surfaces are however necessary for the classical description of TGD necessary to interpret quantum measurements in terms of frequencies and wavelengths classical space-time picture about particles. This reduction implies that the representations of charges of super-symplectic Yangian [K114, L59] are in terms of fermionic strings connecting partonic 2-surfaces, which means enormous simplification of the theory. This representation also involves a generalization of AdS/CFT duality to TGD framework as manifestation of SGCI basically [K27].

#### 18.2.3 Number theoretical physics

Number theoretical physics involves several threads [K123].

1. p-Adic physics as correlate for cognition, imagination, and intentionality [K106] p-Adic physics was originally inspired by the challenge of understanding the mass scales of elementary particles but it soon turned that the interpretation in terms of mathematical correlates of cognition and imagination is very natural. This in turn forced the conclusion that cognition is probably present in all length scales, rather than only at the level of brain. The eventual outcome was a fusion of real and p-adic physics in terms of adelic physics.
2. Classical number fields emerge very naturally in TGD framework [K107]. For instance, the conjecture is that space-time surfaces as preferred extremals of Kähler action are quaternionic sub-manifolds of embedding space endowed with octonionic structure. Also quaternion analyticity [A43, A35] as a generalization of complex analyticity central in string models is very attractive conjecture [K114] in accordance with the original vision that 2-D analyticity in some sense generalizes to its 4-D variant.
3. Infinite primes [K105] are constructed by a repeated second quantization of arithmetic quantum field theory and could be essential for understand of quantum TGD.

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

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

1. The attempt to understand elementary particle mass spectrum led to the hypothesis that p-adic number fields - one for each prime  $p = 2, 3, 5, \dots$ , which are completions of rationals like real numbers, allow to construct what I called p-adic thermodynamics allowing to understand particle masses as kind of thermal masses resulting when massless particles suffer slight thermal mixing with particles with mass scale given by  $CP_2$  mass of order  $10^{-4}$  Planck masses.
2. The failure of well-orderedness property for p-adic numbers brings in the corresponding failure due to a finite measurement resolution and leads to the vision that p-adic numbers are ideal for describing the effects of finite measurement resolution and cognitive resolution.
3. The failure of strict determinism for the partial differential equations suggest strongly that it serves as a correlate for cognition, imagination, and maybe also intention is closely related.
4. The fusion of real physics and various p-adic physics (identified as correlates for cognition, imagination, and intentionality) to single coherent whole leads to adelic physics [K123]. Adeles associated with given extension of rationals are Cartesian product of real number field with all p-adic number fields extended by the extension of rationals. Besides algebraic extensions also the extension by any root of  $e$  is possible since it induces finite-dimensional p-adic extension. One obtains hierarchy of adeles and of corresponding adelic physics interpreted as an evolutionary hierarchy.

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

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

$$S = - \sum_k P_k \log(P_k) \rightarrow \sum_k P_k \log(N_p(P_k)) \quad . \quad (18.2.1)$$

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

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

The possibility of NE together with NMP [K61] implies that the reduction does not always lead to an unentangled state but can generate NE. Living systems would be systems generating NE and biological evolution could be seen as a gradual generation of negentropic resources - I have called them Akashic Records. For rational probabilities entanglement negentropy equals to real entropy [L63]. This might relate to the Jeremy Englands vision that high entropy is relevant for living matter.

What is important that entanglement negentropy and thermodynamical entropy are *not* negatives of each other. Hence NMP is not in conflict with the second law but predicts it for the ordinary matter as a consequence of non-determinism of state function reduction. It is however true that large entropic resources realized as a large number of states with the same energy makes possible both large thermodynamical entropy and NE with large negentropy.

### The extension of real physics to adelic physics

In TGD framework cognition is described in terms of p-adic number fields and has led to a fusion of real and various p-adic physics to what I call adelic physics [K123]. Real physics corresponds to sensory experience and p-adic physics to cognition and imagination. Originally I talked about p-adic physics as physics of cognition and intentionality but I have become ambivalent about intentionality: this issue remains unsettled.

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

1. The naïve idea is that rationals belong to the intersection of reals and p-adics. More generally, points in algebraic extension of rationals would be common to realities and p-adicities which correspond to “thought bubbles” or imaginations. This hierarchy defines a hierarchy of adeles having interpretation in terms of evolution leading to increasingly complex algebraic extensions of rationals.
2. The first guess was that this means at space-time level that embedding space points with rational valued coordinates (or values in the extension of rationals) correspond to common points of real and p-adic space-time surfaces. This picture however leads to problems with both GCI and key symmetries of TGD. What are the preferred coordinates of space-time surface which would be in algebraic extension of rationals in the intersection? Should one restrict symmetry groups to their discrete subgroups?
3. A partial resolution of the problem came from the realization that the intersection of realities and p-adicities corresponds to space-time surfaces, whose representation is such that they make sense both in real and p-adic sense [K123]. This requires that the WCW coordinates of these surfaces are invariant under various symmetries and general coordinate transformations of space-time belong to the extension of rationals in question. At the level of WCW the coordinates are highly unique on basis of symmetries and by GCI at space-time level. This also means discretization of the infinite-dimensional WCW and together with huge isometry group of WCW gives hopes about computability of TGD.

4. As often happens, also the original idea about points of given algebraic extension of rationals as common to real and p-adic space-time surfaces makes sense: one can say that these discrete points define cognitive representations in the real world. The point is that space-time surfaces can be identified as 4-surfaces in  $H$  and discretization is induced by that of  $H$ . At the first step, the pieces of hyperboloids inside  $CD$  and  $CP_2$  can be replaced with their discrete variants making sense both in real and p-adic sense [L68].

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

The outcome is a precise mathematical formulation for the p-adic counterparts of space-time surfaces as preferred extremals of Kähler action. The p-adic variants of coset spaces can be seen as discretizations of real coset spaces with discrete points replaced by p-adic continua analogous to the monads of Leibniz [L68]. This would make possible discretization without loosing differentiability central for field equations. One can define p-adic field equations inside these monads and strong SH makes sense in both real and p-adic sector.

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

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

### p-Adic physics as physics of imagination

A further step in the progress came from the discovery of SH [K27]. 2-dimensional surfaces (string world sheets and partonic 2-surfaces) are fundamental objects and 4-D physics is a kind of algebraic continuation from this intersection of reality and various p-adicities in both real and p-adic sectors of the adelic Universe. 4-D space-time surfaces are preferred extremals of Kähler action making them effectively 2-D in the sense that the 2-D surfaces serve as “space-time genes”. Also the quantum states assignable to the 2-D surfaces can be algebraically continued to the entire 4-D space-time.

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

This argument becomes more precise as one realizes that SH is slightly broken: even information theoretically one has only effective 2-dimensionality [K123]. This means that 4-surfaces as preferred extremals are dictated by the data at string world sheets and possibly also partonic 2-surfaces and by data discrete set of points with preferred embedding space coordinates in the extension of rationals defining the adelic structure by inducing the extensions of p-adic number fields. For p-adic number fields pseudo-constants make it easy to construct the algebraic continuation to

a preferred extremal containing the discretization. For reals this is possible only in special cases. These discretizations correspond to realizable imaginations.

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

### Negentropic entanglement (NE)

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

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

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

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

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

1. The Hilbert spaces defining state spaces has as their coefficient field always some algebraic extension of rationals so that number theoretic entropies make sense for all primes. p-Adic numbers as coefficients cannot be used and reals are not allowed. Since the same Hilbert space is shared by real and p-adic sectors, a given state function reduction in the intersection has real and p-adic space-time shadows.
2. State function reductions at these 2- surfaces at the ends of CD take place in the intersection of realities and p-adicities if the parameters characterizing these surfaces are in the algebraic extension considered. It is however not absolutely necessary to assume that the coordinates of WCW belong to the algebraic extension although this looks very natural.

3. Does NMP apply to the sum of real and p-adic entropies (Option 1) or only to the sum of p-adic entanglement entropies (which can be negative) (Option 2). The situation is not settled yet.
  - (a) For Option 1 the total entropy vanishes identically for *rational* probabilities and NMP would say nothing about the situation [L63]. NMP would not prevent or favor state function reduction. It is not clear whether this situation corresponds to that in the physics of ordinary matter as opposite to that of living matter. For algebraic probabilities there would be a competition between real and p-adic sectors and p-adic sectors would win for algebraic extensions in the sense that p-adic entropy would be larger than real entropy.
  - (b) For Option 2 NMP would stabilize NE also for rational probabilities. One can wonder whether one obtains the ordinary state function reduction at all for this option. In ZEO state function reductions to the opposite boundary of CD would be however forced to occur and second law would be the outcome also in this case.

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

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

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

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

### 18.3 ZEO and generalization of quantum measurement theory to a theory of consciousness

TGD inspired theory of consciousness can be seen as a generalization of the quantum measurement theory by making observer part of physical system as conscious entity subject to laws of quantum physics. I will talk about this conscious entity as self and pose no a priori restrictions what self can be. The basic vision is that quantum measurement theory must be generalized so that observer ceases to be an outsider and is described by the quantum physics. ZEO plays a key role in this generalization and makes highly non-trivial predictions. Raising quantum measurement to a universal physical phenomenon requires the identification of the density matrix of subsystem as a universal observable and introduction of Negentropy Maximization Principle (NMP) [K61] as the fundamental variational principle of consciousness.

#### 18.3.1 ZEO

One must generalize ontology in order to solve the contradiction between deterministic time evolution and the evolution by state function reductions. This requires understanding the notion of

subjective time and its relationship to the geometric time. The new ontology must allow to see selves as something unchanged in some aspects and continually changing in some other aspects. Also the experience about the flow of subjective time must be explained.

1. In TGD framework the answer is ZEO [K61]. The concept of quantum state is generalized. States are now analogs for physical events characterized by initial and final quantum state that is pairs of positive and negative energy states. The conserved quantum numbers of the members are opposite so that zero energy states can be created from vacuum. This is a radical generalization of the physicalist world of view but entirely consistent with conservation laws: there is no need to give laws of physics in order to have free will. Positive and negative energy parts of the zero energy states can be assigned to opposite light-like boundaries of CDs, which are intersections of future and past directed light-cones multiplied by  $CP_2$ . CDs form a fractal scale hierarchy. They can be seen as embedding space correlates for the 4-D perceptive fields of selves.
2. CD is a central notion in ZEO and serves as embedding space correlate for self. State function reduction can occur to either boundary of CD ("upper" or "lower"). Self can be seen as a generalized Zeno effect - a sequence of state function reductions to either boundary of CD. These two kinds of selves can be said to be time reversals of each other. The period of non-boiling pot corresponds to the passive boundary of CD not changing in the reductions: also the parts of zero energy states at this boundary remain unaffected. The opposite - active - boundary is shifted towards future reduction by reduction and states at it are changed. The shifting the geometric future gives rise to the experienced time flow. This is the analog of unitary time evolution.

### 18.3.2 NMP as variational principle of consciousness

One must generalize standard quantum measurement theory to a theory of consciousness. The notions of NMP, entanglement negentropy and negentropic entanglement (NE) are the key notions.

1. Negentropy Maximization Principle (NMP) [K61] is the variational principle of consciousness in TGD framework reducing to quantum measurement theory in Zero Energy Ontology assuming adelic physics. Negentropy Maximization Principle or something akin to it should be consistent with the standard rules of quantum measurement theory and possibly generalize them. In particular, NMP should tell which observables are measured in given entangled situation. The density matrix defined by the entanglement is the unique candidate for the universal observable. All systems could be said to give rise to quantum measurements. NMP must decide how long the self "lives": self lives as long as repeated state function reductions at the same boundary give the maximal negentropy gain.
2. One must have a mathematical definition of negentropy [K61]. When NE is possible and what is the measure for the negentropy? Shannon entropy is the natural starting point but it cannot have negative values in real context. One could define information as a reduction of entropy as conscious observer learns the state of the system under consideration: the IIT approach of Tononi [J149], [L72, L65] relies on this notion and leads to a circular definition of conscious information. Now however the conscious entity would be this system and this definition of information does not apply. One must find a genuine measure of information assignable to entanglement as entanglement negentropy rather than lack of information about the state of either entangled member of entangled by identifiable as entanglement entropy (ordinary Shannon entropy).

Here one cannot avoid number theory and I can only apologize. The p-adic generalization of Shannon entropy by replacing the logarithms of probabilities with the logarithms of their p-adic norms provides a possible solution of the problem [K61, K9]. It is well defined for algebraic entanglement probabilities belonging to the algebraic extension of rationals defining also the extensions of various various p-adic number fields) [L63].

Adelicity (roughly: adeles correspond to Cartesian product of positive real numbers and all p-adic number fields) holds true in the sense that the sum of real and p-adic information

measures (finite number of primes contribute) over all primes vanishes for rational entanglement probabilities. This is not the case for the algebraic extensions of adeles induced by those of rationals [L63].

It is not quite clear whether NMP applies to the sum of p-adic entropies or to the sum of real and p-adic entropies providing alternative definitions of information. Both options conform with the fact that large entropy seems to be prerequisite for life as proposed Jeremy England [I67] [K78] [L41].

3. NE (negentropic entanglement) is a further key notion and entanglement negentropy identified as number theoretic entanglement entropy, which can be negative. NE can only increase in state function reductions and this brings in evolution forced by NMP.

In the formulation of NMP in terms of maximal negentropy gain one considers divisions of the system into subsystem and complement and finds the pair for which the reduction of entanglement would give maximum reduction of entropy. If the system is irreducible this kind of pair characterized by entropic entanglement cannot be found. The eigenstates of density matrix for negentropically entangled subsystems are in 1-1 correspondence. An interesting question is whether associations in the sense of neuro science corresponds to NE between the states of associated systems.

State function reduction cascade is a key notion. State function reduction sequences is a top down cascade propagating downwards to smaller system sized. First the reduction in CD scale occurs. The resulting two subsystems decompose to two parts and so on until decomposition is not possible anymore because it would not generate negentropy.

There is an obvious analogy with the Integrated Information Theory (IIT) of Tononi and Koch. The quantity  $\Phi$  postulated by Tononi and Koch [J149] resembles negentropy in TGD [L72]. The basic objection against IIT is that the notion of conscious information is circular being based on entropy as fundamental notion. Information is defined as reduction of entropy when conscious entity learns what the state of system is. The notion of conscious information cannot involve this kind of dependence. The outcome is a paradox: printer printer text is conscious if no-one knows about the contents of the file, not if some-one already knows since the definition of conscious information reduces it to conscious information gained by the outsider. This is not surprising, since entropy as a notion belongs to the physics of outsider about object rather than subject.

In TGD framework negentropy for entanglement does not involve this kind of assumption since conscious information represents abstraction or rule with the superposed state pairs  $(a_i, b_i)$  representing the instances of a rule  $(A, B)$  and  $A$  and  $B$  representing concepts.

### 18.3.3 Details related to NMP

What happens in state function reduction and what NMP really says is still far from being completely clear. The basic condition is that standard measurement theory emerges as a special case and is forced by NMP [K61]. This does not however fix the NMP completely.

#### 1. *Adelic NMP as the only reasonable option*

I have considered two options for NMP.

1. In the original approach to NMP it was assumed that both generic entanglement with real entanglement probabilities and entanglement with algebraic entanglement probabilities are possible. Real entanglement is entropic and demands standard measurement theory leading to a 1-D eigen-space of the density matrix. Algebraic entanglement can be negentropic in number theoretic sense for some p-adic primes, and in this case state function reduction occurs only if it increases negentropy. It takes place to N-dimensional eigen-space of the density matrix. The basic objection is that real entanglement is transcendental in the generic case reducing to algebraic entanglement only as a special case. Algebraic entanglement is also extremely rare without additional physical assumptions.
2. In the adelic approach entanglement coefficients and therefore also entanglement probabilities are always algebraic numbers from the condition that the notion of p-adic Hilbert space makes sense. Also extensions of rationals defining finite-dimensional extension of p-adic numbers



(roots of  $e$  can appear in extension) must be allowed. Same entanglement can be seen from both real (sensory) and p-adic perspectives (cognitive). The entanglement is always entropic in the real sector but can be negentropic in some p-adic sectors. It is now clear that the adelic option is the only sensible one.

## 2. Variants of the adelic NMP

The adelic option allows to consider several variants.

1. Negentropy could correspond **a)** to the sum  $N = N_R + \sum_p N_p$  of real and various p-adic negentropies or **b)** to the sum  $N = \sum_p N_p$  of only p-adic negentropies.  $N_p$  is non-vanishing for a finite number of p-adic primes only as is easy to find. In both cases  $\sum_p N_p$  could be interpreted as negentropy assignable to cognition.  $N_R$  might have interpretation as a measure of ignorance of one of the entangled systems about the state of other.
2. NMP implies that state function reduction (measurement of density matrix leading to its eigen-space) occurs if negentropy **1)** is not reduced or **2)** increases. This means that NE is stable against NMP.

Can one select between these options?

1. For option **a)** NMP becomes trivial for rational entanglement probabilities as is easy to find: one has  $N = N_R + \sum_p N_p = 0$ . NMP does not force state function reduction to occur but it could occur and imply ordinary state function reduction as a special case for option **1)** (when eigen-spaces are 1-dimensional). Therefore one would have option **1a)**.
2. If option **1a)** is unrealistic, only the options **1b)** and **2b)** with  $N = \sum_p N_p$  are left. For option **2b)** state function necessarily occurs for  $N = \sum_p N_p < 0$  but not for  $N = 0$  - not even in rational case. For option **2b)** the state function reduction could occur also for  $N = 0$ . However, since  $N_p$  is proportional to  $\log(p)$  and the numbers  $\log(p)$  are algebraically independent,  $N = 0$  is not actually possible so that **1b)** and **2b)** are equivalent. Therefore NMP states that  $N = \sum_p N_p$  must increase for  $N < 0$ : this forces state function reduction to an eigen-space of density matrix.

But is it really possible to have  $\sum_p N_p < 0$  making possible ordinary state function reduction? For rational entanglement probabilities this is not possible by  $S_R = \sum_p N_p$  and one might even speculate that for algebraic extensions one has  $\sum_p N_p \geq S_R$ . Mathematician could probably check the situation.  $\sum_p N_p \geq S_R$  holds true, entanglement is stable against NMP and ordinary state function reduction is not possible. This would leave only the option **1a)** and NE with  $N > 0$  would be stable also now.  $N = 0$  entanglement (possibly rational always) would allow ordinary state function reduction.

This leaves still two options. Negentropy gain is **A)** maximal or **B)** non-negative but not necessarily maximal: I have considered the latter option earlier. For option **1a)** reduction is possible only for  $N = 0$  and in this case negentropy gain is zero for all possible eigen-spaces of density matrix and maximality condition does not say anything.

1. For option **1a)** reduction is possible only for  $N = 0$  and in this case negentropy gain is zero for all possible eigen-spaces of density matrix and **A)** and **B)** are equivalent. One obtains ordinary state function reductions.
2. Consider next the equivalent options **1b)** and **2b)** making sense if  $\sum_p N_p < 0$  is possible. For option **A)** negentropy gain is maximal and the reduction occurs to an eigen-space with maximum dimension  $N = N_{max}$ . There can be several eigen-spaces with the same maximal dimension. As a special case one obtains ordinary state function reduction. The reduction probability is same as in standard quantum measurement theory.

For option **B)** the reduction could occur also to any  $N$ -dimensional eigen-space or its sub-space. The idea would be that NMP allows something analogous to a choice between good and evil: the negentropy gain could in this case be also smaller than the maximal one corresponding to  $\log(N_{max})$ . This would conform with the intuition that we do not seem to

live in best possible world. On the other hand, negentropy transfer between systems could be also seen as stealing in some situations and metabolism identified as negentropy transfer could be seen as the fundamental “crime” to which all other forms of reduce.

To sum up, the only option which guarantees without additional assumptions (possibility of  $\sum N_p < 0$ ) ordinary state function reduction and stability of NE is option **1a**).

### 3. Could quantum measurement involve also adelic localization?

For option **B**) there is still one possible refinement involved. p-Adic mass calculations lead to the conclusion that elementary particles are characterized by p-adic primes and that p-adic length scale hypothesis  $p \simeq 2^k$  holds true: a more general form of hypothesis allows also to consider primes near powers  $q^n$  of some small prime such as  $q = 3$ .

Could state function reduction imply also adelic/cognitive localization in the sense that the negentropy is nonzero and positive for only single p-adic prime in the final state? The reduction would occur to  $p^k$ -dimensional eigen-space with  $p^k$  dividing  $N$ : any divisor would be allowed. Note that Hilbert spaces with prime dimension are prime with respect to the decomposition to tensor product so that reduction would select prime power factor of the eigen-space. This would in general reduce negentropy gain.

The information theoretic meaning would be that prime-dimensional Hilbert spaces are stable against decomposition to tensor products so that the notion of entanglement would not make sense and therefore also the change of the state by the reduction of entanglement would be impossible. I have considered the possibility that prime-dimensional state spaces could make possible stable storage of quantum information [L75]. The prime-dimensional state when imbedded to higher-dimensional space - say space representing  $N$  qubits - could be interpreted as an entangled state and would be unstable with respect to state function reduction.

This hypothesis would provide considerable insights to the origin of p-adic length scale hypothesis. To get a contact with physics consider electron as an example.

1. In the case of electron one would have  $p = M_{127} = 2^{127} - 1 \sim 10^{38}$ . Could electron decompose to two entangled subsystems with density matrix equal to  $p \times p$  identity matrix? The dimension of eigen-space would be huge and electron would carry negentropy of 127 bits: also p-adic mass calculations combined with a generalization of Hawking-Bekenstein formula suggest that electron carries entropy of 127 bits: in adelic picture these views are mutually consistent.

The recent view indeed is that all elementary particles correspond to closed monopole magnetic flux tubes with a shape of highly flattened rectangles with short sides identifiable as extremely short wormhole contacts ( $CP_2$  size) and long sides with length of order Compton length. Magnetic monopole flux traverses along first space-time sheet between wormhole throats, goes through wormhole contact, and returns back along second space-time sheet. Many-fermion states are assigned with the throats and are located at the ends of strings traversing along the flux tubes.

Could this structure be in the case of electron a 127-sheeted structure such that the two wormhole contacts carry a superposition of pairs formed by states containing  $n \in \{1, \dots, 127\}$  fermions at second contact and  $n$  antifermions with opposite charges at second contact so that  $2^{127} - 1$  dimensional eigen-space would be obtained for a fermion with given spin and isospin. For instance,  $n = 0$  state with no fermion-pairs could be excluded.

2. Right-handed neutrinos and antineutrinos are candidates for the generators of  $N = 2$  supersymmetry in TGD framework. It however seems that SUSY is not manifested at LHC energies, and one can wonder whether right-handed neutrinos might be realized in some other manner. Also the mathematics involved remains still somewhat unclear. For right-handed neutrinos, which are not covariantly constant transformation to left-handed neutrinos is possible and leads to the mixing and massivation of neutrinos. For covariantly constant right handed neutrino spinors this does not happen but they can included into the spectrum only if they have non-vanishing norm.

This might be the case with a proper definition of norm with  $\bar{\Psi} p^k \gamma_k \Psi$  replaced by  $\bar{\Psi} n^k \gamma_k \Psi$ : here  $n^k$  defines normal of the light-like boundary of CD. Covariantly constant right-handed

neutrinos have neither electro-weak, color, nor gravitational interactions so that their NE would be highly stable. Unfortunately, the situation is still unclear and this leaves open the idea that right-handed neutrinos might play fundamental role in cognition and negentropy storage. Amusingly, I proposed the notion of cognitive neutrino long time ago but based on arguments which turned out to be wrong.

One could indeed consider the possibility that each sheet of the 127-sheeted structure contains at most one  $\nu_R$  at the neutrino end of the flux tube accompanied by  $\bar{\nu}_R$  at anti-neutrino end. One would have a superposition  $p = 2^{127} - 1$  states formed by many-neutrino states and their CP conjugates at opposite “ends” of the flux tube. It is also possible that  $\bar{\nu}_R - \nu_R$  pairs are spin singlets so that one has superposition over many-particle states formed from these analogous to coherent state.

This is not the only possibility. The proposal for how the finite range of weak interactions emerges suggests a possible realization for how the number of states in superposition reduces from  $2^{127}$  to  $2^{127} - 1$ . The left weak isospin of fermion at wormhole throat is compensated by the opposite weak isospin of neutrino/antineutrino plus  $\bar{\nu}_R/\nu_R$  or cancelling its fermion number: therefore weak charges vanish in scales longer than the flux tube length of order of the Compton length. The physical picture is that massless weak boson exchanges occur inside the flux tube which therefore defines the range of weak interactions. Same mechanism could be at work for both wormhole throat pairs and therefore also for fermion and anti-fermion at opposite wormhole throats defining building bricks of bosons. The state  $\bar{\nu}_R - \nu_R$  would be excluded from the superposition of pairs of many-particle states and superposition would contain  $p = 2^{127} - 1$  states.

3. Could this relate to  $h_{eff} = n \times h$  hypothesis? It has been assumed that  $h_{eff}/h = n$  corresponds to space-time surfaces representable as  $n$ -fold singular coverings, whose sheets co-incide at the 3-D ends of the space-time surface at opposite boundaries of CD. There is of course no need to assume that the covering considered above corresponds to singular covering and the vision that only particles with same value of  $n$  appear in same vertices suggests that  $n = 1$  holds true for visible matter.

One can still ask whether the elementary particle characterized by  $p \simeq 2^k$  could corresponds to  $k$ -fold singular covering and to  $h_{eff}/h = k$ ? This would require that phase transitions changing the value of  $k$  take place at the lines of scattering diagrams to guarantee that all particles have the same value of  $k$  in given vertex. These phase transitions are a key element of TGD inspired quantum biology.

In the first order of perturbation theory this would not mean any deviations from standard quantum theory for given  $k$  and the general vision that loop corrections from the functional integration over WCW vanish suggests that there are no effects in perturbation theory for given  $k$ . p-Adic coupling constant evolution would be discrete and make itself visible by the phase transitions at the lines of scattering diagrams (not identifiable as Feynman diagrams). The different values of  $h_{eff}/h = n$  be also seen through non-perturbative effects assignable to the bound states and also via the proportionality of p-adic mass scales to  $p^{-1/2} \simeq 2^{-k/2}$  predicted by p-adic mass calculations.

#### 18.3.4 The notion of self

Self is identified as a generalized Zeno effect and corresponds to a sequence of state function reductions to a fixed (passive) boundary of CD remaining unaffected in the sequence of reductions: also the members of state pairs defining zero energy states at it are unaffected. Active boundary drifts farther away state function reduction by state function reduction and the state at it also changes. The analogy of unitary time evolution is in question and the experienced time corresponds to the increase of the temporal distance between the tips of CD.

1. One possibility is that sensory input and mental images (“Maya”) generated by it can be assigned with the active boundary of CD. A more elegant assumption suggested by quantum measurement theory is that the passive boundaries for sub-CDs give rise to mental images as outcomes of repeated quantum measurements. The unchanging part of self (“Self”) is

associated with the passive boundary. It corresponds to negentropically entangled subsystem having no entanglement with environment. In ordinary ontology it would not be possible keep self un-entangled from the environment.

2. State function reductions occur at either boundary of CD as long as they produce maximal negentropy gain. If the reduction at opposite boundary produces larger negentropy gain, it occurs. Self dies and re-incarnates as time reversed self. During repeated state function reductions at same boundary the part of state at that boundary and boundary itself remains unaffected (this corresponds to unchanging part of self) whereas the state at opposite boundary changes and the boundary also shifts outwards. The increase of the distance between the tips of CD corresponds to the flow of geometric time and gives precise meaning for the ageing of self. For instance, sensory-motor rhythm could correspond to the sequence of repeated state function reductions to opposite boundaries of CD. Motor action would correspond to reversed arrow of time: this conforms with the finding of Libet that conscious decision is preceded by neural activity used to argue that there is no free will.

Time reversed self evolves as reductions shifting the opposite boundary of CD to opposite time direction so that the size of CD continues to increase and defines a measure for the duration of the entire sequence of re-incarnations. This implies quantum physical realization for the idea about transmigration of souls!

3. Repeated state function reductions form a sequence for analogs of unitary time evolutions lasting time  $\Delta t$ , which corresponds to the increase of the temporal distance between tips of initial and final CD. Ordinary Hamiltonian clock time evolution does not make sense except as idealization. Is  $\Delta t$  constant or is it determined by the reduction statistically? The most general and the only non adhoc assumption is that a superposition of CDs with different values of  $\Delta t > 0$  is formed and that each repeated state function reductions perform a position measurement - that is localization of the active boundary of CD - so that one  $\Delta t$  is selected and  $\Delta t$  is thus varying. One can speak about average  $\Delta$  as a kind of chronon of clock-time.
4. Suppose that self dies and thus re-incarnates as time reversed self  $S_1$ , and  $S_1$  in turn dies and reincarnates as  $S_2$  having the same arrow of time as  $S$ . Does  $S_2$  re-incarnate at the time when  $S$  died? This does not make sense. Also the first reduction to opposite boundary of CD must involve non-vanishing  $\Delta t$ . This conforms with what is known about claimed re-incarnations and might allow to test re-incarnation hypothesis.
5. The totally unexpected prediction is therefore that life is not just a brief spark in cosmic darkness. This particular life is only one in a sequence of lives: the next life will be lived at the opposite boundary of personal CD to opposite direction of geometric time. The negentropy gained during his life will be usable as possibly unconscious knowledge during the next life. What our next life will be depends how much we gather negentropic resources for the next life.
6. Self can also make moral choices since NMP in its weak form leaves us freedom to make also bad choices or especially negentropic choices (for details see [K61]). Possible are also choices, which do not yield optimal negentropy gain. By allowing sin NMP also makes possible really big negentropy gains: NMP would be like venture capitalist in this sense. In statistical sense there is however an evolution as increase of the negentropic sources of the Universe. Crime is part of being alive: living creatures are fighting desperately for NE and a clever but immoral manner to gain it is to eat other living beings.
7. One big news is that selves form a hierarchy (CDs within CDs) and sub-selves are identified as mental images. In TGD framework it is also possible for sub-selves of two unentangled selves to entangle negentropically. This corresponds to sharing of mental images and means that our conscious experience is not completely private. The pool of shared mental images might in fact make possible communication and social structures. Sharing of mental images is possible only in many-sheeted space-time forcing to generalize the standard view about subsystem.

## 18.4 Some applications

The ontology behind the applications involves the notion of many-sheeted space-time, ZEO, hierarchy of Planck constants identified in terms of dark matter, and p-adic physics as physics of cognition. Also magnetic body (MB) carrying dark matter and energy having non-standard value of Planck constant  $h_{eff} = n \times h$  identified as intentional agent represents new ontology. The additional assumption  $h_{eff} = h_{gr}$  identifying  $h_{eff}$  with gravitational Planck constant is rather powerful. Also p-adic length scale hypothesis is also central in applications.

### 18.4.1 The notion of magnetic body (MB)

MB is assumed to be carrier of dark matter.

1. The flux tubes of MB can suffer  $h_{eff}$  changing phase transitions inducing the change of the length of flux tube. This leads to a view about living matter as a network of bio-molecules connected by magnetic flux tubes. The ability of biomolecules to find each other in the dense molecular soup would rely on the reduction of  $h_{eff}$  bringing molecules near each other. The reconnections of flux tubes possible if the field strengths are same and therefore also cyclotron frequencies are identical are also expected to central element in bio-communications since they change the topology of the network and make possible analogs of relays.

The receptors to which information molecules attach could be seen as plugs to which magnetic flux tubes having information molecule at its end attach and give rise to a fusion of two flux tubes to a longer flux tube connection. For instance, nerve pulse transmission would be more like building quantum connections than communication.

2. Flux tubes with large  $h_{eff}$  make possible high  $T_c$  superconductivity [K83, K84]. Superconducting structures would be pairs of flux tubes carrying magnetic fluxes which have same or opposite directions. Cooper pairs would have members at separate flux tubes.

#### MB as intentional agent

Magnetic field associated with a given system decomposes to flux tubes and sheets to that system has MB (MB). The physics of MBs could be a new chapter in physics and MB could define the basic space-time correlate for non-locality.

1. Flux tubes of MB would serve as correlates for quantum entanglement, which in TGD framework can be negentropic and for this reason rather stable under state function reductions. In GRT context the idea about wormholes as correlates of entanglement between blackholes is highly analogous. The problem with wormholes is that they are highly unstable. Magnetic flux tubes carrying monopole flux are stable since flux conservation prevents their pinching. The pairs of flux tubes with opposite fluxes can however split to two U-shaped flux tubes by reconnection. It is important to notice that magnetic flux tubes are necessarily closed and can be regarded as flux running along different space-time sheets in opposite direction and from sheet to another through the wormhole contacts at ends.

One can of course ask whether the braiding of flux tubes could be the correlate for entanglement. To my opinion entanglement without braiding is possible.

2. MB and dark matter at it would serve as intentional agent in biological systems [?]. The organism-environment duality would be replaced by the trinity MB-organism-environment. For instance, EEG and its strong correlation with brain state and consciousness could be understood in terms of communication of sensory data from cell membranes to MB and control and coordination signals from MB to biological body [K33]. Signals would consist of dark photons with energies  $E = h_{eff}f = n \times hf$  in bio-photon energy range and thus above thermal energies. For instance, the recently observed synchrony between hemispheres in absence of corpus callosum [J105] could be understood in terms of MB serving as “boss”.
3. The formation of flux tube reconnections would serve as a correlate for directed attention - attention could be directed to objects of external world or to their representations in brain.

The reconnection would take place for U-shaped flux tubes serving as kind of magnetic tentacles and lead to a formation of pairs of flux tubes connecting the two systems. If flux tubes carry monopole flux as one has reasons to expect, the flux tubes would be actually closed two-sheeted structures (also elementary particles would be this kind of structures) and flux tube pair would be pair of these. The flux tubes of MBs would serve as analogs of wave guides along with precisely targeted communications of dark photon signals (“massless extremals” (MEs)) would be possible. Also supra currents would be possible and the TGD based model of high  $T_c$  superconductivity relies on the same mechanism [K83]. These communications would be essential in living matter.

4. The formation of reconnections and phases transitions  $n \rightarrow m$  changing  $h_{eff} = n \times h$  would be a basic mechanism behind biocochemistry. U-shaped flux tubes would act like tentacles emerging from the system and reconnection of the tentacles would build a connection between two systems. The reduction of Planck constant would shorten the connecting flux tubes and could force the systems in the vicinity of each other after which bio-catalysis could take place. Braiding and its 2-braid variant for string world sheets and partonic 2-surfaces in 4-D space-time instead of strings in 3-D space would make possible realization of quantum computer program like structures.

### MB is 4-dimensional

MB as preferred extremal represents in terms of space-time topology and geometry 4-D self-organization patterns, behaviors, functions, and skills. What is new that self-organization occurs for 4-D patterns rather than 3-D ones. The entire process is replaced with a new one. Sequence of state function reductions leads from a 4-D self-organization pattern to an asymptotic 4-D self-organization pattern [K82].

Morphogenesis provides examples of this kind of phenomena [I60, I61, I80]. The first key idea is that DNA and cell replication is induced by the replication of MBs serving as information carriers (see <http://tinyurl.com/ydg6okkk>) [K82]. The second key idea is that in zero energy ontology (ZEO) MB is 4-dimensional and represents behavioral patterns rather than only 3-dimensional patterns.

According to Michael Levin, concerning morphogenesis and morphostasis the basic challenge is to understand how the shape of the organism is generated and how it is preserved. The standard local approach based on belief on genetic determinism does not allow one to answer these questions satisfactorily.

1. The first approach to this problem relies on a self-organization paradigm in which the local dynamics of cells leads to large scale structures as self-organization patterns. In TGD framework 3-D self-organization is replaced with 4-D self-organization (the failure of strict determinism of the classical dynamics is essential motivating zero energy ontology (ZEO)). One can speak about 4-D healing: expressing it in somewhat sloppy manner, the space-time surface serving as a classical correlate for the patient is as a whole replaced with the healed one: after the 4-D healing process the organism was never ill in geometrical sense! Note that in quantal formulation one must speak of quantum superposition of space-time surfaces.
2. Second approach could be seen as computational. The basic idea is that the process is guided by a template of the target state and morphogenesis and healing are computational processes. What Levin calls morphogenetic fields would define this template. It is known that organisms display a kind of coordinate grid providing positional information that allows cells to “decide” about the profile of genetic expression (for references see [I61]). In TGD framework MB forming coordinate grid formed from flux tubes is a natural candidate for this structure. They would also realize topological quantum computation (TQC) with basic computational operations realized at the nodes of flux tubes to which it is natural to associate some biological sub-structures.

The assumption about final goal defining a template can be argued to be too strong: much weaker principle defining a local direction of dynamics and leading automatically to the final state as something analogous to free energy minimum in thermodynamics might be enough. Unfortunately,

second law is the only principle that standard physics can offer. Negentropy Maximization Principle (NMP) provides the desired principle in TGD framework. Also the approach of WCW spinor field to the maximum of vacuum functional (or equivalently that of Kähler function) gives a goal for the dynamics after the perturbation of the organism causing "trauma". If Kähler function is classical space-time correlate for entanglement negentropy, these two views are equivalent.

TGD thus suggests an approach, which could be seen as a hybrid of approaches based on self-organization and computationalism. The MB becomes the key notion and codes also for learned behaviors as TQC programs coded by the braiding of flux tubes. The replication of the MB means also the replication of the programs behind behavioral patterns (often somewhat misleadingly regarded as synonymous with long term memories): both structure and function are replicated. This hypothesis survives the killer tests provided by the strange findings about planaria cut into two and developing new head or tail while retaining its learned behaviors: the findings indicate that behavioral programs are preserved although planaria develops a new brain.

#### $h_{gr} = h_{eff}$ hypothesis

Nottale [E1] introduced originally the notion of gravitational Planck constant  $\hbar_{gr} = GMm/v_0$ , where  $M$  is large mass such as that of Earth or Sun and  $m$  the mass of quantum coherent object and  $v_0$  is a parameter with dimensions of velocity [E1]. Nottale did not propose macroscopic quantum coherence in astrophysical scales but in TGD framework this is a natural option [K100, K76].

The obvious question is whether the gravitational Planck constant deduced from the Nottale's considerations and the effective Planck constant  $h_{eff} = n \times h$  deduced from ELF effects on vertebrate brain and explained in terms of non-determinism of Kähler action could be identical. At first this seems to be non-sensical idea since  $\hbar_{gr} = GMm/v_0$  has a gigantic value. The hypothesis  $h_{eff} = \hbar_{gr}$  leads to much stronger predictions [K78, ?] than either hypothesis alone. One can also introduce analogs of  $\hbar_{gr}$  for other interactions: the idea is that when the coupling strength between two charges becomes so large that perturbation theory does not exist, a phase transition increasing the Planck constant happens and guarantees the convergence.

The essential point is that  $h_{eff}$  and  $\hbar_{gr}$  would characterized body parts of MB: this allows to understand the dependent on masses of two particles. The flux tubes with a given value of  $h_{eff}$  would carry only particles of particular mass  $m$  so that the random soup of biomolecules would become a highly ordered structure analogous to library in which each book type is its own shelf. Furthermore, the cyclotron energies  $E_c \propto h_{eff}/m$  would be same irrespective of particle mass  $m$  although cyclotron frequencies are different.

The proposed identification of the energy range of dark photon cyclotron energies in living matter is as visible and UV range assigned to bio-photons which would therefore result in the transformation of dark photons to ordinary photons. Further important point, is that the energy spectrum would be in the range of molecular excitation energies (visible and UV range) so that dark photons transformed to ordinary ones would allow MBs to control biochemistry.

By Equivalence Principle one can describe gravitational interaction by reducing it to elementary particle level. For instance, gravitational Compton lengths do not depend at all on the masses of particles. Also the radii of the planetary orbits are independent of the mass of particle mass in accordance with Equivalence Principle. For elementary particles the values of  $\hbar_{gr}$  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* [E5, E10] discussed in [K104] 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  $\hbar_{gr}$  associated with Earth-Cooper pair system and assumes that the velocity parameter  $v_0$  appearing in it corresponds to the Earth's rotation velocity around its axis, one obtains correct order of magnitude for the effect requiring  $r \simeq 3.6 \times 10^{14}$ .

The most important implications are in quantum biology and Penrose's vision about importance of quantum gravitation in biology might be correct.

1. This result allows by Equivalence Principle the identification  $\hbar_{gr} = h_{eff}$  at elementary particle level at least so that the two views about hierarchy of Planck constants would be

equivalent. If the identification holds true for larger units it requires that space-time sheet identifiable as quantum correlates for physical systems are macroscopically quantum coherent and gravitation causes this. If the values of Planck constant are really additive, the number of parallel space-time sheets corresponding to non-determinism evolution for the flux tube connecting systems with masses  $M$  and  $m$  is proportional to the masses  $M$  and  $m$  using Planck mass as unit. Information theoretic interpretation is suggestive since hierarchy of Planck constants is assumed to relate to negentropic entanglement very closely in turn providing physical correlate for the notions of rule and concept.

2. That gravity would be fundamental for macroscopic quantum coherence would not be surprising since by EP all particles experience same acceleration in constant gravitational field, which therefore has tendency to create coherence unlike other basic interactions. This in principle allows to consider hierarchy in which the integers  $h_{gr,i}$  are additive but give rise to the same universal dark Compton length.
3. An interesting question is how large systems can behave as coherent units with  $\hbar_{gr} = GMm/v_0$ . In living matter one might consider the possibility that entire organism might be this kind of system. Interestingly, for larger masses the gravitational quantum coherence would be easier. For particle with mass  $m$   $h_{gr}/h > 1$  requires larger mass to satisfy  $M > M_P^2/m_e$ . The first guess that life has evolved from long to shorter scales and reached elementary particle last. Planck mass is the critical mass corresponds to the mass of water blob with volume of size scale of  $10^{-4}$  m (big neuron) is the limit.

The general proposal discussed above is testable. In particular, a detailed study of molecular energies with those associated with resonances of EEG could be highly rewarding and reveal the speculated spectroscopy of consciousness.

### 18.4.2 MB and biology

MB could play a key role in biology as intentional agent using biological body as motor instrument. MB could even serve as a template for biomolecules and even that fundamental bio-chemical processes are induced by those for MB. Dark cyclotron photons transformed to ordinary photons would be the fundamental control tool of MB. Also reconnection of flux tubes, change of length of flux tubes induced by the change of the value of  $h_{eff} = h_{gr}$ , superconductivity associated with a pair of flux tubes could be fundamental control mechanisms.

### MB, biophotons, and biochemistry

The model for quantum biology relying on the notions of MB and dark matter as hierarchy of phases with  $h_{eff} = nh$ , and biophotons [K23, K14] identified as decay products of dark photons. The assumption  $h_{gr} \propto m$  becomes highly predictable since cyclotron frequencies would be independent of the mass of the ion.

1. If dark photons with cyclotron frequencies decay to biophotons, one can conclude that biophoton spectrum reflects the spectrum of endogenous magnetic field strengths. In the model of EEG [K33] it has been indeed assumed that this kind spectrum is there: the inspiration came from music metaphors suggesting that musical scales are realized in terms of values of magnetic field strength. The new quantum physics associated with gravitation would also become key part of quantum biophysics in TGD Universe.
2. For the proposed value of  $h_{gr}$  1 Hz cyclotron frequency associated to DNA sequences would correspond to ordinary photon frequency  $f = 3.6 \times 10^{14}$  Hz and energy 1.2 eV just at the lower limit of visible frequencies. For 10 Hz alpha band the energy would be 12 eV in UV. This plus the fact that molecular energies are in eV range suggests very simple realization of biochemical control by MB. Each ion has its own cyclotron frequency but same energy for the corresponding biophoton.
3. Biophoton with a given energy would activate transitions in specific bio-molecules or atoms: ionization energies for atoms except hydrogen have lower bound about 5 eV (<http://tinyurl>).



com/233vcad ). The energies of molecular bonds are in the range 2-10 eV (<http://tinyurl.com/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.

It must be made clear that TGD has had an interpretational problem related to the identification of biophotons as decay product of dark protons [?, K78]. The resolution of this problem leads to conclusion that both Earth's and galactic MBs control living matter with EEG related by scaling. This would be rather dramatic realization of non-locality.

The problem is following. If one wants bio-photon spectrum to be in visible-UV range assuming that bio-photons correspond to cyclotron photons, one must reduce the value of  $r = h_{gr}B_{end}/mv_0$  for Earth particle system by a factor of order  $k = 2 \times 10^{-4}$ .  $r$  does not depend on the mass of the charged particle. One can replace  $B_{end}$  with some other magnetic field having value which is considerably smaller. One can also increase the value of  $v_0$ .

1. For  $h_{gr}$  determined by Earth's mass and  $v_0 = v_{rot}$ , where  $v_{rot} \simeq 1.55 \times 10^{-6}c$  is the rotation velocity of Earth around its axis and for  $B_{end} \rightarrow B_{gal} = 1$  nT, where  $B_{gal}$  is typical strength of galactic magnetic field, the energy of dark cyclotron energy is 45 eV (UV extends to 124 eV). This is roughly by a factor 50 higher than the lower bound for the range of bio-photon energies. One possibility is that  $B_{gal}$  defines the upper limit of the dark photon energies and has variation range of at least 7 octaves with lower limit roughly  $1/50$  nT.

One can also consider the possibility  $B_{gal}$  defines lower bound for the magnetic field strengths involved and one has  $v_0 > v_{rot}$ . For sun the rotation velocity at Equator is  $v_{rot} = 2 \times 10^{-5}$  m/s and  $v_0$  is  $v_0 \simeq 5.8 \times 10^{-4}c$ . One has  $v_0/v_{rot} \simeq 29.0$ . If same is true in case of Earth, the value of the energy comes down from 25 eV to 1.6 eV which corresponds to visible wave length.

The assignment of  $B_{gal}$  to gravitational flux tubes is very natural. Now however the frequencies of dark variants of bio-photons would not be in EEG range: 10 Hz frequency would correspond to  $5 \times 10^{-4}$  Hz with period of 42 min. The time scale of 42 min is however very natural concerning consciousness and could be involved with longer bio-rhythms. Scaled EEG spectrum with alpha band around 46 min naturally assignable to diurnal sub-rhythms could be a testable prediction. Natural time would be sidereal (galactic) time with slightly different length of day and this allows a clear test. Recall the mysterious looking finding of Spottiswoode that precognition seems to be enhanced at certain time of sidereal day [J126]. Cyclotron frequency 1 Hz would correspond to 7 hours. One can ask whether 12 hours (25) is the natural counterpart for the cyclotron frequency 1 Hz assignable to DNA. This would correspond to lower bound  $B_{gal} \rightarrow 7B_{gal}/12 \simeq .58$  nT or to  $v_0 \rightarrow 1.7v_0$ .

2. The idea has been that it is dark EEG photons, which correspond to bio-photons. Could one assign bio-photons also to dark EEG so that magnetic fields of Earth and galaxy would correspond to two different control levels? If  $B_{end} = .2$  Gauss is assumed to determine the scale of the magnetic field associated with the flux tubes carrying gravitational flux tubes, one must reduce  $h_{gr}$ . The reduction could be due to  $M \rightarrow M_D = kM$  and due to the change of  $v_0$ .  $k$  could characterize the dark matter portion of Earth but this assumption is not necessary.

This would require  $k = M_{dark,E}/M_E \simeq 5 \times 10^{-5}$  if one does not change the value of  $v_0$ . This value of  $k$  equals to the ratio of  $B_{gal}/B_{end}$  and would be 1/4:th of  $k = 2 \times 10^{-4}$ . One might argue that it is indeed dark matter to which the gravitational flux tubes with large value of Planck constant connect biomatter.

- Suppose that one does not give up the idea that also Earth mass gives rise to  $h_{gr}$  and scaled analog of EEG. Then  $M_D$  must correspond to some mass distinguishable from and thus outside Earth. The simplest hypothesis is that a spherical layer around Earth is in question. TGD based model for spherical objects indeed predict layered structures [K118]. There are two separate anomalies in the solar system supporting the existence of a spherical layer consisting of dark mass and with radius equal to the distance of Moon from Earth equal to 60.3 Earth radii [K100]. The first anomaly is so called Flyby anomaly and second one involves a periodic variation of both the value of the measured Newton's constant at the surface of Earth and of the length of the day. The period is about 6 years and TGD predicts it correctly.

One can imagine that dark particles reside at the flux tubes connecting diametrically opposite points of the spherical layer. Particles would experience the sum of gravitational forces summing up to zero in the center of Earth. Although the layer would be almost invisible (or completely invisible by argument utilizing the analogy with conducting shell) gravitationally in its interior,  $h_{gr} = M_D m / v_0$  would make itself visible in the dynamics of dark particles! This layer could represent magnetic Mother Gaia and EEG would take care of communications to this layer.

The rotation velocity  $v_{rot,M} \simeq 2.1 \times v_{rot,E}$  of Moon around its axis is the first guess for the parameter  $v_0$  identifiable perhaps as rotation velocity of the spherical layer. A better guess is that the ratio  $r = v_0 / v_{rot,M}$  is the same as for Sun and as assumed above for Earth. This would give for the ratio of cyclotron frequency scales  $r = (B_{end} / B_{gal}) \times 2.1$ . 66.7 min, which corresponds to  $B_{gal} = .63$  nT, would correspond to .1 s. For this choice 1 Hz DNA cyclotron frequency would correspond 11.7 h rather near to 12 h. This encourages the hypothesis that 72 min is the counterpart of .1 s cyclotron time. The cyclotron time of DNA (very weakly dependent on the length of DNA double strand) in  $B_{gal}$  (or its minimum value) would be 12 h.

Magnetic body of Earth controlling bio-dynamics would be a dramatic manifestation of non-locality to say nothing about the control performed by galactic magnetic body.  $M_D$  would be associated with the magnetic Mother Gaia making life possible at Earth together with magnetic Mother Galactica. Both MBs would be in continual contact with biomolecules like ATP and the molecules for which ATP attaches or provides the phosphate. Metabolic energy would be used to this process. These MBs would be Goddesses directing its attention to tiny bio-molecules. If this picture is correct, the ideas about consciousness independent on material substrate and assignable to a running computer program can be safely forgotten.

### Model for the flux tube connections between biomolecules

A more concrete TGD based model for the flux tubes connections between molecules relies on the general ideas of TGD inspired quantum biology [K60].

- Biomolecules containing aromatic rings are known to play a fundamental role. For instance, most neurotransmitters and psychoactive drugs involve aromatic rings). All DNA nucleotides contain them and there are 4 proteins, which also have them. Trp and phe are of special importance and form a pair structurally analogous to a base pair in DNA strand. The rings are assumed to carry the analog of supra current and be in or at least be able to make transition to a state with large  $h_{eff} = n \times h$ . The delocalization of electron pairs in aromatic ring could be a signature of  $h_{eff} / h > 1$ .
- Trp-phe pairing [K60] would be responsible for information molecule-receptor pairing. Information molecule and receptor would be at the ends of flux tubes serving as communication lines, and the attachment of info molecule to receptor would fuse the two flux tubes to longer one. After that communication would become possible as dark photon signals and dark supra currents. Formation of info molecule-receptor complex would be like clicking icon generating a connection between computers in net. Info molecules would generate the communication channels - they would not yet be the signals. This distinguishes TGD view from standard neuroscience.

3. All quantum critical phenomena involve generation of large  $h_{eff}$  phases and changes of  $h_{eff}$  in the sense that their values are different at different ends of space-time surface at boundaries of CD. Folding emerges or disappears at QC possible in certain temperature range of width about 40 K and depending on pH. The flux tubes associated with phe and trp containing aromatic rings carrying "supra current" would become dark (either  $h \rightarrow h_{eff}$  or  $h_{eff} > h$  increases) and thus much longer and reconnect temporarily and force phe and trp in a close contact after the reverse transition inducing shortening. This is a general mechanism making biomolecules able to find each other in what looks like molecular soup in the eyes of standard biochemist. The contacts between amino-acids phe and trp formed in this manner would be structurally identical with the hydrogen bonding between members of DNA base pairs and they would fix the final folding pattern to high degree.

### Pollack's mechanism

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water [L34, I86, I70] (see <http://tinyurl.com/oyhstc2>). The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is  $H_{1.5}O$  and can be understood if every fourth proton is dark proton residing at the flux tubes of the MB assignable to the exclusion zone and outside it [L34] [K60].

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclear strings whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner [K65, K48]. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs.

Pollack's exclusion zones (EZs) might for instance explain why DNA is negatively charged. EZs or their generalization could play fundamental role in metabolism with protons running through mitochondrial membrane being dark as also other biologically important ions involved. EZs could be important even in electrolysis and allow to explain what happens in cold fusion. These hypothesis could be tested.

### Remote DNA replication

The works of Luc Montagnier [I36] and Peter Gariaev [I65] suggests that remote replication of DNA is possible. The developments in the model of dark DNA allow to imagine a detailed mechanism for how water can represent DNA and how DNA could be transcribed to dark DNA - essentially the analog of DNA-RNA transcription would be in question. The transcription/association represents a rule and rules are represented in terms of negentropic entanglement (NE) in TGD framework with pairs of states in superposition representing the instances of the rule. Transition energy serves as a characterizer of a molecule - say DNA codon - and the entangled state is a superposition of pairs in which either molecule is excited or dark DNA codon is excited to higher cyclotron state with same energy: this requires tuning of the magnetic field and sufficiently large value of  $h_{eff}$  at the flux tube. NE would due to the exchange of dark photons: this corresponds to wave DNA aspect. Dark cyclotron photons also generate negatively charged exclusion zones (EZs) discovered by Pollack and in this process transform part of protons to dark ones residing at the magnetic flux tubes associated with EZs and forming dark proton sequences. This allows to identify a mechanism of remote replication.

The results of Montagnier and Gariaev strongly suggest that genetic code is representation by dark photons, presumably by frequencies. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L31] [K85] (see <http://tinyurl.com/zg3aa7>) 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.

### 18.4.3 Metabolism

The TGD inspired view about metabolism is as a mechanism making possible transfer of NE from phosphates to ATP and further to receiver molecules. TGD leads to new ideas about photosynthesis and suggests that also animal cells can perform process analogous to photosynthesis. Also remote metabolism is possible and there is evidence that it indeed occurs.

#### Metabolic energy is needed to transfer NE

At deep level metabolic energy might correspond to NE and thus information. Conscious information would be thus the basic currency and the transfer of metabolic energy and metabolites would make possible transfer of NE. It could be transfer of systems consisting of negentropically entangled parts or it could be transfer of NE with larger system, even Earth. NMP would force the systems to fight for NE and this would lead to the fight for metabolic resources. The transfer of entanglement (NE) is basic mechanism in quantum computation and would mean in biology stealing of NE, the fundamental crime! Metabolism in TGD framework is discussed in detail in [K51].

I have considered three possible three possible identifications of NE.

1. NE could be small scale entanglement - say between parts of molecules. This option is not favored by the needed large values of  $h_{gr}$  and thus of mass  $M$ .
2. NE could be between nutrient and larger structure - say Earth, Sun, or some other large enough structure to give a value of  $h_{gr} = GMm/v_0$  guaranteeing that dark cyclotron energies (no dependence on mass  $m$ ) in the range of bio-photon energies (visible and UV) and guarantee that EEG frequencies correspond to these energies. This option discussed in [K78]. Nutrients would be carriers of both metabolic energy and NE. This option does not conform with the fact that even electrons can provide metabolic energy and in TGD framework therefore also NE for some bacteria (see <http://tinyurl.com/o8xqh6g>). This suggests that nutrients carry only the energy needed to transfer NE.
3. NE could be also between a larger structure and phosphate molecule added to ADP using metabolic energy. This option is the simplest one and would predict that phosphates are in unique role as standard entanglers to mass  $M$ . Any source of metabolic energy is in principle possible since metabolic energy is only needed to transfer the flux tube connecting phosphate to mass  $M$  to ADP so that ATP is obtained. The flux tube would represent the "high energy phosphate bond". ATP in turn attaches the flux tube to biomolecule, which becomes negentropically entangled. Metabolism would be make the transfer of NE possible. Metabolites would not contain information but it would be assignable to the flux tube between phosphate and mass  $M$ . Magnetic Mother Gaia would have very concrete meaning.

A good candidate for the larger structure could be a spherical layer at the distance of Moon from Earth would give correct value for  $h_{eff} = h_{gr}$  [K78].

### Pollack's mechanism and photosynthesis

An obvious idea is that Pollack's mechanism or its generalization is the predecessor of photosynthesis. The question is therefore whether photosynthesis could involve the formation of exclusion zones (EZs) by the analog of whether photosynthesis could involve the formation of exclusion zones (EZs) by the analog of Pollack's mechanism [L34, I86, I70] (see <http://tinyurl.com/oyhstc2> leading to charge separation taking place also in photosynthesis. Pollack's mechanism creates in presence of radiation and water bounded by a gel at the boundary of water and gel an EZ, which is a layer negatively charged water with effective stoichiometry  $H_{1.5}O$  consisting of layers with hexagonal structure. The TGD inspired proposal is that hydrogen bonded pairs of  $H_2O$  molecules are formed and that each of them loses one proton as dark proton at magnetic flux tubes outside EZ. The notion of many-sheeted space-time and topological field quantization are essential elements of the proposal. Same phenomenon could be caused also by irradiation by sun light.

The light dependent step  $2H_2O \rightarrow 4H^+ + 4e^- + O_2$  of photosynthesis pumps protons through thylakoid membranes (for an illustration see <http://tinyurl.com/ycecu6uf>). The electrons excited by photons of sunlight are transferred along electron transport chain and lose energy used to pump protons through the thylakoid membrane and being thus transferred from stroma to grana against electric gradient. ADP transforms to ATP as these protons return to back through ATP synthase. This step is repeated again and again.

Could dark protons created by the analog of Pollack's mechanism be involved with photosynthesis? In what step the protons are transformed to dark protons by this mechanism?

1. The model of cell membrane leads to a proposal that pumps and channels quite generally are dark magnetic flux tubes and protons (and also other ions) are transferred through them as dark protons (dark ions). This would imply almost dissipation-free transfer.
2. The protons are pumped as dark protons through the thylakoid membrane along dark magnetic flux tubes serving as pumps using the energy provided by electrons flowing down in the electron chain. The dark protons return from grana through ATP synthase as dark protons as ATP is generated and transform with some rate back to ordinary protons in stroma. Otherwise the fraction of dark protons would steadily increase.
3. This leaves two options under consideration. Already the step  $2H_2O \rightarrow 4H^+ + 4e^- + O_2$  step  $2H_2O \rightarrow 4H^+ + 4e^- + O_2$  creates dark protons by a generalization of Pollack's mechanism or this step creates ordinary protons transformed by Pollack's mechanism to dark protons as they are transferred to dark magnetic flux tubes serving as pumps. The first option looks more plausible.

### The analog of photosynthesis in animal cells

Visible and UV light can provide metabolic energy for animal cells. There are various light therapies (see <http://tinyurl.com/hescd3x>) using red or IR light, and they could basically provide metabolic energy. In [I40] (see <http://tinyurl.com/hgtaqr6>) it is reported that IR laser light depolarizes cell membranes implying stimulation. This could be understood if IR light corresponds to a Josephson frequency  $eV/m_e$  assignable to the cell membrane. Also visible light has similar effects and one can ask whether animal cells could perform the analog of photosynthesis using essentially same basic mechanism as used by plant cells.

What is interesting is the electron transport chain is involved also with the cellular respiration. Cells would act like plant cells and the analog of photosynthesis could be in question. This would explain the claims that the members of some religious cults can practically live utilizing only sunlight. I have actually proposed that analog of photosynthesis storing the energy by  $ADP + P_i \rightarrow ATP$  type process using standard machinery could be actually involved and transfer the energy of IR light to metabolic energy further distributed by ATP.

The metabolic machinery for cellular respiration contains so called oxidative phosphorylation (OP) as a basic step: OP adds to ADP a phosphate giving metabolic currency ATP. ATP in turn distributes the metabolic energy further. OP uses electron transport chain to transfer metabolic energy from NADH by  $NADH \rightarrow NAD^+H^+ + 2e^-$ . The electrons go through the electron transport chain as in photosynthesis and transfer protons outside the mitochondrial membrane

very much like through thylakoid membrane in photosynthesis. The protons return through ATP-synthase and induce  $ADP + P_i \rightarrow ATP$ .

The metabolic energy must come from somewhere and OP indeed follows Krebs cycle (see <http://tinyurl.com/p6599hq>) in which the energy is extracted from nutrients and given to the NADP molecule. The photon energy could be fed directly to OP electron transport chain just as photon energy is transferred to this chain in photosynthesis. The presence of electron transport chain is necessary and one must feed the electrons and protons to this chain somehow.

1. Could the analog of photosynthetic reaction  $2H_2O \rightarrow 4H^+ + 4e^- + O_2$  with visible photons replaced with IR photons produce dark protons? Whether this is energetically possible and whether the electrons have high enough energies to drive the dark protons through the membrane is far from clear. One can of course imagine, that the number of pumped protons per electron is lower than usually.
2. A mechanism that I have called quantum credit card or remote metabolism [K51] looks more plausible. The splitting  $2H_2O \rightarrow 4H^+ + 4e^- + O_2$  could occur - not by absorption of positive energy photon but by emission of negative dark IR photon with the energy of visible photon. Cell would actively suck metabolic energy from IR light source. The emitted dark negative energy IR photon would decay to ordinary IR photons in reverse time direction, which would look like fusion in standard time direction and is thermodynamically non-favoured. ZEO predicting kind of syntropic processes to occur in living matter would be an essential prerequisite.

### Remote metabolism

ZEO makes possible both arrows of geometric time in living matter so that negative energy signals in reversed time direction become possible and one must generalize thermodynamics by introducing the notion of syntropy introduced already by Fantappie [J133]. Active metabolism that I have referred to as quantum credit card mechanism or a remote metabolism [K51, K52] becomes possible: system gets positive energy as a recoil effect by sending negative energy dark photons to a source able to receive them. In ZEO based formulation of quantum measurement theory the generation of negative energy photons corresponds to a state function reduction creating self with reversed arrow of geometric time.

There are several examples where remote metabolism might be involved.

1. Some spiritual groups and also traditionally the people called saints are reported to survive by using only sunlight as their source of metabolic energy.
2. Sled dogs [I20] (see <http://tinyurl.com/zg9j3p9>) can run for several days without eating and no signatures of ordinary metabolism have been found. This phenomenon cannot of course be specific to sleigh dogs. Remote metabolism could explain the phenomenon as an extraction of metabolic energy from non-standard sources in absence of standard sources - say from the magnetic body associated with the collective formed by the dogs.
3. Yan Xin Qigong practitioners report that in so called Bigu state there is no need to eat solid food at all for days, weeks, months or even years. Western science is beginning to take Bigu state (<http://tinyurl.com/y7unnww4>) seriously [I12] and the first national conference on Bigu state was held at the Pennsylvania State University in 2000, with presenters such as Rustum Roy, founding director of Penn State's Materials Research Laboratory and Hans Peter Duerr, former director of the Max Planck Institute.
4. Callahan [I14] has reported that plants suffering under-nutrition can attract insects responsible for their pollination. Callahan has also reported that plants and insects communicate using infrared light which according to his findings serves as a sensor input in insect olfaction: also in this case quantum credit card mechanism building magnetic flux tube bridges guiding the insects to the plant might be at work. In the case of IR metabolism electrons could send to the energy source dark negative energy IR photons, which decay to ordinary IR photons. This would be an active variant of metabolism and time reversal of the usual mechanism.

5. Gut cells without mitochondria can survive (see <http://tinyurl.com/hqq79th>)!  $ADP \rightarrow ATP$  transformation should occur since ATP is the universal energy currency. Could it take place as remote metabolism by sending negative energy photons to the cells having the mitochondria. The electron transfer chain is preceded by Krebs cycle (see <http://tinyurl.com/p6599hq>) extracting the energy from nutrients: could the absorption of negative energy photons induce the decay of nutrient without transfer of energy to electron chain of the mitochondria. This would be like kicking laser from population reversed state to ground state by phase conjugate negative energy irradiation. The hungry gut cell without mitochondria would be allowed to eat in the table of the luckier ones. This is again one quantum objection against vulgar darwinism.

### Homeopathy, water memory, and immune systems

In [K48] a TGD based model of water memory and homeopathy is discussed. An important step in progress was due to Pollack's findings about exclusion zones of water explained in terms of fourth phase of water [L34]. Second step or progress was inspired by an anomaly claimed by Tajmar *et al* [E10, E5] and known as strong gravimagnetism. The attempt to understand the claim led to  $h_{eff} = h_{gr} = h_{em}$  hypothesis unifying two TGD views about the notion of hierarchy of Planck constants proposed to characterize the phases of dark matter.

If dark proton (nucleon) sequences realized genetic code [L52] (see <http://tinyurl.com/jgffj1be>), water would already realize genetic code at the level of dark matter and chemical realization would have evolved from this more fundamental realization.

In this framework [K48] the attempt to understand homeopathy leads to additional insights about about water as living system and about prebiotic life as being based on the dark realization of genetic code realized in terms of dark proton strings which are nothing than dark variants of nuclei. Formation of exclusion zones would be formation of primitive lifeforms and primitive form of metabolism. Homeopathy could be seen as a manifestation of a fundamental form of immune system based on the recognition of invader molecules using reconnection mechanism for magnetic flux tubes and on mimicking the braiding of the MBs of invader molecules using dark variants of proteins (later proteins) and eventually representing them symbolically in terms of dark DNA (later ordinary DNA) coding for the dark proteins. Genetic code might have geometric interpretation as coding for the 2-braiding of 3-D coordinate grids represented by magnetic flux tubes serving as the 4-D template coding not only for the structure of the organism but also its functions as spatio-temporal patterns. Protein folding would represent a behavior of protein and DNA would code also for it.

#### 18.4.4 Proposals for the Physical Realizations of Genetic Code

The view about evolution as a random process suggests that genetic code is pure accident. My own view is that something so fundamental as life cannot be based on pure randomness. TGD has led to several proposals for genetic code, its emergence, and various realizations based on purely mathematical considerations or inspired by physical ideas [K119]. One can argue that genetic code is realized in several ways just like bits can be represented in very many ways. Two especially interesting proposals have emerged. The first one is based on geometric model of music harmony involving icosahedral and tetrahedral geometries. Second model having two variants is based on dark nuclear strings. Both models predict correctly the numbers of DNA codons coding for a given amino-acid.

For the successful options entire codons rather than letters are represented. The difference between letter-wise representation and codon-wise representations is analogous to that between spoken and written languages. In spoken languages words are not analyzed further to letters.

1. The geometric theory of harmony [L31] represents codons as 3-chords without assigning fixed notes to A,T,C,G and explains also DNA-amino-acid correspondence.
2. For the first variant of dark nuclear string serves as analog of DNA strand. The map of codons to the dark nucleon states of dark nucleon consisting of dark  $u$  and  $d$  type quarks does the same and also predicts the degeneracies successfully.

This model can be modified by replacing  $u$  and  $d$  by dark nucleon states  $p$  and  $n$  without any change in predictions related to genetic code. The evidence that DNA codons indeed couple to dark nucleon states [L67] supports this option.

### Geometric Theory of Harmony and Genetic Code

The idea that the 12-note scale could allow mapping to a closed path going through all vertices of icosahedron having 12 vertices and not intersecting itself is attractive. Also the idea that the triangles defining the faces of the icosahedron could have interpretation as 3-chords defining the notion of harmony for a given chord deserves study. The paths in question are known as Hamiltonian cycles and there are 1024 of them [A7]. These paths can be classified topologically by the numbers of triangles containing 0, 1, or 2 edges belonging to the cycle representing the scale. Each topology corresponds to particular notion of harmony and there are several topological equivalence classes.

In the article [L36] I introduced the notion of Hamiltonian cycle as a mathematical model for musical harmony and also proposed a connection with biology: motivations came from two observations. The number of icosahedral vertices is 12 and corresponds to the number of notes in 12-note system and the number of triangular faces of icosahedron is 20, the number of amino-acids. This led to a group theoretical model of genetic code and replacement of icosahedron with tetra-icosahedron to explain also the 21st and 22nd amino-acid and solve the problem of simplest model due to the fact that the required Hamilton's cycle does not exist. The outcome was the notion of bioharmony.

All icosahedral Hamilton cycles with symmetries ( $Z_6, Z_4, Z_2^{rot}$  and  $Z_2^{refl}$ ) turned out to define harmonies consistent with the genetic code. In particular, it turned out that the symmetries of the Hamiltonian cycles allow to predict the basic numbers of the genetic code and its extension to include also 21st and 22nd amino-acids Pyl and Sec: there are actually two alternative codes - maybe DNA and its conjugate are talking different dialects! One also ends up with a proposal for what harmony is leading to non-trivial predictions both at DNA and amino-acid level.

The conjecture is that DNA codons correspond to 3-chords perhaps realized in terms of dark photons or even ordinary sound. There are 256 different bio-harmonies and these harmonies would give additional degrees of freedom not reducing to biochemistry. Music expresses and creates emotions and a natural conjecture is that these bio-harmonies are correlates of emotions/moods at bio-molecular level serving as building bricks of more complex moods. Representations of codons as chords with frequencies realized as those of dark photons and also sound is what suggests itself naturally. This together with adelic physics involving hierarchy of algebraic extensions of rationals would explain the mysterious looking connection between rational numbers defined by ratios of frequencies with emotions.

### Mapping DNA and Amino-Acids to Dark Nucleon States

Could dark nuclear strings provide a representation of the genetic code. The answer was totally unexpected: the states of dark nucleons formed from three quarks can be grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, and 20 amino-acids and there is natural mapping of DNA and RNA type states to amino-acid type states such that the numbers of DNAs/RNAs mapped to given amino-acid are same as for the vertebrate genetic code.

The dark model emerged from the attempts to understand water memory [K48]. The outcome was a totally unexpected finding [K65, K48]: the states of dark nucleons formed from three quarks connected by color bonds can be naturally grouped to multiplets in one-one correspondence with 64 DNAs, 64 RNAs, 20 amino-acids, and tRNA and there is natural mapping of DNA and RNA type states to amino-acid type states such that the numbers of DNAs/RNAs mapped to given amino-acid are same as for the vertebrate genetic code.

The basic idea is simple. The basic difference from the model of free nucleon is that the nucleons in question - maybe also nuclear nucleons - consist of 3 linearly ordered quarks - just as DNA codons consist of three nucleotides. One might therefore ask whether codons could correspond to dark nucleons obtained as open strings with 3 quarks connected by two color flux tubes or as closed triangles connected by 3 color flux tubes. Only the first option works without additional



assumptions. The codons in turn would be connected by color flux tubes having quantum numbers of pion or  $\eta$ .

This representation of the genetic would be based on entanglement rather than letter sequences. Could dark nucleons constructed as string of 3 quarks using color flux tubes realize 64 DNA codons? Could 20 amino-acids be identified as equivalence classes of some equivalence relation between 64 fundamental codons in a natural manner? The codons would be not be anymore separable to letters but entangled states of 3 quarks.

If this picture is correct, genetic code would be realized already at the level of dark nuclear physics and maybe even in ordinary nuclear physics if the nucleons of ordinary nuclear physics are linear nucleons. Chemical realization of genetic code would be induced from the fundamental realization in terms of dark nucleon sequences and vertebrate code would be the most perfect one. Chemistry would be kind of shadow of the dynamics of positively charged dark nucleon strings accompanying the DNA strands and this could explain the stability of DNA strand having 2 units of negative charge per nucleotide. Biochemistry might be controlled by the dark matter at flux tubes.

The ability of the model to explain genetic code in terms of spin pairing is an impressive achievement, which I still find difficult to take seriously.

1. The original model mapping codons to dark nucleon states assumed the overall charge neutrality of the dark proton strings: the idea was that the charges of color bonds cancel the total charge of dark nucleon so that all states  $uuu, uud, udd, ddd$  can be considered. The charge itself would not affect the representation of codons. Neutrality assumption is however not necessary. The interpretation as dark nucleus resulting from dark proton string could quite well lead to the formation the analog of ordinary nucleus via dark beta decays [L71] so that the dark nucleus could have charge. Isospin symmetry breaking is assumed so that neither quarks nor flux tubes are assigned to representations of strong  $SU(2)$ .

There is a possible objection. For ordinary baryon the mass of  $\Delta$  is much larger than that of proton. The mass splitting could be however much smaller for linear baryons if the mass scale of excitations scales as  $1/h_{eff}$  as indeed assumed in the model of dark nuclear strings [L42, L71].

2. The model assumes that the states of DNA can be described as tensor products of the four 3-quark states with spin content  $2 \otimes 2 \otimes 2 = 4 \oplus 2_1 \oplus 2_2$  with the states formed with the 3 spin triplet states  $3 \otimes 3 = 5 \oplus 3 \oplus 1$  with *singlet state dropped*. The means that flux tubes are spin 1 objects and only spin 2 and spin 1 objects are accepted in the tensor product. One could consider interpretation in terms of  $\rho$  meson type bonding or gluon type bonding. With these assumptions the tensor product  $(2 \otimes 2 \otimes 2) \otimes (5 \oplus 3)$  contains  $8 \times 8 = 64$  states identified as analogs of DNA codons.

The rejection of spin 0 pionic bonds looks strange. These would however occur as bonds connecting dark codons and could correspond to different p-adic length scale as suggested by the successful model of X boson [L76].

One can also ask why not identify dark nucleon as as closed triangle so that there would be 3 color bonds. In this case  $3 \otimes 3 \otimes 3$  would give 27 states instead of 8 ( $\oplus 1$ ). This option does not look promising.

3. The model assumes that amino-acids correspond to the states  $4 \times 5$  with  $4 \in \{4 \oplus 2 \oplus 2\}$  and  $5 \in \{5 \oplus 3\}$ . One could tensor product of spin 3/2 quark states and spin 2 flux tube states giving 20 states, the number of amino-acids!
4. Genetic code would be defined by projecting DNA codons with the same total quark and color bond spin projections to the amino-acid with the same (or opposite) spin projections. The attractive force between parallel vortices rotating in opposite directions serves as a metaphor for the idea. This hypothesis allow immediately the calculation of the degeneracies of various spin states. The code projects the states in  $(4 \oplus 2 \oplus 2) \otimes (5 \oplus 3)$  to the states of  $4 \times 5$  with same or opposite spin projection. This would give the degeneracies  $D(k)$  as products of numbers  $D_B \in \{1, 2, 3, 2\}$  and  $D_b \in \{1, 2, 2, 2, 1\}$ :  $D = D_B \times D_b$ . Only the observed degeneracies

$D = 1, 2, 3, 4, 6$  are predicted. The numbers  $N(k)$  of amino-acids coded by  $D$  codons would be

$$[N(1), N(2), N(3), N(4), N(6)] = [2, 7, 2, 6, 3] .$$

The correct numbers for vertebrate nuclear code are  $(N(1), N(2), N(3), N(4), N(6)) = (2, 9, 1, 5, 3)$ . Some kind of symmetry breaking must take place and should relate to the emergence of stopping codons. If one codon in second 3-plet becomes stopping codon, the 3-plet becomes doublet. If 2 codons in 4-plet become stopping codons it also becomes doublet and one obtains the correct result  $(2, 9, 1, 5, 3)!$

It is difficult to exaggerate the importance of this simple observation suggesting that genetic code is realized already at the level of dark or even ordinary nuclear physics and bio-chemistry is only a kind of shadow of dark matter physics.

### Mapping DNA and Amino-Acids to Dark 3-Nucleon States

The assumption that entire codon rather than letter corresponds to a state of dark proton does not conform with the model for the origin of purines as DNA nucleotides [L67] assuming that purines and in fact all nucleotides are combined with dark proton unless one assumes that 3 nucleotides combine with the same dark proton. This looks somewhat artificial but cannot be excluded.

Amazingly, the arguments of the model involve only the representations of rotation group and since  $p$  and  $n$  have same spin as  $u$  and  $d$ , the arguments generalize to 3- nucleon states  $(ppp, ppn, pnn, nnn)$  connected by two color bonds and organized to linear structures. Concerning genetic code, exactly the same predictions follow in the recent formulation of the model. In this case quark color is not present. One could however use the 1-dimensionality and the ordering of dark nucleons as already described.

This variant has several nice features. The model is consistent with the model for dark nucleon strings consisting of nucleons and color bonds between them. There is no need to introduce  $\Delta$  type nucleon states and colored states are not needed in fermionic sector. Color bonds must be colored if one wants ordinary bosonic statistics for flux tubes but here braid statistics might help. Colored bonds could of course have some important function.

### 18.4.5 Applications to neuroscience

Models of EEG and nerve pulse are basic applications of the notion of MB in neuroscience. The basis idea is that EEG and its fractal counterparts are communications to the various layers of MB having onion-like structure with cyclotron frequency correlating with the size of the layer. Josephson junctions about which basic example is cell membrane would communicate sensory information to MB as dark photons.

### Experimental evidence for MB

The team led by Michael Tyszka, associate director of Caltech Brain Imaging Center, has however discovered that the resting state network seems to work normally in people born without corpus callosum [J105] (see <http://tinyurl.com/3gjhtgb>)! As if brain hemispheres were communicating by some other means than neural signalling! This finding challenges not only the views about the origin of brain synchrony as being created by neural circuits but also the models of autism and schizophrenia explaining them in terms of impaired communications between hemispheres.

The MB of entire brain controls it and could naturally do this via the intermediate control of brain hemispheres forcing them to operate in the same rhythm. Brain synchrony and resting network would not be produced by resonant neuro-circuits as usually believed but by the spatiotemporal coherence of the EEG radiation from the MB of entire brain forcing brain hemisphere MBs to oscillate in the same rhythm and in turning synchronizing the brain hemispheres [K81]. This would be like forcing soldiers to march in the same pace and brain hemispheres could co-operate without any neural communication between hemispheres. The communication between hemispheres would be needed for more refined collaboration involving “discussion” between hemispheres: hemispheres of a person without corpus callosum would be like soldiers obeying blindly the orders. This might be also an essential element of autism and schizophrenia.

### EEG as communications between MB and BB

The general model for EEG follows neatly from this picture combined with the general model of high  $T_c$  superconductivity [K83, K84]. A fractal hierarchy of EEGs and its generalizations identified in terms of generalized Josephson radiation is predicted with levels labeled by p-adic length scales and the value of  $\hbar$  at various levels of dark matter hierarchy [K33]. At macrolevel one can approximate neuronal and axonal (and also cell-) membrane as Josephson junction formed by the two lipid layers of the membrane. At microscopic level ionic pumps and channels defined by Josephson junctions involving magnetic flux tubes connecting interior and exterior of the cell.

“Generalized” means that Josephson frequency as energy difference  $E = ZeV/h_{eff}$  of Cooper pair for membrane potential is replaced with the sum of difference of cyclotron energies and  $E$ . This implies that the variations of membrane potential by oscillations and nerve pulses induced frequency modulation of the frequency of dark photons sent to the MB. This defines a coding of the information carried by nerve pulses do dark photons. Whale’s song represents a good analogy for the coding. Besides EEG one would have its counterparts for various organs, organelles and even cell.

### Nerve pulse

The basic hypothesis has been that quantum jump takes the resting potential below the threshold for the generation of nerve pulse [K86]. One can imagine several ways for how this could happen. Some 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.

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. 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.

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. 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.

4. The 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 topological quantum computer (TQC) since 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 ways. 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 possible manner to achieve this if new nuclear physics is indeed present.

#### 18.4.6 Remote mental interactions

MB would be central for understanding of remote mental interactions as special case of those occurring between MB and biological body. Now the biological body would not be own biological body and could be even non-living system containing quantum critical parts. Remote mental interactions would not be anything exotic or special. In this framework [K110, K113] also hypnosis [L27] and psychedelic experiences [K108] might be seen as remote mental interactions.

#### Precognition, psychokinesis, telepathy

I have considered various remote mental interactions in the book [K110]. Much of the material has evolved via the panel discussions associated with Journal of Non-locality and I am grateful for Lian Sidorov and people working in her group for a fruitful collaboration during these years.

1. Magnetic flux tube pairs involving also MEs (“massless extremals” [K10, K74] as analogs of laser beams) connecting the sender and receiver make possible a universal mechanism for the transfer of intent and action. The pair of flux tubes forms a kind of sensory-motor loop. In biology the fundamental realization could be by a pair of flux sheets going through the strands of DNA with passive strand sending sensory data to the MB and active strand receiving control commands leading to various forms of gene expression. MEs are ideal for the transfer of both classical information and momentum.

This is not the only possible realization. For instance, one could think that the passive strands of DNA send sensory data to the MB of DNA and active strands of DNA receive control commands: time scale would be rather slow. Also the lipid layers of cell membrane could have similar division of labor and now the time scale could be that for nerve pulse.

2. The transfer of intent gives rise to mechanism of remote interaction which can act both endo- and exogenously. Magnetic flux tubes characterized by their fundamental frequencies make possible bridges between sender and receiver (say healer and healee) and allow a resonant interaction in which healer can initiate various control commands acting as 4-dimensional templates represented as holograms. Also smaller MEs can be send along the MEs serving as bridges (this is like throwing balls with light velocity!).

3. The MEs and magnetic flux tube pairs connecting sender and receiver can act as a reference wave which can initiate an arbitrarily complex hologram representing biological program. Sender has the ability to generate and amplify the frequencies which induce holograms representing the control commands. In particular, in living matter sender can initiate complex biological programs without knowing anything about their functioning.

One can distinguish between psychokinesis applied to living matter and inanimate matter.

1. When the target consists of living matter, the mechanisms would be same as in communications between magnetic and biological bodies making possible bio-control of biological body by MB and the receipt of sensory input from biological body by MB. Hypnosis would be one example of this kind of interaction.
2. Remote mental interactions in the case inanimate matter could use simpler variants of the fundamental mechanisms utilized in living matter. For instance, zero energy ontology assigns with the CD of electron and quarks time scales .1 s and 1 ms defining fundamental biorhythms. The CD assignable to elementary particles could be involved also with psychokinesis. NE could be essential for the transfer of metabolic energy (say in simple psychokinesis moving an object) and for control actions -say in intentional change of sequences of binary digits produced by random number generator. Target system would not be completely inanimate. Thermodynamical restrictions favor large values of Planck constant.

The basic problem in many remote mental interactions such as the intentional effect on random number generator is “Who knows how?”. How the mere intent can be transformed to action without any knowledge about the details of the action? The attempt to understand how neuro-feedback affect the behavior of single neuron leads to the same question.

1. Magnetic mirrors make possible also feedback and this feedback could make possible learning. For instance, in psychokinesis (especially so in micro PK), this learning would be crucial and analogous to that what occurs when we learn to drive a car. In healing this kind of feedback might help to find the healing frequency by trial and error.
2. It is quite possible that also multibrain and -bodied higher level collective selves actively participate in the process as a third party such that the remote mental interactions would act as a relay states. I have suggested similar explanation for Sheldrake’s findings about learning at the level of species and Tiller’s findings about the “transfer of intent”. This could make possible coherent amplification effects (TEM, prayer groups) and could make available information resources of all brains involved with the group. This could for instance explain the ability of a remote viewer to see an object on basis of data which need not have any meaning for her.
3. A fast amplitude modulation of alpha waves introducing higher harmonics to the carrier wave is a good candidate for mediating communication between brains and higher level multibrain selves. Mesoscopic “features” in brain involve precisely this kind of amplitude modulation and might represent just this kind of messages. Interestingly, also speech is produced by a fast amplitude modulation of 10 Hz basic vibration frequency of speech organs (assignable to electron CD as a fundamental frequency) and kHz (quarks) frequency is a special frequency from the point of view of hearing.

The article of J. Spottiswoode [J126] discusses two strange findings about remote mental interactions.

1. There is a statistical tendency of the anomalous cognition (AC) performance to concentrate in a 2 hour period around 13.30 of the local sidereal time (ST), which is the time measured using as a reference distant stars and thus running at a slightly different rate than the solar time: the lag is  $\Delta T = 24/365$  hours  $\sim 3.7$  minutes during 24 hours.
2. The anticorrelation between the level of geomagnetic fluctuations and AC performance has also a maximum during 2-hour period around  $\sim 13.30$  ST.

The fact that AC performance is associated with the same sidereal hour suggests the identification of the galactic magnetosphere as a conscious involved with remote cognition. For interstellar and galactic magnetic fields cyclotron time scales correspond to the time scales of human consciousness so that also these magnetic flux quanta could receive sensory input from biosphere and control it.

### Hypnosis as remote mental interaction

In TGD framework one can argue that hypnosis represents an example about the fact that brain is not “private property”: hypnotist uses the biological body and brain of the subject as instrument [L27]. Therefore remote mental interaction would be in question. This idea generalizes: if one accepts self hierarchy, one can assign to any kind of higher level structure - family, organization, species, .... - a higher level self and MB carrying dark matter, and these MBs can use lower level MBs as their instruments to realize their intentions. Biological bodies would be an important level in the hierarchy, which would continue down to cellular, molecular, and perhaps to even lower levels.

This view challenges the prevailing views about brain as a sole seat of consciousness and the assumption that conscious entities assigned with brains are completely isolated. Given MB can use several biological bodies although one can assign to it the one providing the sensory input - at least during wake-up state. Note however that it is easy to produce illusion that some foreign object is part of biological body.

For more than decade ago I proposed a model for so called bicamerality based on the notion of semitrance [K95]. In semitrance the brain of subject becomes partially entangled with a higher level self - in this case the self of family or more general social group uses the biological body of member for its purposes. Higher level self gives its commands and advice interpreted by the bicameral as “God’s voice”. The consciousness of schizophrenic might be basically bicameral. Also hypnotic state and dream consciousness are candidates for bicameral consciousness.

In [L27] I develop essentially this idea but using as input the recent understanding of about TGD inspired theory of consciousness and quantum biology and end up with a proposal for a detailed mechanism for how the MB hijacks some parts of the brain of the subject: prefrontal cortex and anterior cingulate cortex are argued to be the most plausible targets of hijacking. Also a mechanism explaining how the sensory hallucinations and motor actions are induced by hypnotist by inhibiting a halting mechanism preventing imagined motor actions to become real and sensory imagination to become “qualiafied”.

### Psychedelic experiences and time non-locality

There is a book about psychedelic induced experiences titled as “Inner paths to outer space” (<http://tinyurl.com/gnb4bp9>) written by Rick Strassman, Slawek Wojtowicz, Luis Eduardo Luna and Ede Frecska [J103]. The TGD inspired hypothesis [K113] goes as follows.

1. Psychedelics bind to the same receptors as the neurotransmitters with similar aromatic rings (weaker assumption is that neurotransmitters in question possess aromatic rings). This is presumably consistent with the standard explanation of the effect of classical psychedelics as a modification of serotonin uptake. This binding replaces the flux tube connection via neurotransmitter to some part of the personal MB with a connection via psychedelic to some other system, which might be even in outer space. A communication line is created making among other things possible remote sensory experiences.

Magnetic fields extending to arbitrary large distances in Maxwell’s theory are replaced with flux tubes in TGD framework. The MBs of psychedelics would carry very weak magnetic fields and would have very large  $h_{eff}$  - maybe serving as a kind of intelligence quotient.

2. This would be like replacing the connection to the nearby computer server with a connection to a server at the other side of the globe. This would affect the usual function of transmitter and possibly induce negative side effects. Clearly, TGD inspired hypothesis gives for the psychedelics much more active role than standard hypothesis.

3. Psychedelics can be classified into two groups depending on whether they contain derivative of amino-acid trp with two aromatic rings or phe with one aromatic ring. Also DNA nucleotide resp. its conjugate have 2 resp. 1 similar aromatic rings. This suggests that the coupling between information molecule and receptor is universal and same as the coupling between the two bases in DNA double strand and consists of hydrogen bonds. This hypothesis is testable since it requires that the trp:s/phe:s of the information molecule can be brought to same positions as phe:s/trp:s in the receptor. If also protein folding relies on this coupling, one might be able to predict the folding to a high degree.
4. A highly suggestive idea is that molecules with aromatic rings are fundamental conscious entities at the level of molecular biology, and that more complex conscious entities are created from them by reconnection of flux tubes. DNA/RNA sequences and microtubules would be basic examples about this architecture of consciousness. If so, protein folding would be dictated by the formation trp-phe contacts giving rise to larger conscious entities.

This model meets of course strong objection: finite light velocity does not allow communications with outer space in standard physics framework. In TGD framework ZEO changes the situation. Second objection is that the communications require huge amount of energy unless they are precisely targeted. The third objection is that quantum coherence in very long, even astrophysical scales is required. In TGD framework these objections do not apply.

## 18.5 Morphogenesis in TGD Universe

The problem of structure formation in biology - morphogenesis - was put under the rug by most biologists after the emergence of genetics. Sheldrake [L18, I76] is one of those who have taken it seriously and has been labelled as a crackpot by mainstreamers (I have discussed Sheldrake's views from TGD point of view in [L18, L57]). One just assumes that the structures are there and performs chemistry around these structures. This approach is very practical and has given an enormous amount of data but very little understanding.

In standard physics the description of spatial structures would be in terms of enhanced densities of biomolecules or of their gradients in some space-time region. This is the only possibility because the space-time of standard physics is topologically and geometrically utterly trivial. Empty Minkowski space is an excellent approximation for it.

What philosopher has to say about this? If space-time topology were topologically non-trivial, situation would change dramatically. Already Wheeler saw this possibility and in the biology inspired by TGD (for which Wheeler suggested its name) all structures correspond to structures of topologically non-trivial space-time identified as surface in certain 8-D space-time: space-time sheets, magnetic flux tubes, etc... The entire TGD inspired quantum biology relies on this vision. The structures that we see around us would represent the non-trivial topology of space-time surface.

All structures - including bio-molecules, membrane like structures, organelles, organs, ... - would be 4-D space-time surfaces. Again philosopher gets excited since this would reduce the notion of shape in biology to a precisely defined and testable geometrodynamics coupling to em fields.

### 18.5.1 The dynamics of space-time surfaces

This dynamics predicts two kinds of space-time regions [L51] (see <http://tinyurl.com/yboog5sr>).

1. The regions of first kind are locally minimal surfaces. These minimal surfaces are as 4-D analogs of geodesic lines analogs of asymptotic states of particle physics for which interactions are not on. They also satisfy non-linear geometrization of massless field equations so that both particle and wave aspects are present. What is especially important is that static minimal surfaces have vanishing mean curvature and look like saddles locally. They cannot be closed surface if stationary.
2. Second type of regions are not minimal surfaces: there is a non-trivial coupling of the minimal surface term to 4-force density analogous to the divergence of Maxwellian energy momentum

tensor. This is a generalization of the dynamics of a point-like charged particle in Maxwell field. These regions are identified as interaction regions: in particle physics these two regions correspond to external free particles and the interaction region. Magnetic flux tubes play fundamental role in TGD based quantum biology are deformations of string like objects, which represent simplest 4-D minimal surfaces.

Essential is the coupling between induced Kähler form (mathematically like Maxwell field) and the geometry of the surface: the divergence of energy momentum current assignable to the analog of cosmological term (4-volume) equals to the divergence of that assignable to Kähler action: this expresses local conservation of four-momentum. One could also speak about coupling between Kähler field and gravitational field: Penrose's intuition about the role of gravitation in biology would be correct.

When the coupling is absent, minimal surface property implies the separate vanishing of both divergences and separate conservation of corresponding energy-momenta. All the known extremals of Kähler action are minimal surfaces: this is due to their very simple algebraic properties making easy to discover them. Physically this correspond to quantum criticality: dynamics is universal and does not depend on coupling parameters.

### 18.5.2 General view about morphogenesis

These observations lead to a rather general view about morphogenesis.

1. The presence of the Kähler field (em field is sum of Kähler field and second term) makes possible flow equilibria such as cell membrane, which are not minimal surfaces. These surfaces can be closed and stationary making possible isolation from environment crucial for living organisms.

Spherical soap bubble is a good analogy: it is not minimal surface as the soap films spanned by frames are. They look locally like saddle surfaces with opposite external curvatures in two orthogonal directions, this implies that they cannot be closed surfaces. Bubble is not possible without a pressure difference  $\Delta p$  between the interior and exterior of the bubble: the blowing of the soap bubble generates  $\Delta p$ , and means external energy feed analogous to metabolic energy feed.

$\Delta p$  is analogous to a non-vanishing voltage  $V$  over cell membrane. The electric field of cell membrane and the energy feed providing the energy of electric field as metabolic energy are essential for the stability. More generally,  $V$  would generalize to non-vanishing of energy momentum tensor of Kähler field with non-vanishing divergence serving as a correlate for the energy transfer between Kähler and volume (gravitational) degrees of freedom.

This generalises to all morphologies, which correspond to closed surfaces. They necessarily involve both Kähler electric and magnetic fields coupling to the geometry to stabilize the morphology. This statement would give some content for the exaggerated claim that biology is nothing but electricity + Schrödinger equation that I heard during my first student year.

2. For instance, the presence of Kähler electric field can correspond to electric fields of cell membrane or along a part of body. If it is too weak, things go wrong in development. As was found decades ago, consciousness is lost if the electric field between frontal lobes and hindbrain gets too weak or has wrong direction [J34]. Cell dies if the membrane potential becomes zero and EEG disappears in death. Also microtubules have electric field along their axes essential for their existence.

Michael Levin and his collaborators [I60, I61, I80] have discovered further fascinating connections between electric fields and morphogenesis. One of the discoveries is that the electric fields of the embryo are controlled by neurons of the still developing brain (see <http://tinyurl.com/y77fcc7r>). This conforms with the view that neurons and their MBs correspond to a higher level in the hierarchy than ordinary cells and there take care of control in longer scales. The MB of the developing brain would be the controller.

3. A non-trivial coupling (four-momentum transfer) between the volume and Kähler degrees of freedom requires that the energy momentum currents have opposite and non-vanishing



divergences. For the energy momentum tensor of ordinary Maxwell field the divergence is proportional to the contraction of Maxwell current and Maxwell field so that the current must be non-non-vanishing.

In TGD the energy momentum tensor is replaced with energy momentum current allowing to have well-defined notion of energy momentum and corresponding conservation laws. Now the divergence contains two terms. The first one is the contraction  $Tr(T_K H^k)$  of energy momentum tensor  $T_K$  of Kähler action with the second fundamental form  $H^k$ : this term proportional to  $T_K$  is new. Second term is proportional to the contraction  $j_K J \nabla h^k$  of the induced Kähler form  $J$  with Kähler current  $j_K$  and gradients  $\nabla h^k$  of embedding space coordinates analogous the divergence of energy-momentum tensor  $j^\beta F^\alpha_\beta$  in the case of ordinary Maxwell action. One expects both terms to be non-vanishing.

For the mere Kähler action, which I believed for decades to determine the preferred extremals,  $j_K$  is either vanishing or light-like. In presence of coupling it can be both non-vanishing and time-like. The realization that cosmological term is present was forced by the twistor lift of TGD whose existence is possible only for  $H = M^4 \times CP_2$  [K114, L99].

4. The predicted stabilizing Kähler (and em) currents would naturally correspond to the DC currents flowing along the body in various scales discovered already by Becker [J160, J34] and found to be essential for the survival of the organism. In particular, Becker's DC currents are essential for the healing of wounds and in the regeneration of organs. In the first first aid stage of the healing DC currents are generated locally and after than central nervous system (CNS) takes care of the generation of the current (for TGD based discussion of Becker currents see [K82] (see <http://tinyurl.com/ydg6okkk>) or [K84]). Also this is easy to understand from the proposed stability criterion.

### 18.5.3 Quantitative view

The emergence of life would require the coupling between Kähler and volume degrees of freedom. The following gives a quantitative discussion based on p-adic length scale hypothesis and twistor lift of TGD [K114, L61].

1. The coefficient  $\Lambda/8\pi G \equiv 1/L^4$  of the volume term in the action is analogous to cosmological constant in general relativity. The predicted wrong sign of  $\Lambda$  is the stumbling block of superstring theories. In TGD framework the sign is correct.
2. p-Adic coupling constant evolution predicts that the cosmological constant depends on p-adic length scale  $L(k)$  characterizing the size scale of the Universe, most naturally as that of horizon size. In zero energy ontology (ZEO)  $L(k)$  is identifiable as the size scale of causal diamond (CD) [L61].

One important implication is a solution to the problem of cosmological constant. Although cosmological constant is huge at very early times (or more precisely, in very short p-adic length scales), it is small in the length scales of recent cosmology. The values of cosmological constant at smaller p-adic lengths scales are however visible also in the recent day physics in many-sheeted space-time and biology could make them visible as the following arguments show.

3. There are two paired p-adic length scales: short p-adic length scale  $L(k_1)$  and long p-adic length scale  $L(k)$ . The vacuum energy density  $\rho_{vac} = \Lambda/8\pi G$  is naturally proportional to  $1/L^4(k_1)$ . One has energy  $E = 1/L(k_1)$  per 3-volume  $L(k_1)^3$ .

$\rho_{vac} = \Lambda/8\pi G$  is also naturally proportional to  $1/GL^2(k)$  since  $\Lambda = x/L(k)^2$  is natural by dimensional considerations. If  $L(k)$  corresponds to the size scale of the horizon,  $\Lambda$  decreases during cosmic evolution and the problem of cosmological constant disappears. One has

$$\frac{1}{L^4(k_1)} = \frac{\Lambda}{8\pi G} \quad , \quad \frac{\Lambda}{8\pi} = \frac{x^2}{L^2(k)} \quad . \quad (18.5.1)$$

Here the p-adic length scale  $L(k)$  could characterize the p-adic size scale of CD.  $G = l_{Pl}^2$  is gravitational constant,  $l_{Pl}$  Planck length scale, and  $L = L(k_1)$  is a smaller length scale.  $L(k_1)$  expressible using the geometric mean

$$L(k_1) = \left(\frac{8\pi G}{\Lambda}\right)^{1/4} = x^{-1/2} \sqrt{L(k) l_{Pl}} . \quad (18.5.2)$$

of  $L(k)$  and Planck length  $l_{Pl}$  and allows an identification as a p-adic length scale for a suitable choices of the parameter  $x$  [L61]. One has  $(8\pi)^{1/4} \simeq 2.4$ .

What could this pairing of short and long p-adic length scales mean? The notion of magnetic body (MB) could provide an explanation. MB has onion-like layered structure with layers labelled by p-adic length scales up to some maximum size scale. This suggests that a biological structure with size scale  $L(k_1)$  has MB for which the largest layer has the size scale  $L(k)$ .  $L(k_1)$  would correspond to smallest length scale in the hierarchy. Both scales could correspond to size scales of CDs.

**Remark:** When  $L(k_1)$  is scaled by  $2^r$  ( $k_1 \rightarrow k_1 + r$ ),  $L(k)$  is scaled by  $2^{2r}$ , ( $k \rightarrow k + 2r$ ).

4. From the parameterization

$$\rho_{vac} = y \frac{H^2}{8\pi G} \quad (18.5.3)$$

of the dark energy density in terms of Hubble constant at given space-time sheets one obtains an estimate for the inverse of the Hubble constant  $H$ , which depends on space-time sheet in terms of  $L(k)$ , as

$$\frac{1}{H(k)} = \sqrt{\frac{y}{8\pi x}} L(k) . \quad (18.5.4)$$

$H(k)$  refers now to Hubble constant in given p-adic length scale characterizing a level in the hierarchy of space-time sheets and is *not* the ordinary Hubble constant defined in very long scales at GRT limit of TGD. Naturality suggests the condition  $\sqrt{\frac{y}{8\pi x}} = 1$ .

One expects that the coupling between Kähler action and volume term can be non-vanishing only if the two contributions to the energy momentum tensor are of the same order of magnitude. Otherwise minimal surface property takes care that field equations are satisfied, and one does not obtain closed membrane like structures crucial for life.

1. To achieve this, Kähler action  $\propto E^2 - B^2$  must be of the same order of magnitude as  $(\Lambda/8\pi G) \equiv x/GL^2(k)$  giving in the case of cell membrane for the Kähler electric field strength the rough estimate

$$E \sim \frac{\sqrt{x}}{l_{Pl} L(k)} . \quad (18.5.5)$$

**Remark:** The electric field of the cell membrane corresponds to  $E \sim 5 \times 10^{-4} \text{ eV}^2$  in the units of particle physicist ( $\hbar = 1$  and  $c = 1$ ) in which unit of distance is  $1/\text{eV}$  and one has  $1 \text{ m} \leftrightarrow 1.24 \times 10^6 \text{ eV}^{-1}$ .

2. If an estimate for the typical strength  $E$  of bio-electric field is given, one can get some idea about the length scale  $L(k)$  as

$$L(k) = \frac{\sqrt{x}}{l_{Pl}E} . \quad (18.5.6)$$

By feeding in Planck length  $l_{Pl} \sim 1.6 \times 10^{-35}$  m and the electric field  $E \sim 5 \times 10^6 \text{ V/m}$  of the cell membrane, one obtains for the cell membrane the estimate

$$\begin{aligned} L(k) &\sim \sqrt{x} \times L_0 , & L_0 &= 1.1 \times 10^6 \text{ ly} . \\ L(k_1) &= x^{-1/4} L_1 , & L_1 &= \sqrt{l_{Pl} L_0} = 4.2 \times 10^{-7} \text{ m} . \end{aligned} \quad (18.5.7)$$

Note that  $L(k)$  scales as  $x^{1/2}$  and  $L(k_1)$  as  $x^{-1/4}$ .

3. The value of electric field for cell membrane is essential for the argument. If one wants to generalize the argument from cell membrane to other systems, one must have an idea about how it scales. Membrane potential is near the value for which the potential energy  $ZeV_0$  for a Cooper pair is slightly above the thermal energy at physiological temperature. Hence the possible magnetic flux tube assignable to membrane proteins acting as Josephson junctions through cell membrane carry weakest possible electric field: this conforms with metabolic economy. A natural generalization would be that for a flux tube of length  $L$  one has  $E = V_0/L$ . This gives the scalings

$$L(k) \propto \left(\frac{L}{L_c}\right) , \quad L(k_1) \propto \left(\frac{L}{L_c}\right)^{1/2} . \quad (18.5.8)$$

The value of the parameter  $x$  is open and one can make only guesses. Naturality would suggest that  $x$  is not too far from unity.

**Option I:** The size of the Milky Way is estimated to be about  $L_{MW} = 10^5$  ly.  $L(k) = L_{MW}$  would be obtained for  $x = .01$ . One should be however cautious with this estimate: also  $x \sim 1$  might be acceptable.

1. For  $L(k_1)$  the formula  $L(k_1) = x^{-1/2} \sqrt{L(k) l_{Pl}}$  gives for  $x = .01$

$$L(k_1) = 4 \text{ nm} .$$

This is near the p-adic length scale  $L(149) = 5$  nm assignable to the ordinary cell membrane. There are indeed indications that galactic year defines a biorhythm [?]. For  $x = 1$  giving  $L(k) = 10^6$  ly one would have  $L(k_1) = 1.26$  nm, which does not correspond to cell membrane length scale.

2. For the inverse of the Hubble constant  $H(149)$  one obtains for  $x = .01$  the estimate

$$\frac{1}{H(k)} \simeq 2 \sqrt{\frac{y}{8\pi x}} L(k) . \quad (18.5.9)$$

$H(149)$  does not correspond to standard cosmological constant. One has  $H(149) = L(k)$  for  $y = 2\pi x = .0628$ .

3. The scaling  $L(k) \rightarrow 10^5 L(k)$  the size scale of the observed Universe about 15 Gly scales  $L(k_1 = 149)$  to  $L(k_1) = 1.3 \mu\text{m}$ , which corresponds to  $L(165) = 1.25 \mu\text{m}$  in a reasonable approximation ( $L(167) = 2.5 \mu\text{m}$  is the p-adic length scale of nuclear membrane). This scale would correspond to a distance through which one has membrane potential  $V_0$ . Could the size scales of galaxy and observed Universe indeed correspond to those of lipid layer of cell membrane and cell membrane?

**Option II:** One could argue that the long length scales correspond to the size scale of Earth. In TGD based view about EEG MB as onion-like structure has also layer with size scale of Earth radius  $R_E$ .

1. The condition that  $L(k) = R_E = 6.3 \times 10^6 \text{ m}$  gives  $x = 6.4 \times 10^{-16}$  and  $L(k_1) = 6.7 \text{ mm}$ .  $L(k_1)$  could characterize a brain structure involved in the generation of EEG. Note that the estimate assumes the electric field of cell membrane. One can argue that the value of  $x = 6.4 \times 10^{-16}$  is highly un-natural.
2. There are indications for the existence of life in Mars, whose radius is 1/2 of that for Earth.  $L(k)$  would scale down by 1/2 as also the cell membrane thickness. Could this be assumed also for the **Option I**? By the proposed criterion the strength of electric field  $E$  for cell membrane should be 2 times stronger than for Earthly cell (for same physiological temperature). For instance, membrane potential could be same but membrane thickness could be 1/2 of that for Earthly membrane.

Interestingly, the TGD based version of Expanding Earth model [L118, L117] predicts that Earth experienced a rapid expansion doubling its radius. Even more, neuronal cell membranes are 2 times thicker than ordinary cell membranes. Animals utilizing aerobic respiration emerged in Cambrian explosion and eventually also neurons and TGD suggests an explanation in terms of oxygenation as the life in underground oceans entered to the surface through the cracks generated by the expansion [L124].

#### 18.5.4 Morphogenesis in astrophysical scales?

The proposed general picture has interesting implications for the TGD view about stars and planets. Minimal surfaces have vanishing mean curvature vector  $H^k$  defined by the trace of the second fundamental form. The external curvatures sum up to zero and the surface looks like saddle surface locally. This strongly suggests that one cannot have (spherically symmetric) closed 3-surfaces obtained by taking two almost copies of 3-surface having a boundary and gluing them together along boundaries as the assumption that there are not boundaries requires. Could stars and planets be flow equilibria analogous to soap bubbles for which pressure difference is necessary and is provided by an external energy feed (blowing the bubble). When the energy feed ceases, the bubble collapses? The analogy with the stellar dynamics leading eventually to a collapse to a blackhole is obvious.

#### Morphogenesis and metabolic energy feed in astrophysical scales as explanation for some puzzling findings?

The analogy with morphogenesis could allow to build a more coherent picture from several puzzling observations related to TGD made during years.

1. One cannot obtain an embedding of Schwarzschild exterior metric without the presence of long range induced gauge field behaving like  $1/r^2$  [K118]. Any object with long range gravitational field must have also electroweak gauge charge. The charge can be made arbitrarily small but must be non-vanishing. The natural guess was that em charge - closely related to Kähler charge - is in question. If flow equilibrium analogous to soap bubble is in question, the charge must be Kähler charge with the energy momentum currents of Kähler field feeding energy to prevent gravitational collapse.
2. During 1990s I did considerable amount of work [K118] in attempts to construct spherically symmetric solutions of field equations using only Kähler action but failed. In this case, the

field equations state the vanishing of the divergences of energy-momentum and color currents. All known extremals of both Kähler action and its twistor lift involving also volume term analogous to cosmological term are minimal surfaces and extremals of both Kähler action and volume term.

The failure to discover extremals which are not minimal surface might be simply due to the fact that they are not simple. One can however ask whether there are actually no radially symmetric stationary extremals of Kähler action? Could volume term be needed to stabilize them?

3. 4-surfaces with vanishing induced Kähler field are necessarily minimal surfaces. The vanishing of induced Kähler field is however not necessary. In fact all known non-vacuum extremals of Kähler action are minimal surfaces. The known repertoire of minimal surfaces includes cosmic strings, massless extremals representing radiation, and  $CP_2$  type extremals with Euclidian signature of induced metric representing elementary particles. For these Kähler action is present but minimal surface field equations give extremal property separately in volume and Kähler degrees of freedom.

For  $CP_2$  type extremals having light-like geodesic  $X^1 \subset M^2$  as  $M^4 = M^2 \times E^2$  projection, deformations as holomorphic maps  $CP_2 \rightarrow E^2$  are not possible without a coupling between Kähler and volume degrees of freedom: the reason is that non-vanishing Kähler current is generated. For mere volume term they would be possible.

4. Cosmic strings would dominate in the very early cosmology before space-time as a 4-surface with 4-D  $M^4$  projection had emerged. The vision is that the thickening of their  $M^4$  projection during cosmic expansion generated Kähler magnetic flux tubes carrying magnetic monopole fluxes. The thickening of cosmic strings need not leave them minimal surfaces but one expects that this is true approximately.

The feed of energy and particles from flux tubes (suggesting that they are not minimal surfaces) would have generated visible matter and led to the formation of stars. The flux tubes would take the role of inflaton field in standard approach. Flux tubes would have also second role: they would carry the quanta of gravitational and gauge fields and thus would be mediators of various interactions.

Dark matter identified as phases with non-standard value of Planck constant  $h_{eff}/h_0 = n$  having purely number theoretical origin in adelic physics [L97, L98] would reside at magnetic flux tubes and the general vision about TGD inspired biology is that it controls the ordinary biomatter, which would involve metabolic energy feed as a stabilizer of the flow equilibrium. This picture suggests a generalization.

Consider as an example cosmic strings  $X^4 = X^2 \times S^2 \subset M^4 \times CP_2$ , where  $S^2$  is a geodesic sphere - either homologically trivial or non-trivial. Consider  $M^4$  deformations transversal to  $X^2$  expected to lead to a thickening of cosmic strings during cosmic evolution.

- (a) For homologically trivial  $S^2$  and  $X^2 = M^2 \subset M^4 = M^2 \times E^2$  holomorphic deformations  $S^2 \rightarrow E^2$  are minimal surface extremals with a vanishing induced Kähler form. It is plausible that these deformations generalize to transversal holomorphic deformations of  $X^4 = X^2 \times S^2 \subset M^4 \times CP_2$  if the normal spaces of  $X^2$  in  $M^2$  form an integrable distribution.
  - (b) For homologically non-trivial  $S^2$  and  $X^2 = M^2 \subset M^4 = M^2 \times E^2$  holomorphic deformations  $S^2 \rightarrow E^2$  with vanishing Kähler current and without genuine coupling between volume and Kähler degrees of freedom are not possible. This is true also for a general string world sheet  $X^2$ .
5. The vision about dark nucleosynthesis [L86], which emerged from the model of “cold fusion” has led to the proposal that dark nucleosynthesis preceded ordinary nucleosynthesis. Dark proton sequences were generated first by the analog of Pollack effect [L34], [L34] at magnetic flux tubes suffering also weak decays to produce states involving dark neutrons. These states decayed to dark nuclei with smaller value of  $h_{eff}/h = n$  and eventually this process led to the formation of ordinary nuclei. This process liberated practically all nuclear energy and

heated the system and led eventually to the ordinary nuclear fusion occurring in the cores of stars.

In living systems dark nuclei realized as dark proton sequences realize dark analogs of DNA, RNA, amino-acids, and tRNA and would provide the fundamental realization of the genetic code [L110, L109]. This picture predicts a hierarchy of dark nuclear physics and dark realizations of the genetic code and analogs of the basic biomolecules. Could biology be replaced by a hierarchy of “biologies” in a more general sense.

6. In the generalized biology stellar cores would provide metabolic energy realized basically as energy flow associated with Kähler field in stellar core making possible to realize star as an analog of cell membrane as flow equilibrium. Also the flow of Kähler charge, presumably in radial direction, would be involved if the energy momentum current of the induced Kähler field is non-vanishing and could relate to the mass loss of stars.

Even in the case of planets dark nucleosynthesis could provide a radial energy flow to guarantee stability. Nucleosynthesis could have occurred inside planets and have produced heavier nuclei. The standard picture about stars as providers of heavier elements and supernova explosions giving rise to fusion generating elements heavier than Fe could be wrong.

7. This picture conforms with what we know about dark matter. Dark matter would consist of  $h_{eff}/h_0 = n$  phases of ordinary matter at magnetic flux tubes. If also magnetic flux tubes are minimal surfaces in good approximation, gravitational degrees of freedom assignable to the volume action as analog of Einstein-Hilbert action and stringy action would not interact with Kähler degrees of freedom appreciably except in the events in which dark energy and matter are transformed to ordinary matter. These events could be induced by collisions of magnetic flux tubes. The energy exchange would be present only in systems not representable as minimal surfaces. Dark matter in TGD sense has key role in TGD inspired quantum biology.

### Blackhole collapse as an analog of biological death?

Before one can say something interesting about blackholes in this framework and must look more precisely what cosmic strings are. There are two kinds of cosmic strings identifiable as preferred extremals of form  $X^2 \times Y^2 \subset M^4 \times CP_2$ .  $X^2$  is minimal surface.

1.  $Y^2$  can be homologically non-trivial complex sub-manifold of  $CP_2$  for which second fundamental form vanishes identically. Induced Kähler form is non-vanishing and defines monopole flux. Both Kähler and volume term (cosmological constant term formally at least) contribute to energy density but the energy momentum currents and also tensors have vanishing divergence so that there is no energy flux between gravitational and Kähler degrees of freedom.
2.  $Y^2$  can be also homologically trivial geodesic sphere for which Kähler form and therefore Kähler energy density vanishes identically. In this case only cosmological constant  $\Lambda$  represents a non-vanishing contribution to the energy so that energy transfer between gravitational and Kähler degrees of freedom is trivially impossible.

What could happen in blackhole collapse?

1. Blackhole is not able to produce “metabolic energy” anymore and preserve the spherically symmetric configuration anymore. The outcome of blackhole collapse could be a highly folded flux tube very near to minimal surface or perhaps, or even a cosmic string. The latter option is not however necessary.
2. Is this string homologically non-trivial having large string tension or homologically trivial and almost vacuum for small values of  $\Lambda$ ? The huge mass density of blackhole does not favour the latter option. This leaves under consideration only the homologically non-trivial cosmic strings or their deformations to flux tubes.

The string tension for cosmic string is estimated to be a fraction of order  $10^{-7}$  about the effective string tension of order  $1/G$  determined by blackhole mass which is proportional to the Schwarzschild radius. Therefore the cosmic string should be spaghetti like structure inside

the horizon having length about  $10^7$  time the radius of blackhole. Note that TGD predicts also second horizon below Schwarzschild horizon: the signature of the induced metric becomes Euclidian at this horizon and this could explain the echoes claimed to be associated with the observed blackhole formation [L64, L128].

3. One could say that Big bang starting from homologically non-trivial cosmic strings would end with Big crunch ending with similar objects.

Living systems are conscious and there is indeed a strong analogy to TGD inspired theory of consciousness. One could say that the particular sub-cosmology corresponds to a conscious entity (many-sheeted space-time predicts a Russian doll hierarchy of them) which repeatedly lives and dies and re-incarnates with opposite arrow of time.

1. In zero energy ontology (ZEO) key role is played by causal diamonds (CDs) carrying analogs of initial and final states at their boundaries are in key role. The  $M^4$  projection of CD is intersection of future and past directed light-cones. The shape of CD strongly suggests Big Bang followed by Big Crunch.
2. TGD inspired theory of consciousness predicts that conscious entities - selves - correspond to a generalized Zeno effect. Self is identified as a sequence of “small” state function reductions (weak measurements) increasing gradually the size of CD by shifting the active boundary of CD farther away from that passive boundary which is not changed (Zeno effect).

The states at the active boundary are affected unlike those at the passive boundary. Self dies when the first “big” state function reduction to the active boundary occurs and the roles of the active and passive boundary are changed. The arrow of geometric time identified as the distance between the tips of CD changes and the CD starts to grow in opposite time direction. The evolution of self is a sequence of births and deaths followed by a re-incarnation.

3. In astrophysical context this evolution would be a sequence of lifes beginning with a Big Bang and ending with a Big Crunch with two subsequent evolutions taking in opposite time directions. Somewhat like breathing. This breathing would take place in all scales and gradually lead to a development of sub-Universes as the size of CD increases.
4. In ZEO the first big state function reduction to active boundary of CD occurs when all weak measurements have been done and there are no observables commuting with the observables, whose eigenstates the states at the passive boundary are. Self dies and reincarnates.

One can also try to build a classical view about what happens. Measurement involves always a measurement interaction generating entanglement. Could the transfer of quantum numbers and conserved quantities (also color charges besides Poincare charges) between Kähler and volume degrees of freedom define the measurement interactions in practice. When this transfer vanishes, there is no measurement interaction and no further measurements are possible. Also metabolism ceases and self dies in biological sense.

## Chapter 19

# Questions about IIT

### 19.1 Introduction

I received a link to a very interesting article by John Horgan in Scientific American with title “Can Integrated Information Theory Explain Consciousness?” [J123] (see <http://tinyurl.com/h7btppb>). Originally IIT is a theoretical construct of neuroscientist Giulio Tononi (just Tononi in the sequel). Christof Koch is one of the coworkers of Tononi. IIT can be regarded as heavily neuroscience based non-quantum approach to consciousness and the goal is to identify the axioms about consciousness, which should hold true also in physics based theories. The article of Horgan was excellent and touched the essentials and it was relatively easy to grasp what is common with my own approach to consciousness and comment also what I see as weaknesses of IIT approach.

To my opinion, the basic weakness is the lack of formulation in terms of fundamental physics. As such quantum physics based formulation is certainly not enough since the recent quantum physics is plagued by paradoxes, which are due the lack of theory of consciousness needed to understand what the notion of observer means. The question is not only about what fundamental physics can give to consciousness but also about what consciousness can give to fundamental physics.

The article “Consciousness: here, there and everywhere” of Tononi and Koch [J174] (see <http://tinyurl.com/zgm985f>) gives a more detailed summary about IIT. The article “From the Phenomenology to the Mechanisms of Consciousness: Integrated Information Theory” [J149] (see <http://tinyurl.com/z9s4k7n>) gives a more technical description of IIT. Also the article of Scott Aaronson [J161] (see <http://tinyurl.com/zarjffz>) was very helpful in providing computer scientific view about IIT and representing also mathematical objections.

In the article [J149] it is emphasized that IIT is a work in progress. This applies also to TGD and TGD inspired theory of consciousness. Personally I take writing of TGD inspired commentary about IIT as a highly interesting interaction, which might help to learn new ideas and spot the weaknesses and imperfections in the basic definitions of TGD inspired theory of consciousness. If TGD survives from this interaction as such, the writing of these commentaries have been waste of time.

#### 19.1.1 Criticism of the axioms of IIT

Consider first a brief critical review of the axioms of IIT.

##### Philosophical assumptions

1. Consciousness is regarded as an intrinsic property of matter like mass or charge. This view restates essentially materialistic world view and its problems are well-known (qualia, free will, intentionality).
2. Panphysicism is accepted. This is quite a big step from neuroscience, which tries to reduce consciousness to a property of brain. The motivation probably comes from the idea that computers might be conscious systems too.



There is no mention of hierarchies although hierarchical structures have turned out to be important also in neuroscience as the success of deep learning programs relying on hierarchies shows. The standard failure of conscious theorists seems to be the assumption that matter is either conscious or not. In physics the notions of scale hierarchies and hierarchies of systems with subsystems with... are standard and this would suggest that also conscious entities form a hierarchy.

### Causal evolution and the notion of information

One considers a network and decompositions of system (say brain) into two parts A and B and considers causal evolutions between states of A and B. They could be specified by collections of bits with individual bit telling whether a given neuron fires in given region. A and B could correspond to input and output of computation or to sensory input and motor response (or response at the level of brain in case that there is not motor response (locked-in patient)).

Causal evolutions between A and B are considered: they might correspond to nerve pulse patterns leading from state of A to that of B. One can define information for a causal evolution from A to B as difference of entropies:  $I(A, B) = S(A|B) - S(B)$  Conditional entropy for the state of A with that for B subtracted.  $\Phi$  corresponds to  $I(A, B)$  for a pair for which it is a maximum.

One can criticize this view.

1. The precise identification of the network and of states of the network remains unclear. In the case of computers this is not a problem and one can calculate  $\Phi$  and decide whether a computer running given program is conscious or not.
2. In the definition of Shannon entropy one implicitly assumes external conscious observer and information corresponds to her information gain as she learns what the state of B is. This notion of conscious information circular and identifies the conscious information of system about itself with that of external system about it.
3. Intuitively it is clear that this information is maximal if A and B corresponds to input and output of a deterministic computer program assigning to each input an output such that all outputs are different and  $H(A|B)$  vanishes so that a measure for the complexity of the input is in question. To my opinion this tends to restrict the property called consciousness to be property of classical computers.

To make the criticism more precise, one can look at the expression for  $I(A, B) = S(A|B) - S(B)$  with conditional probabilities defined by  $p(A|B) = p(A, B)/p(B)$ . If A and B are independent events that is if the output has no correlation with input as in the case of thermodynamical system, one has  $p(A, B) = p(A) \times p(B)$  and one has  $I(A, B) = S(A) - S(B)$ . Second law tells that the information is negative. In thermal equilibrium  $I(A, B) = 0$ . Quite a reasonable result.

Intuitively optimal situation is achieved when  $S(A|B)$  having interpretation as the entropy associated with the causal evolution is zero: evolution would be completely deterministic as in classical computer programs or quantum computer programs during computation. Therefore classical computer programs, which do not map two inputs to same output would be ideal (the error correction program mentioned by Scott Aaronson) as far as consciousness is involved: this is not surprising taking into account the idea about neuron as bit.

The situation would be optimal for the maximally entropic initial state: this looks admittedly strange. Printing of a page of text about whose content I know nothing would be a highly conscious process! If I knew the content of the page, it would not be a conscious process! Obviously this is true but for me, not the system claimed to be conscious! The circulatory definition of conscious information leads to this non-sensical result. All definitions of conscious information based on ordinary Shannon entropy lead to the same result. One should have genuine definition of information.

### Causal networks and the assignment of qualia to the links of the causal network

Causal network is assumed with motivations coming from neuroscience and qualia are assigned with the links of this network. They would correspond to axons or neural pathways in neuroscience.

Also this view can be criticized.

1. The idea that various sensory qualia could be understood in terms of topological structure of a network formed by neurons and axons is old but has not led to the understanding of qualia. The neural network looks exactly the same in various sensory areas. Also the sensory pathways look the same.
2. Causal interactions between parts of brain are assumed to give rise to consciousness. People having no corpus callosum have synchronous left and right hemispheres [J105] (see <http://tinyurl.com/3gjhtgb>)! One might expect that causal interactions between hemispheres must be responsible for the synchrony. There seems to be something like “boss” forcing both hemispheres to synchrony.

### Exclusion axiom

Exclusion states the decomposition  $(A,B)$  with maximum of  $\Phi$  contributes to conscious experience. There would be competition for consciousness.

Exclusion axiom cannot make sense for arbitrary system since it always allows decomposition with maximum  $\Phi$ . Exclusion axiom also leads to a strange situation if there is also competition between systems of different sizes. The larger one takes the overall system size to be, the smaller the probability of a system with given size to be conscious. A way to escape the situation is to assume hierarchy of consciousness with levels naturally characterized by length and time scales so that one considers systems smaller than given scale at given level.

### 19.1.2 Comparison with TGD view

TGD inspired theory of consciousness is essentially quantum measurement theory in Zero Energy Ontology (ZEO).

### 19.1.3 Self as generalized Zeno effect in Zero Energy Ontology

1. In ZEO physical states are replaced by pairs of states analogous to physical events: the members of state pair are localized to 3-surfaces at opposite light-like boundaries of causal diamond (CD) defined as intersection of future and past directed light-cone and replacing its points with  $CP_2$ . Causal diamonds form a hierarchy and this implies self hierarchy with subselves as subselves assignable to sub-CDs. In twistor lift of TGD ZEO and CDs forced by finiteness of the action [L59].

The assumption that the states having vanishing total conserved quantum numbers and classical charges realizes conservation laws and allows consistency with physics without loss of non-determinism required by free will (subject to constraints of state function reduction). Negentropy Maximization Principle (NMP) is the basic variational principle of TGD inspired theory of consciousness.

2. Self as generalized Zeno effect corresponds to a sequence of state functions leaving the state at “passive” boundary of CD and the passive boundary itself unaffected and changing the state at active boundary and moving it farther away from the passive boundary. This shift is quantum process involving localization for the positions of active boundary and reducing to a sequence of discrete unitary time evolutions defining the analog of unitary time evolution in ordinary quantum theory. This shift of active boundary of CD gives rise to the experience about flow of time. The passive boundary gives rise to experience about the existence of permanent self. Subselves as mental images give rise to qualia as their unchanging part.
3. Self dies as the first state function reduction to the opposite boundary of CD is forced by NMP but is predicted to re-incarnate as time reversed self. A possible interpretation for sensory-motor cycle is as sensory mental image and its time reversal identified as mental image assignable to motor action. Motor action would mean sensory input in reversed direction of time at some level of self hierarchy. This conforms with the Libet’s finding that conscious decision about motor action is preceded in geometric time by neural activity.

### Criterion for consciousness

The notion of conscious self relies on the notion of quantum entanglement to which one can assign information measures.

1. Conscious self would correspond in zero energy ontology (ZEO) to negentropically entangled system at the passive boundary of CD and would not decompose to tensor products of unentangled systems. Selves can be assigned with causal diamonds (CDs), and the simplest option is that CD corresponds to single self. Sub-CDs correspond to sub-selves experienced by self as mental images. This condition decomposes the system uniquely to conscious entities and it is not sensible to ask whether arbitrarily chosen subsystem is conscious or not. Only the state at the “passive” boundary of causal diamond (CD) correspond to self in this sense. The state at the active boundary of CD which moves reduction by reduction farther away from the passive boundary is entangled and one cannot decompose it in this way. Note that self has sub-selves, which represent sub-CDs and these contribute to mental images of self.
2. The notion of many-sheeted space-time is essential. Subselves correspond to smaller space-time sheets “glued” to space-time sheet assignable to self. They represent subsystems but not as a tensor factor as in standard quantum theory based on single-sheeted space-time. The theory of hyperfinite factors allows more general notion of tensor product, and it seems that this kind of tensor product is in question.

This relates closely to the notion of measurement resolution. Self experiences subself as mental image but the mental images of subself are experienced as an average. This prevents self from drowning to conscious information. Second implication of this notion of subsystem forced by many-sheeted space-time is following: two selves at the same hierarchy level are by definition un-entangled. Their subselves can however entangle to single subself shared as mental image by both. This could be behind stereo vision and “stereo consciousness” and could be essential for communications. Also remote mental interactions would involve stereo consciousness.

The fundamental criterion for consciousness would be therefore formulated in terms of entanglement. At the level of living systems betabolic energy feed would be a more practical criterion to decide whether some living system is conscious at some hierarchy level. Self-organizing systems are systems in which the feed of energy to the system leads to a complex self-organization patterns. Are these systems conscious? Does the feed of energy lead to a generation of negentropic entanglement (NE) and metabolism leading to a dynamics analogous to that in biochemistry (NE is always present in p-adic sectors). Any system has magnetic body (MB, also a new element) and one must consider seriously this possibility. The time scale of this dynamics could be quite slow. Second important factor is the coupling of dark matter at MBs to ordinary matter. If this coupling is small, consciousness does not have much causal power.

### Negentropic entanglement as the counterpart of $\Phi$ in TGD

In TGD framework information ( $\Phi$ ) is associated with NE for which the sum of number theoretic entanglement negentropies assignable to p-adic primes is maximal [L65] [K61]. The notion of NE and precise formulation of NMP has taken a long time. The recent formulation is in terms of adelic physics combining real number based physics of sensory experience with various p-adic physics of cognition. The key realization was that there is just single number theoretically universal entanglement. In real context it has always non-negative entropy and measures the lack of information of outsider about the system. In p-adic contexts the p-adic variant of entropy can be negative and has interpretation as information and measures the conscious information of system about itself.

1. Both real entropy and its p-adic variants in algebraic extension of rationals defining the coefficients of Hilbert space is used (this is essential and forced by number theoretical existence). In p-adic context the definition of entanglement entropy relies on a modification of Shannon entropy satisfying same axioms as in real case. For given p-adic prime this entropy can be negative and is identified as negentropy associated with entanglement. The superposition of state pairs  $(a_i, b_i)$  can be identified as an rules with pairs as instances of the rule. Information

can be said to be in the quantum relationship between A and B - not about A or B. One finds also now the pair for which NE is minimal. State function reduction can occur for this pair and reduce the entropic entanglement or produce more NE.

2. Number theoretical universality is an important additional restriction demanding that the entanglement probabilities in various p-adic sectors are of form  $P_i = X_i/N$ , where  $N$  is the number of state pairs in the superposition and  $X_i$  depend only on the algebraic numbers defining the extension having unit p-adic norm but do not involve ordinary p-adic integers and therefore have unit p-adic norm. This implies that the sum of p-adic negentropies is maximal and depends on  $N$  only and equals to the real entropy associated with maximal entanglement with  $p_i = 1/N$ . the sum of p-adic negentropies is not smaller than real entropy and equals to it for rational entanglement  $p_i = 1/N$ .

Could the paradoxical situation encountered in IIT (printer is conscious when it prints file about contents of which no one knows and unconscious otherwise) make sense in TGD framework somehow?

1. Conscious entity - self - would live in adelic world and would be negentropically entangled subsystem - superposition of several state pairs. Self can be regarded as generalized Zeno effect in ZEO. NMP does allow state function reduction during its lifetime to the passive boundary of CD so that outsider could not learn what it's state is!
2. Real entanglement entropy would describe this missing information and the sum of p-adic negentropies the conscious information possessed by the self (for rational entanglement probabilities these two measures would have same value). In TGD inspired theory of consciousness the paradoxical statement would thus make sense! Schrödinger cat remains conscious as long as no-one is able to measure the state of cat (note that here dead-alive dichotomy as a metaphor is not good). Conscious systems would be secretive!

The correlation produced by causal evolution in IIT is replaced with NE in TGD. Hence the two views look rather different as far as conscious information is considered. On the other hand, classical physics is exact part of TGD and quantum classical correspondence is realized by strong form of holography (SH). Quantum computation accompanies self and quantum computation is accompanied by a quantum superposition of classical computations. Therefore one can ask whether the generalization of the formula for  $I(A, B)$  could be meaningful in TGD and even relate to consciousness.

1. In TGD framework the superpositions of classical space-time surfaces identified as preferred extremals connecting the positive and negative parts of zero energy states at opposite boundaries of CD define the counterparts of causal evolutions. Quite generally, classical deterministic evolution is highly analogous to a classical computer program.
2. The analog of  $I(A, B)$  in TGD could be assigned with the evolution zero energy state based on time evolution of the space-time surfaces: A and B would correspond to the positive and negative energy parts of states at opposite boundaries of CD (initial and final states of classical time evolution) defining self. B would correspond the passive boundary of CD and A to the active boundary, which moves farther from B during the reduction sequence and states at it experience a discretized variant of unitary time evolution. The evolution for the active boundary of CD is the analog of unitary Schrödinger evolution and analogous to quantum computer program.

*Note:* In TGD framework quantum theory is purely classical theory formally! WCW spinor fields representing zero energy states are indeed purely classical spinor fields formally. Only state function reduction is something genuinely quantal.

3.  $S(A|B)$  could be interpreted as entropy generated by evolution analogous to classical computation. The time evolution however fails to be strictly deterministic and particle reactions represented topologically in terms of generalized Feynman diagrams would naturally relate to this non-determinism. Hence  $S(A|B) > 0$  is expected to hold true and could be very much like entropy generated by particle decays and creation and the interpretation in terms of thermodynamics would be natural.

4. The very existence of self thus breaks second law (note however that state function reductions occur for sub-CDs assignable to mental images which die and are reborn). As self dies, thermodynamical entropy increases since this reduction is non-deterministic. On the other hand, new time-reversed self is born and carries NE and there is negentropy gain by NMP [K61]. Second law holds true in time scales longer than the life time of the long-livest self.  $I(A, B) > 0$  could be thus assigned with selves during their life-time. Since the state function reduction to the opposite boundary of CD is non-deterministic, the conjecture that  $I(A, B)$  equals to negentropy gain in this reduction, does not make sense.
5. The definition of  $I(A, B)$  is non-trivial problem and discretization implied by finite measurement resolution at fundamental level is necessary in order to avoid mathematical difficulties in the case of deterministic evolution.

### The counterparts of networks in TGD

In TGD framework the networks emerge naturally as networks of magnetic flux tubes [L65].

1. The “boss” forcing the synchrony of disconnected left and right hemispheres would be magnetic body (MB) of brain [L69]. Magnetic bodies appear in all scales. NE between nodes of this network is what is more significant.
2. The so called tensor networks [B10] [L60] (see [http://tgdtheory.fi/public\\_html/articles/tensornet.pdf](http://tgdtheory.fi/public_html/articles/tensornet.pdf)), which have emerged as realizations of error correction codes in quantum computation and realize holography can be seen as a realization of NE. One can say that each node is unitary in generalized sense and that the nodes at the ends of lines are unitarily entangled. The realization in terms of magnetic flux tubes could define kind of template for the dynamics of bio-systems. Magnetic body (MB) would define both geometric and dynamical template for bio-chemistry and even genetic code could be reduced to this level. MB would extend the organism-environment duality to trinity. It has been proposed that entanglement between the nodes leads to the emergence of 3-space. What would emerge in TGD framework would not be 3-space but proprioception - conscious experience about 3-space. These networks would define “magnetic spine” of an organism.
3. The dynamics of MB (motor actions of MB as reconnections, contractions of flux tube, changes of the topology of the network inducing NE transfer) and also the dynamics at MB (supra currents, dark photons propagating along flux tubes in targeted way) would define the analog for the causal dynamics appearing in IIT. ADP-ATP transition attaching phosphate to ADP has interpretation as transfer of NE. Phosphate-X (X some large system) flux tube is attached to ADP to give ATP-X NE and when ATP gives phosphate to bio-molecule Y one obtains Y-X NE (for what Y could be, see below). Metabolic energy could go basically to transfer NE between systems. This would mean that the local dynamics of the network would be central for what it is to be living.
4. This picture would suggest that the changes of topology making possible transfer of negentropy are crucial for consciousness in living systems. Dynamics of bits in static networks represents only the classical communications associated with genuinely quantal system.

Bio-photons identified as decay products of dark photons with large value of Planck constant  $h_{eff}$  is an essential element of resonant like precisely targeted communications along flux tubes of MB. It must be made clear that TGD has had an interpretational problem related to the identification of bio-photons as decay products of dark protons [?, K78]. The resolution of this problem leads to conclusion that MBs with field strengths assignable to Earth’s *resp.* galactic magnetic fields control living matter and have EEGs related by scaling: for details see [L65].

What the mysterious looking entity  $X$  could then be?

1. The MB of Earth assignable with Earth’s mass via  $h_{eff} = h_{gr} = GMm/v_0$ , where  $v_0$  is a parameter with dimensions of velocity, is the first candidate for  $X$  but for it EEG would be scaled down since the flux tubes would correspond to those of galactic magnetic body with  $B_{gal} \sim 10^{-9}$  Tesla: 10 Hz alpha band would correspond to 72 minute time scale and natural periodicity would be given by sidereal day.

2. What puts bells ringing is that Spottiswoode observed that sidereal day defines periodicity for precognition [J126]. A mass  $M_D \simeq 5. \times 10^{-5} M_E$  forming a spherical layer at the distance of Moon from Earth associated with the magnetic Mother Gaia controlling bio-dynamics would correspond to the ordinary EEG. This would also predict that 1 s cyclotron time for DNA sequences in  $B_{end} = .2$  Gauss corresponds to 12 h cyclotron time for  $B_{gal} = .63$  nT.

The presence of these two MBs be a dramatic manifestation of non-locality and profoundly change neuroscience views about consciousness. These MBs would make life possible at Earth. Both MBs would be in continual contact with biomolecules like ATP and the molecules for which ATP attaches or provides the phosphate. Metabolic energy would be used to this process. These MBs would be “goddesses” directing their attention to tiny bio-molecules. If this picture is correct, the ideas about consciousness independent on material substrate and assignable to a running computer program can be safely forgotten.

### Qualia in TGD framework

In TGD the qualia correspond to the eigenvalues assignable to the observable measured during repeated state function reductions leaving the states at the passive boundary of sub-CDs representing mental images of self invariant. Non-locality and new view about time allows to consider also the possibility that qualia can be assigned with the sensory organs [K44]. One cannot of course exclude the possibility that also neurons can have primary sensory experiences rather than just sharing the primary sensory mental images assignable to the sensory organs.

Sensory qualia reduce in principle to quantum numbers assignable to the maximally commuting set of observables, which in turn would reduce to Cartan algebra for the Lie algebra of symmetries. This algebra is infinite-dimensional in TGD framework since the mathematical existence of the theory demands maximal possible symmetries at the level of “World of Classical Worlds” (WCW). If this view is correct, sensory qualia would be universal.

### Panphysicism in TGD

Pan-physicism is basic prediction of TGD approach. Entire hierarchy of selves is predicted. The mental images of self are identified as subselves and there is p-adic length scale hierarchy defining a cognitive hierarchy and hierarchy of Planck constants  $h_{eff} = n \times h$  defining a hierarchy of dark matters. Our mental images correspond to conscious entities and we ourselves are mental images of higher level self. The hierarchy of space-time sheets of many-sheeted space-time is essential element and lost in the GRT-gauge theory limit of TGD. One can say that length scale reductionism is replaced with fractality.

This kind of scale hierarchy would immediately allow to answer questions like “Is cerebellum conscious?” and “Are we conscious during sleep?”. The answer would be “yes, but in different scales than brain in wake-up state”. The duration of mental images of cerebellum would be measured in perhaps milliseconds. The conscious motor actions of cerebellum would correspond to fine details of motor actions. During sleep absence of sensory input and motor output would mean that corresponding mental images are absent. In TGD framework this alone explains why we do not have memories about sleep periods!

#### 19.1.4 Are the following questions addressed in IIT?

There are many questions, which the articles about IIT that I have seen does not address.

1. What directed attention means in IIT? Could one assign this to a link of network?
2. What, if anything, free will means in IIT?
3. What intentionality means in IIT? Can computer behave intentionally?
4. What could serve as correlate of cognition?
5. Why metabolism?
6. Why EEG?

TGD answer to some of these questions can be found from [L65]. For a more detailed TGD based criticism of IIT see [L72].

### 19.1.5 Some abbreviations

In the sequel I will answer the questions raised by Lian Sidoroff about IIT, by Patrizio Tressoldi about intention and energy, and by Ben Goertzel about IIT and possibility of post-quantum physics.

To help the reader I list some abbreviations to be used in the sequel. Zero Energy Ontology (ZEO), Causal Diamond (CD), World of Classical Worlds (WCW), Strong (Form of) Holography (SH), Negentropy Maximization Principle (NMP), Negentropic entanglement (NE), Magnetic Body (MB), Biological Body (BB).

## 19.2 Questions about IIT, remote mental interactions, intentionality, and need for post-quantum theory to describe consciousness

In the following are my TGD inspired responses to the questions posed by Lian Sidoroff - mostly about IIT and remote mental interactions, to the questions of Patrizio Tressoldi related to the notions of intentionality and energy, and to the questions of Ben Goertzel about IIT and remote mental interactions and possible need for post-quantum physics to understand consciousness. I do not copy below the full questions of Lian since they would take too much space. The chapter about non-locality in TGD framework [L65] summarizes TGD background. I have also written about two chapters related to IIT [L72, K97].

### 19.2.1 Basic TGD based criticism of IIT

IIT in its basic form seems to regard consciousness and life as rather independent properties of system. For computers the value is maximal when the output of program distinguishes between all inputs and - rather counter-intuitively - if the entropy of the initial state identifiable as lack of information of the external observer about the state of system is maximal.

It is of course an open question how many common properties conscious and living systems share but my intuitive view is that life is prerequisite of intelligent consciousness able to receive information about environment and react to changes in it. Also the TGD view about self implies that conscious system eventually dies and is living in this minimal sense not yet implying genetic code. One could therefore test the street plausibility of IIT by evaluating  $\Phi$  reliably for some system and finding whether other plausible signatures of consciousness familiar from living systems are present when the value of  $\Phi$  is high.

There is a long list of such signatures: abilities to self-organize under energy feed, to attend, to intend, and to respond via sensory-motor loop, behavior suggesting free will and cognition,... At the physical level there is metabolism, EEG, biochemistry involving bio-catalysis, perhaps even some kind of genetic code at level deeper than chemistry, replication, etc...

To my opinion, IIT would be very natural description of consciousness if AI systems were conscious. These systems perform algorithms written by programmers. So called deep algorithms with many hierarchical levels have been unexpectedly successful: this has been seen as a message that the physical Universe is in some sense very simple and has natural hierarchical structure (see <http://tinyurl.com/hz2jp8z>). These programs can even rewrite themselves but also this is based on program written by a programmer. In a well-defined sense these systems are intelligent, and one can even make them to mimic free will by using random generators. They are however not intentional and I think that this is the fatal failure. They are like some brain patients with damaged frontal lobes. These persons are intelligent but cannot intend and realize their intentions in the time time scales needed in say everyday life.

## 19.2.2 Questions by Lian Sidoroff

### Responsiveness

**Q1:** How do we define consciousness phenomenologically? Could responsiveness serve as a signature of consciousness?

The motivation for the question comes from Aaronson's observation that a system doing mere parity check can be much more conscious than human brain if  $\Phi$  is used as criterion. To my opinion Scott is quite right. Something is missing from IIT:  $\Phi$  cannot serve as sole criterion for what it is to be conscious. The following considerations are strongly TGD centered reaction to the idea.

1. Responsiveness means essentially motor action induced by sensory input. The problem is that any system responds to perturbations. For instance, computer programs can respond by learning and can even by rewriting themselves. I would not conclude from this that the computer running this kind of program is conscious. To my opinion one should characterize what the responsiveness of conscious system does mean.

Perhaps it could mean response, which is somehow unexpected. Say, my PC doing something that it is not programmed to do. Or a response of a computer network in a scale much larger than one would expect to a perturbation that the system is not programmed to notice at all. In TGD framework it would reflect non-locality involving essentially entanglement in long scales.

2. Conscious response requires directed attention selecting some preferred target. Also computers can be taught to direct respond to specific features and this could be called directed attention. What makes the directed attention conscious? That it is directed in an unexpected manner? A computer responding to signals which it is not programmed to respond?
3. Can the system with large  $\Phi$  direct its attention? To my TGD inspired opinion the change of the topology of the network occurring by state function reductions in appropriate scales is absolutely essential for directed attention. At given level of hierarchy it has interpretation as changing focus of attention.  $\Phi$  is defined for a fixed network. I see this as a problem (, which might be easily removable).

At the fundamental ATP level directed attention corresponds to the transfer of NE involving the change of topology of network in molecular scale: this would be responsiveness in molecular scale. Metabolic energy is needed to make possible NE transfer and therefore the rate for the use of metabolic energy looks like a reliable criterion for being consciousness. The axiomatics of IIT seems to miss this aspect totally.

Also general self-organizing systems involve feed of energy. Are they conscious and in what time scale? Is this time scale too long/short for human observer? Could general self-organizing systems have motor actions as reactions to stimuli?

4. In TGD Universe response involves sensory message to MB and the message inducing motor action sent as signal in reverse time direction. In ZEO this corresponds to a state function reduction to the opposite boundary of sub-CD in which subself "dies" and reincarnates as time reversed self. This time reversed subself corresponds to a signal to geometric past, which initiates neural activities (Libet's findings find explanation). Besides responsiveness and intentionality can be seen as a characteristic of consciousness and I find difficult to see how a computer with large  $\Phi$  could have it.

I would thus argue that conscious response involves the time reversed reaction (creation time reversed subself) giving rise to motor action allowing to distinguish it from the response of a non-conscious systems.

5. Locked-in patients are conscious but have no motor activities so that the naïve behavioristic dogma fails. To be responsive in TGD Universe it is however enough for MB to respond by generating a control signal, which would normally induce neural activities leading to a motor response but remain now only an imagined motor action (maybe). This cannot happen for locked-in patients but does not mean that the patient is unconscious since there would be



reaction also at neuronal scale. Could general self-organizing system or even computer have MB carrying dark matter as  $h_{eff} = n \times h$  phases, which reacts and responds but the response is not visible to us because we are not yet able to observe dark matter?

To my opinion responsivity is only one signature of consciousness. The ability to intend and realize intentions, and free will reflecting itself as a non-deterministic behavior, are additional criteria. In TGD Universe one cannot talk about systems which are conscious but dead and I tend to believe that this is true universally. Living systems self-organize and presumably so also conscious systems.

MB is essential piece of the story about living conscious systems in TGD framework. EEG and its variants in various scaled up frequency ranges make possible communications between various onion like layers of MB and biological body (BB) using dark photons. It looks natural to assign to a conscious and living system MB carrying dark matter matter as  $h_{eff} = n \times h$  phases making the system macroscopically quantum coherent: this would make possible for the system to generate macroscopic quantum entanglement and behave like a single coherent unit.

1. Can one assign scaled variant EEG to systems like ant nest or bee flock, or even Internet. Could one measure the analog of EEG experimentally?
2. In human EEG there is clear decomposition to quasi-stationary periods of duration of order .3 seconds (roughly) separated by sharp transition periods (see [J79] and [L26]). These could be identified as correlates for mental images as sub-selves. Could one distinguish between the EEG counterparts of subself and its time-reversal? If one can identify the analog of EEG for say ant nest, could one identify also these correlates of mental images of ant nest?

Could one use these criteria tell whether classical computer is conscious?

1. There is energy feed but can one say that computer is self-organizing system? The defining feature of classical computer is that it has fixed circuitry and it does just what the program tells it to do: this does not look like self-organization. There are programs able to rewrite themselves but also these are based on programs.
2. Could classical computer have MB, which self-organizes and can act as intentional agent and therefore force the computer to do something original?
3. Could classical computer have something analogous to EEG? Is classical computer like locked-in patient? If one requires also NE, it seems that the idea about classical computer as a conscious entity can be forgotten unless one regards life and consciousness as completely independent phenomena.
4. Could the two big MBs (assignable to Earth and galaxy) come in rescue and blow spirit to the classical computers? Maybe but this spirit might not have anything to do with the computation running in it.

In the case of quantum computers situation changes in TGD. Self can be in very abstract sense be seen as a quantum computer program, which runs as long as generalized Zeno effect lasts and dies when the program halts. What is new is the reincarnation as time-reversed self making possible computation able to overcome the standard limits for ordinary computation and computation not possible in standard positive energy ontology could be carried in ZEO in finite time.

### Network perturbation as variant of responsivity

Massimini [J91] has suggested a kind of microscopic variant of responsivity. Perturb brain directly by say transcranial magnetic perturbation and find whether there is a response in the scale of brain. Massimi found that TMS perturbation allowed to distinguish between sleep and awake states. This option would apply also to locked-in patients and looks rather reasonable. Again one must however remember that also the scale matters. Part of brain could allow consciousness in some scale and this scale could be rather small, even that for single neuron or pair or neurons connected by axon.

**Q2:** Could sensitivity to network perturbations be scaled to GCP network. Could it be possible to wake it up in major global events such as catastrophes and could this wake-up state be detected?

**A:** Perturbation would be now a major global event. GCP includes also the users might be essential so that one could not regard GCP as independent conscious entity. The connections in the network are dynamical in the sense that two participants can be connected or not and in this sense this brings in mind biomatter. TGD framework also MB of this network would be responsible for reacting to global stimulus and possibly inducing some synchronous reaction visible in the entire network but I would suspect that one cannot treat the network as separate.

## Integration

**Q3:** Where does Remote Viewing perception fall on the spectrum of consciousness? Where does intent/target focus fit in this AIM (Hobson)/IIT (Tononi) phase space and what kind of influence does it exert on the state of consciousness?

**A:** Lian argues that the perception of RV viewed target is something very different from that postulated in IIT. This difference could reflect also the fact that RV percept is gradually evolving. Ordinary percepts are stimulated by waking up already existing standardized mental images.

Stereograms could provide a good analogy for how RV evolves. The stereograms contains a lot of wrong cues and if you direct attention to these details you are lost. There is however a method: look at the picture very near so that you are not able to direct your left-brainy attention to the details and suddenly with the help of your holistic right brain you see the beautiful 3-D picture! After than you can fill in the details.

This process means an emergence of totally new mental image, discovery, and I think that what people are achieving in science now and then is just this. Interestingly, a 40 Hz peak in EEG accompanies the emergence of the 3-D picture [J21]. It accompanies also the transition to a meditative state. The elimination of small scale details is essential part of the process and meditative practices do this.

Here the weakness of IIT in its static form becomes obvious. What would be needed is emergence of a totally new kind of network pattern. This experience cannot be described assuming a fixed network: computers do not have enlightenment experiences. In TGD this would mean emergence of new negentropically entangled subsystem in state function reduction to opposite boundary for some sub-CD.

Note that the integration of conscious experience corresponds naturally to NE in TGD framework.

## La Bete

Why are spontaneous non-local conscious phenomena (telepathy, precognition) associated with meditation and dreaming? The absence of sensory and motor component in conscious experience would not mask the mental images involved with remote mental interactions. The explanation for the emergence of stereogram could also help to understand. One develops holistic view getting rid of details and is able to see the big picture. Ability to see in given resolution is also an implication of the scale hierarchy for conscious entities.

### a) Could one test non-locality in long scales?

LS mentions examples about non-locality in remote mental interactions. Persinger *et al* have published a lot of articles related to biophotons, EEG, and long length scale entanglement between brains. See for instance [J94, J95, J96]: for TGD interpretation see [K23].

Spottiswoode found evidence that the probability for the occurrence of precognition is maximum at a fixed hour of sidereal day [J126]. On the other hand, the condition that the cyclotron frequencies for  $h_{gr}$  assignable to Earth mass correspond to the energy scale of bio-photons requires that the flux tubes of galactic MB with  $B_{gal} \simeq .36$  nT mediate the gravitational interaction of Earth.

This implies that the cyclotron frequency 10 Hz for “endogenous” dark magnetic field .2 Gauss is scaled down by factor  $5 \times 10^{-5}$  and corresponding time scale is 36 minutes. EEG time scales in the range 1 s - .01 s correspond to a scaled up time scale range 7.2 min - 12 hours -

typical time scales assignable with daily conscious activities. Ordinary EEG would correspond to  $h_{gr}$  assignable with a mass shell at distance of Moon for which there is also other evidence [K78]. Also this is a rather dramatic prediction.

The existence of a scaled down variant of EEG in this frequency range in the em spectrum of brain could be tested. The crucial test would be whether the day associated with this EEG is sidereal day (mean duration is 23 hours, 56 minutes, 4.0916 s) rather than solar day. The rotation period of Earth around galactic center is 26,000 years: could this period reflect itself as a periodic modulation in the evolution of human consciousness? Milankovic theory for ice ages involving also the rotation around galactic nucleus predicts 21,000 year astronomical periodicity giving the period for the occurrence of ice ages (see <http://tinyurl.com/qhnzt5r>). This could provide very concrete reasons for the modulation.

**Q4a:** Can we test the IIT hypothesis on a nonlocal scale - and thus break free of the neuro-centric definition of consciousness?

**A:** I would ask can one test non-locality, which as such does not provide support for IIT, which relies still physicalistic picture about consciousness as a property of physical system.

#### **b) Complexity,telepathy, power amplification, a replicate of RV**

Lian suggests a detailed protocol for an analog of RV experiment testing various aspects of non-locality but to my view it tests non-locality but not IIT.

A very brief summary of the experimental protocol proposed of Lian goes as follows. The experiment involves 8 different stimulations of 4 mice A,B,C,D and mouse F not familiar with other mice and without any stimulation. For A,B,C,E but not D the stimulation involves stimulation of fear circuit. For A,B,C,D but not E also the image of cat is shown. Also the image of some other mouse is shown; A sees B or C; B sees A, C sees A; D sees E; E sees B. This stimulation creates a associations fear-presence of cat- presence of some other mouse for some sub-association of this. Mouse C is activated in additional manner strengthening the fear-cat-mouse A association. The reactions of other mice are monitored as one of them, mouse A, is isolated from others receives a stimulus activating the fear circuit.

**Q4b: Telepathy.** Is the fear transferred telepathically to the mice and does it induce also the associations? There are also subquestions.

**Q4c: Power amplification.** Will repeated application of the experimental stimulus (power amplification) increase/ broaden the activation at the receiver's end?

**Q4d: Replica of RV.** One encloses mouse B generating fear association in mouse A to a black box. If mouse A is able to remote view the presence of B in the box, the fear circuit should activate. Does this occur? What if mouse C with larger association basin is in the box. Is the telepathic effect stronger?

**A:** My own answer to the questions is in general affirmative if the telepathic communication really occurs. I dare not predict whether it does!

This experiment would test non-locality of consciousness but it is not clear to me whether this test can provide evidence pro or con IIT.

#### **c) Is sleep conducive to nonlocal network activation?**

A similar experiment could be run with any dreaming mammals to test the effect of particular brain states on facilitation/ inhibition of these nonlocal resonant loops and the ability of the ensuing "dynamic coalition of adaptively resonant populations of neuron" to reach conscious dominance,

**Q4e:** Would activation of fear at the "sender mouse" while the receiver is in various sleep stages (nREM S2, S3-4, REM) result in more rapid/ more powerful activation at the receiver's end?

If metabolic energy interpreted as energy going to re-organized network connections, metabolic energy does not go during sleep (rather than dreaming) to the build of mental images related to sensory and motor activities, and must go to something else and building up and activating of network connections in longer length scales would be natural target. EEG is indeed concentrated to theta and below which would mean that the scale of the layers of MB involve would be roughly 4-10 times longer (1-4 Hz during sleep) than usually (10 Hz). The four states of sleep would correspond to different length scales for MB. Activation would mean that cyclotron radiation and generalized Josephson radiation generated in neuronal neuronal membrane proteins acting as generalized Josephson junctions propagate along flux tubes. A possible interpretation for MB would

be as counterpart for the third person aspect of consciousness.

What the telepathic activation of sensory and fear circuits during sleep could the mean? The natural guess is that it wakes up some sensory areas and by association fear circuit so that one would have analog of REM sleep manifesting as the activation of higher EEG bands serving also as signature for the telepathic response.

### Is $\Phi$ dependent on brain's phase space - can the brain alternate between classical and quantum computational modes?

**Q5a:** What role do you think microtubules play in gating and reshaping brain computational patterns?

**A:** I see microtubules as one layer in the self hierarchy and proposed for about two decades ago a vision in which microtubules act as quantum antennas [K74] sending and receiving signals and performing frequency modulation by modulating their lengths.

I have also considered a model of microtubules inspired by the findings of Bandyonophyay *et al* [J110]. This model [L45] leads to rather concrete ideas about aromatic rings as basic units of molecular consciousness and would explain why aromatic rings are so important (contained by all DNA nucleotides and by some amino-acids and typical for neuro-active molecules such as psychedelics [L35]).

External AC perturbations of microtubules at critical frequency would induce what I have interpreted as a quantum phase transition between two configurations A and B of microtubules: only the configuration B for which helical symmetry is broken is observed in laboratory (objection against Penrose-Hameroff hypothesis) but the configuration A with helical symmetry would be created in this phase transition increasing  $\hbar_{eff}$  and quantum coherence length as helical symmetry suggests [L45].

Quantum criticality is in accordance with the general vision about living systems as quantum critical systems and would make possible large  $\hbar_{eff}$  phases and dark photons with energy scaled up by  $\hbar_{eff}/\hbar$  so that it is above thermal threshold - perhaps in the range of bio-photon energies - and can induce molecular transitions. Topological quantum computations [K4] involving braiding of the flux tube connections between microtubuli and axonal membranes such that nerve pulses induce re-braiding as a kind of memory representation can be also considered.

The second question concerns the roles of classical and quantum computations for brain. Brian Millar has suggested that the brain contains both classic and quantum computational functions. The fact that nonlocal conscious interactions may and do occur superimposed on routine diurnal consciousness (the operator in a typical RV session is a perfect example of such a superimposition of rapidly alternating states or computations activities; spontaneous telepathy has been reported in both nocturnal and diurnal contexts; and studies of distant mental interactions with living systems, including human receivers, do not require the target to achieve any particular mental states, although many operators find it more effective to go through a cool-down or meditative phase at the beginning of the session) suggests that both of these computational processes occur simultaneously - however, in the highly competitive environment of brain activity, it may be that the power of such alternative (possibly MT-mediated) resonant circuits may remain below the threshold of awareness under most circumstances, being brought into the spotlight only by deliberate suppression of classic neuronal activity, coupled with the power amplification derived from persistent target focus. The question is following.

**Q5b:** Could there be a connection between the effects of slow wave sleep and meditation on the global gating configuration of the brain - perhaps leading to a reshuffling and eventually more favorable, more "sensitive" quantum computational state - whether based on MTs or another interface (Millar's quantum brain)? Could circadian rhythms play a role in such a daily balance between classical and quantum brain computational modes?

**A:** Before answering the question some background.

1. I would not see classical and quantum computations as alternatives. Self represents quantum computation like process having analogs of quantum and classical computation as its aspects, which could be also seen as dual representations in the sense of holography. Here I however understand with classical computation something much more general than that occurring in my PC.

2. MB and braiding of flux tubes makes possible quantum computation type activities: quantum computation in standard sense is probably quite too restricted metaphor. Classical computation in the sense as I understand it, is even more dangerous metaphor. Classical computationalism involves many assumptions, which seem to guarantee that ideal computer is un-conscious: the notion of memory storage and deterministic program represents too such notions. In TGD framework there are no files in which data would be stored [K90]. There is no deterministic classical program running in brain.
3. I would compare self as a generalized Zeno effect to a quantum computation, which halts as self dies and reincarnates at the opposite boundary of CD and a new quantum computation proceeding in opposite direction of clock time using the wisdom gained as NE is performed (the temporal distance between tips of CD increases all the subjective time). Each mental image would be kind of quantum computation and repeated re-incarnations might make it possible to overcome the usual restrictions on what one can do in finite time [L66] (see <http://tinyurl.com/jpzd6xq>).
4. The space-time surface connecting initial and final 3-surfaces at the boundaries of CD would define classical time evolution analogous to classical computation serving. More concretely, the dynamical time like braiding of flux tubes (dance metaphor) would generate a space-like braiding (think of dancers with threads from the feet to wall: dance is coded to a memory about the dance) [K4].
5. One would have quantum superposition of these space-time surfaces and it would represent self-organization pattern in 4-D sense. The state function reduction sequence during the life period of self would lead to asymptotic pattern. A space-time representation for function, skill, or memory understood as learned skill would be in question. The experiments with flatworms [I80] demonstrate that the both ends of flatworm can inherit the memories in this sense: the replication of MB could explain this [K82]. The classical space-time surfaces have therefore several interpretations: as space-time correlate for intentional action, behavior, function, classical computation, etc...

The dominance of slow wave EEG during sleep would mean that magnetic bodies with weak magnetic fields and larger size roughly defined by the wavelength associated with EEG frequency would dominate. These would correspond to more non-local and more abstract conscious information and information processing. The difference to daytime situation would be quantitative: the spatial and time scales would be longer.

The absence of sensory input during both meditation and slow wave sleep would give for MB a more pronounced role. It can use brain for its purposes and probably does so since brain uses metabolic energy also during sleep and is conscious in some, probably different scales that at day-time. What could be those purposes? Do we entangle with other brains perhaps and give rise to entangled self formed by the sleeping brains - representing perhaps "human condition"?

#### $\Phi$ and Ueber- $\Phi$

**Q6:** How do you see the interplay between the consciousness of Self and the ability to participate in such nonlocal conscious phenomena in terms of  $\Phi$ ?

My answer reflects by belief system. This may sound dogmatic but I just cannot take  $\Phi$  as the solution to the riddle of consciousness for the reasons that I have explained. Therefore I am unable to answer the question.

### 19.2.3 Questions by Patrizio Tressoldi

There are actually two questions by Patrizio Tressoldi related to intentionality and energy.

**Q7a:** Is it possible to measure the "mental energy" underlying both local and non-local mind-matter interactions? Is it also possible to investigate the characteristics of these interactions, e.g. do these interactions look like a single shot or like a long-lasting wave of energy? Could this line of investigation shed light on the basic "stuff" of our mind?

What has been observed by Tressoldi *et al.* (in press) after one pilot, one failed and one positive replication can be summarized as follows: mental entanglement (ME) at distance with

a photomultiplier reveals its effects by increasing the bursts of photons exceeding by more than  $6\sigma$  the average count, corresponding to bursts with more than ten photons. In other words, it seems that ME effects correspond to very fast bursts of light of approximately 20 photons/sec equivalent to an energy estimated in 65 eV, at approximately 788 THz, a really non trivial energy. Furthermore, these effects seem to appear even after a delay of approximately 35 minutes.

**A:** My view is that remote mental interactions involve both quantal and classical aspects. Classical aspect requires a contact of magnetic bodies of the two systems by reconnection - correlate for directed attention. Classical signals would propagate along the flux tubes connecting the two systems. Reconnection would occur for instance in experiments of Persinger's group involving rotation magnetic fields and bio-photons discussed in [K23]. Reconnection is made more probable if the magnetic field of either system or both is dynamical, say rotating. After the reconnection classical dark photon signals would flow between the two systems, and also supra currents of say dark electrons are possible. Classical signals require metabolic energy. For instance, EEG would correspond to this kind of communications between biological and MB and the dark photons with  $h_{eff} = n \times h$  of EEG would have energies in the range of bio-photon energies.

Teleportation can be seen as communication - in particular communication of mental images - and requires also classical communication. Could maximally entangled subsystem representing mental image be teleported without destroying the original mental image? No-cloning theorem tells that complete cloning is not possible for a general quantum state. There are however exceptions: a quantum state with maximal entanglement can be cloned (see <http://tinyurl.com/h48qjp8>). Maximal entanglement - entanglement probabilities are identical - corresponds p-adically to maximally negentropic entanglement. Maximally negentropic entanglement is p-adic notion (cognition) and much more general than maximal entanglement. Is it possible to clone also it?

**Q7b:** Human (external qi) intention is a form of information. There are many reports on this. The first few white papers by William Tiller are interesting (see <http://tinyurl.com/j5xyjn8>).

What if intention is simply thought-like energy? See our study "*Can Our Minds Emit Light at Distance? A Pre-Registered Confirmatory Experiment of Mental Entanglement with a Photomultiplier*" in press in Neuroquantology (see <http://tinyurl.com/h4eoxgw>).

**A:** I identify energy as a physicists and what comes in mind is metabolic energy. I see metabolic energy as a prerequisite for intention but cannot identify it as intention. Intention has inherent directedness but energy as a notion does not have it. My own proposal is based on ZEO in which zero energy states have as correlates (quantum superpositions of) space-time surfaces connecting 3-surfaces at past and future boundaries of CD. Zero energy states are asymmetric with respect to the exchange of boundaries. The state at other boundary is reduced and unaffected during the sequence of state function reductions as also this boundary. The state at other boundary changes and also the boundary shifts farther away. Zero energy states would be by their directedness natural correlates for intentions and space-time surfaces could represent the classical space-time correlates of intentions. They can be seen also as correlates for functions (in biological sense) and behaviors.

## 19.2.4 Questions by Ben Goertzel

The first question of Ben Goertzel relates to IIT. The remaining questions are subquestions inspired by a general question "*Is recent quantum theory enough?*".

### Could integrated information help to understand Psi phenomena?

**Q8:** Could looking at integrated information on the quantum level (or in the context of some extension of current quantum theory) yield insight regarding Psi phenomena? Might there actually be subtle integrated information spanning systems that are currently thought of as "disentangled" from each other? Could this provide the foundation for some sort of "universal consciousness"?

**Answer:** As I have already explained, I do not see the measure for integrated information as internally consistent. In TGD framework integrated information is replaced with entanglement negentropy. Negentropic entanglement (NE) in large scales is an important aspect of remote mental interactions since it binds conscious entities to larger conscious entities temporarily and is central element of directed attention and also of remote mental interactions which do not differ in any

radical manner from those occurring between MB and BB. In this framework consciousness and even cognition are universal.

### Post-quantum physics?

**Q9.** Supposing that some sort of non locality going beyond what is allowed in classical physics is required to explain Psi phenomena - is quantum theory actually enough? Or do we need some broader form of non locality? If so, what additional aspects must the non locality needed to explain Psi possess?

**A:** To my opinion the prevailing quantum theory is not enough.

1. To develop a new theory it is best to start from a problem of old theory. The basic problem to start from is now quantum measurement theory. The identification of experienced time with the geometric time and therefore of the corresponding causalities leads to the basic paradox and to the plethora of “interpretations” trying to overcome the problem. In TGD framework zero energy ontology (ZEO) allows to overcome the paradox. ZEO predicts also temporal non-locality and by holography 4-D dynamical patterns become basic physical objects as they indeed are in biology and neuroscience.
2. The non-locality in ordinary quantum mechanics has no classical (geometric or topological) space-time correlate. The non-locality at space-time level emerges in TGD framework from the replacement of point like particles with 3-D surfaces (or pairs of them at opposite boundaries of CD. Particle is classically space-time quantum, one might say. This allows to understand classically non-locality as it appears in EPR and also in remote mental interactions: magnetic flux tubes serve as a geometric correlate for entanglement so that situation ceases to be so “spooky”.

At the level of WCW one has locality. Apart from state function reduction the theory is even classical formally: WCW spinor fields are formally classical free spinor fields satisfying the analog of massless Dirac equation realized as a generalization Super Virasoro conditions familiar from super string models and expressing generalization of conformal invariance.

3. Quantum consciousness theories demand macroscopic quantum coherence but standard quantum theory does not give much hopes about this: Planck constant is too small. The anomalous quantal effects of ELF em fields on vertebrate brain led originally to the idea about hierarchy of Planck constant  $h_{eff} = n \times h$  labelling dark matter as phases of ordinary matter. This hierarchy is strongly suggested also by the generalization of super-conformal symmetries in TGD framework gives rise to a hierarchy of quantum criticalities labelled by the values of  $h_{eff}$ . The hierarchy would also have a concrete geometric interpretation in terms of the topology of many-sheeted space-time. The latter is possible only if one assumes that space-times are representable as 4-surfaces.

**Q10:** Will the standard “scientific method” as now practiced and understood (involving gathering empirical data that is considered as “provisionally true” in an objective sense, and validated as such by members of the scientific community) be adequate for understanding Psi phenomena? Or might an understanding of Psi phenomena require a shift to a new understanding of science, involving a more radical subjectivity, a more relational interpretation of observations or — something else?

**A:** I believe that this not the case. I believe that remote mental interactions as also those crucial for living matter are quantum critical phenomena. This makes it difficult to replicate the experiments. First of all, the experimenter must know that a critical system is in question. If dark matter indeed corresponds to large  $h_{eff}$  phases generated at criticality, the attempts to detect dark matter identified as some exotic particle are bound to fail and have indeed failed. Dark matter could be detected only transforming it to ordinary matter or vice versa and this would occur at quantum criticality. Quantum criticality would also make possible long range correlations and the interaction between experimenter and the experimental arrangement including subject persons in experiments carried out in medicine (interactions between magnetic bodies). Therefore the idea about possibility to completely isolate observer and observed system in principle fails in quantum

critical case (TGD Universe is quantum critical meaning that any system is quantum critical in some time scale!).

**Q11:** Are our current notions of “causation” and “correlation” adequate to understand Psi phenomena? Or need they be extended somehow? If so, how?

**A:** My belief is that the problems of quantum measurement theory can be solved by distinguishing geometric and subjective time and corresponding causations. The first causation is that of field equations and the latter causation that of free will and can be assigned with quantum jump/state function reduction. This causation replaces superpositions entire geometric time evolutions with new one and this is something new (note however Wheeler’s delayed choice experiment). ZEO based quantum measurement theory would be the manner to describe it.

Correlation assignable to geometric time (or between space-time-time points or their generalization to 3-surfaces) is a generalization of that applied in quantum field theories. Correlation have any meaning with respect to subjective time since it does not correspond to continuous coordinate at fundamental level although one can assign to it clock time in ZEO as increasing distance between the tips of CD.

**Q12:.** Can we make scientific (or some sort of meaningful post-scientific) sense of the notion of a broader universe beyond our physical universe? How does the mystical notion of a world beyond our world, relate to the higher-dimensional aspects of physical reality postulated in modern physics theories? What properties would a broader “world beyond our world” need to have, in order to have useful explanatory value for phenomena we observe in this world, or for experiences we have and report that hint at the existence of realities beyond this physical world?

**A:.** I see several levels in the geometric hierarchy of geometric objects. Besides space-time surfaces, which are dynamical objects, there is embedding space and WCW, which are non-dynamical geometric objects and dictated by general arguments highly uniquely.

1. The minimal generalization is to keep space-time 4-D but assume that it is 4-surface in a higher-dimensional space-time - call it  $H$  - having standard model symmetries and explaining corresponding quantum numbers elegantly. The minimal choice is 8-D  $H = M^4 \times CP_2$ . The emerging space-time concept - many-sheeted space-time - is topologically extremely rich and leads to new notions like MB and space-time surfaces having interpretation in terms of dark matter as  $h_{eff} = n \times h$  phases. MB extends the system-environment double of biology to the triple MB-system-environment and is responsible for most non-trivial elements of TGD inspired biology.

Also the embedding space  $H$  plays a central role. In ZEO also the hierarchy of causal diamonds (CDs) in  $H$  serving as correlate for self hierarchy is important and is needed to realize holography and its strong form. The pairs of 3-surfaces with members at opposite boundaries of CD is correlate for (classical) event and WCW spinor field representing zero energy state is the analog of Schrödinger amplitude in this space of classical events. The twistor lift of TGD [L59] requires ZEO and CDs: the action for infinitely-sized space-time surfaces in  $H$  would be infinite because of the volume term implied by the twistorial life and identifiable in terms of cosmological constant: for CDs it is finite.

Strong form of holography (SH) implied by strong form of general coordinate invariance implies that string world sheets and partonic 2-surfaces carry the data needed to construct zero energy states and also space-time surfaces as preferred extremals of Kähler action. They would act as “space-time genes”.

WCW would represent the highest level of hierarchy and has decomposition to sub-WCWs assignable to CDs in their size scale hierarchy with levels labelled by integer characterizing the size scale of CD (by number theoretical universality argument).

Therefore space-time surface would be replaced with a hierarchy of strings, string world sheets and partonic 2-surfaces, pairs of 3-surfaces at opposite boundaries of CD and connecting 4-surfaces, hierarchy of CDs, embedding space, WCW!

2. A further generalization is required by the need to have space-time correlates for cognition and imagination. Here p-adic number fields provide a natural candidate and one ends up with an extension of real physics to p-adic physics involving p-adic variants for the above geometric structures. The physics in various number fields are in turn combined to give rise



to adelic physics in which one replaces space-time surface with the Cartesian product of its variants in various number fields obeying same field equations and having even same formal representation at the level of “space-time genes”.

The space of quantum states is however common to all sectors of the adelic world and the coefficient field of this Hilbert space must be in intersection of all number fields and thus consist of numbers identifiable as algebraic numbers in some extension of rationals inducing finite-D extensions of p-adic number fields. There exists an infinite number of extensions of rationals and they define naturally an evolutionary hierarchy so that evolution corresponds to increase in algebraic complexity.

**Q13:** How useful is Sheldrake’s notion of “morphic resonance”? Is it too vague to be used to draw concrete conclusions about practical situations? How might it be refined into more precise ideas? How does it relate to quantum mechanics?

**A:** My answer to this question has developed during last half year and discussions with Sheldrake in SSE-2016 conference inspired to find a concrete interpretation for the action of morphogenetic field. I have considered morphogenesis in earlier articles [L32, L74, L73, L61]. Below I describe the most important aspects of TGD model as I see it now.

### 1. Magnetic body as template for the dynamics of the ordinary matter

I would understand “morphic resonance” as one implication of ZEO and of the notion of MB (MB). The ZEO replaces 3-space as basic geometric object with a pair of 3-surfaces with members at opposite boundaries of CD. By holography this pair is equivalent with 4-D space-time surface. MB can be seen also as 4-D field pattern satisfying the conditions defining preferred extremal of basic action principle and actually implying strong form of holography (SH). MBs as 4-D objects would serve as space-time correlates for functions/behaviors/habits and even intentions. 4-D self-organization by quantum jumps would lead to asymptotic 4-D MB. Note that also geometric past also changes in each quantum jump. This time-non-locality was realized already in the context of ordinary quantum theory by Wheeler (delayed choice experiment). The effect has been verified.

MBs have a rich topological dynamics. Flux tubes contract or expand in  $h_{eff}$  changing phase transitions bringing molecules near each other; U-shaped flux tubes reconnect to form flux tube pair connections between distant molecules are larger systems in bio-catalysis - this is also basic mechanism of directed attention; the braiding of flux tubes defines space-time realizations for topological quantum computer programs; the replication of MB would be behind replication of DNA and of transcription and also behind the replication in longer scales. The dark matter at magnetic flux tubes would be in macroscopically quantum coherent phases and the idea is that it would control ordinary matter having dynamics of MBs as a template. Biochemistry would be to some extent shadow for the dynamics of MB. For instance, the already mentioned strange findings about split flatworms could be understood in terms of the replication of MB in 4-D sense: not only BB but also functions and behaviors would be replicated.

Morphic resonance could represent a special instance about the replication of MB in 4-D sense. An important aspect would be that MBs in question are really large: the part of MB corresponding to alpha frequency could correspond to Earth size. This makes possible large scale non-local effects and racial learning. One can even consider the idea about MB associated with entire species. Spottiswoode reports that enhanced precognition occurs with period of sidereal (galactic) day. One ends up also to the proposal that the magnetic field of about 10 Hz and galactic MB corresponds to scaled variant of EEG with periods varying from few minutes to 12 hours. These periods would correspond to ordinary day-time consciousness.

Dark matter as large  $h_{eff} = h_{gr}$  phases at flux tubes would be the connection to new quantum mechanics.

### 2. Morphogenesis and generalized Chladni mechanism

What would be the concrete realization of morphogenesis in this picture?

1. 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 [L73]. 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. The structures condensing around nodal surfaces could be also magnetic flux bodies themselves and one could have hierarchical structure. Magnetic bodies carrying Bose-Einstein condensates of charged ions would not experience any electric force at nodal surfaces and magnetic force would be parallel to the nodal surface.

2. The induced fields associated with the simplest “topological light rays” (“massless extremals”, MEs) are of form  $\sin(\omega(t-z))\epsilon(\rho)$ , ( $c = 1$ ).  $\epsilon(\rho)$  is polarization function and  $\rho$  is a coordinate varying in the direction of local polarization and can be chosen rather freely. Now it is taken to be the radial cylindrical coordinate.  $\epsilon(\rho)$  can have zeros, which makes possible stationary nodal surfaces also in the case of propagating MEs.
3. The objection is that TGD does not allow single-sheeted realizations of standing waves needed for instance to realize the standing waves assignable to induction coil and wires of electric circuits. This objection is not lethal. In many-sheeted space-time one can realize effective sinusoidal standing waves as 2-sheeted structures from two MEs propagating to opposite spatial directions and carrying plane waves with a fixed frequency. These two-sheeted structures would serve as basic building bricks. The test particle having necessarily wormhole contacts to both MEs would experience the force caused by the sum of the induced gauge fields assigned to the two MEs. The force would be same as that caused by a standing wave with separable temporal and spatial dependence not realizable as preferred extremal: that is a product of trigonometric functions - say product of form  $\sin(\omega t)\sin(\omega z)\epsilon(\rho)$ .

MEs have also always constant direction of polarization. Circularly polarized effective fields could be generated by pairs of MEs for which one has two linear polarizations in orthogonal directions with a phase lag of  $\pi/2$ .

4. The electric force would vanish at nodal surfaces, which would thus define naturally the shape of a stationary structure defined by molecules or parts magnetic bodies which serve as templates for them. These surfaces would correspond to the vanishing of  $\sin(kz)$  factor and to the vanishing of  $\epsilon(\rho)$  factor.

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.

5. 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.

### 3. The classical dynamics of TGD as dynamics of avoidance

Chladni mechanism is essentially dynamics of avoidance. Charged particles go to the nodal surfaces, where electric forces vanish. The twistor lift of TGD of the generalization of Kähler action adding to it volume term. Amazingly, the dynamics for this action can be seen as a generalization of the dynamics of avoidance.

The addition of the volume term to Kähler action implied by the twistor lift of TGD [L59] has very nice interpretation as a generalization of equations of motion for a world-line extended to a 4-D space-time surface [L61]. The field equations generalize in the same manner for 3-D light-like surfaces at which the signature of the induced metric changes from Minkowskian to Euclidian, for 2-D string world sheets, and for their 1-D boundaries defining world lines at the light-like 3-surfaces. For 3-D light-like surfaces the volume term is absent. Either light-like 3-surface is freely

choosable in which case one would have Kac-Moody symmetry as gauge symmetry or that the extremal property for Chern-Simons term fixes the gauge.

The known non-vacuum extremals are minimal surface extremals of Kähler action and it might well be that the preferred extremal property realizing strong form of holography quite generally demands this. The addition of the volume term could however make Kähler coupling strength a manifest coupling parameter also classically when the phases of  $\Lambda$  and  $\alpha_K$  are same. Therefore quantum criticality for  $\Lambda$  and  $\alpha_K$  would have a precise local meaning also classically in the interior of space-time surface. The equations of motion for a world line of U(1) charged particle would generalize to field equations for a “world line” of 3-D extended particle.

This is an attractive idea consistent with standard wisdom but one can invent strong objections against it in TGD framework.

1. All known non-vacuum extremals of Kähler action are minimal surfaces and the minimal surface vacuum extremals of Kähler action become non-vacuum extremals. This suggests that preferred extremals are minimal surface extremals of Kähler action so that the two dynamics apparently decouple. Minimal surface extremals are analogs for geodesics in the case of point-like particles: one might say that one has only gravitational interaction. This conforms with strong form of holography (SH) stating that gauge interactions at boundaries (orbits of partonic 2-surfaces and 2-surfaces at the ends of CD) correspond classically to the gravitational dynamics in the space-time interior.

Note that at the boundaries of the string world sheets at light-like 3-surfaces the situation is different: one has equations of motion for geodesic line coupled to induce Kähler gauge potential and gauge coupling indeed appears classically as one might expect! For string world sheets one has only the topological magnetic flux term and minimal surface equation in string world sheet. Magnetic flux term gives the Kähler coupling at the boundary.

2. Decoupling would allow to realize number theoretical universality since the field equations would not depend on coupling parameters at all. It is very difficult to imagine how the solutions could be expressible in terms of rational functions with coefficients in algebraic extension of rationals unless  $\alpha_K$  and  $\Lambda$  have very special relationship. If they have different phases, minimal surface extremals of Kähler action are automatically implied. If the values of  $\alpha_K$  correspond to complex zeros of Riemann  $\zeta$  [L43], also  $\Lambda$  should have same complex phase, in order to have genuine classical coupling. This looks somewhat un-natural but cannot be excluded.

The most natural option is that  $\Lambda$  is real and  $\alpha_K$  corresponds to zeros of zeta. For trivial zeros the phases are different and decoupling occurs. For trivial zeros  $\Lambda$  and  $\alpha_K$  differ by imaginary unit so that again decoupling occurs.

3. One can argue that the decoupling makes it impossible to understand coupling constant evolution. This is not the case. The point is that the classical charges assignable to super-symplectic algebra are sums over contributions from Kähler action and volume term and therefore depend on the coupling parameters. Their vanishing conditions for sub-algebra and its commutator with the entire algebra give boundary conditions on preferred extremals so that discrete coupling constant evolution creeps in classically from the spectrum of quantum critical coupling constants!

The condition that the eigenvalues of fermionic charge operators are equal to the classical charges brings in the dependence of quantum charges on coupling parameters. Since the elements of scattering matrix are expected to involve as building bricks the matrix elements of super-symplectic algebra and Kac-Moody algebra of isometry charges, one expects that discrete coupling constant evolution creeps in also quantally via the boundary conditions for preferred extremals. Coupling would be forced by boundary conditions!

The above arguments seem to kill the idea that the dynamics of Kähler action and volume term could couple in space-time interior. The coupling between the two dynamics would be induced just by the condition that the space-time surface becomes an analog of geodesic line by arranging its interior so that the U(1) force vanishes! This would generalize Chladni mechanism! The interaction would be present but be based on going to the nodal surfaces! One would have dynamics of

avoidance! Also the dynamics of string world sheets is similar: if the string sheets carry vanishing  $W$  boson classical fields, em charge is well-defined and conserved. One would also avoid the problems produced by large coupling constant between the two-dynamics present already at the classical level. At quantum level the fixed point property of quantum critical couplings would be the counterparts for decoupling.

To sum up, it seems that the complete decoupling of the dynamics of Kähler action and volume term in the interior is favored by both SH, realization of preferred extremal property (perhaps as minimal surface extremals of Kähler action, number theoretical universality, discrete coupling constant evolution, and generalization of Chladni mechanism to a dynamics of avoidance.

### 19.3 Comments about Ben Goertzel's Eurycosm approach to consciousness

Ben Goertzel considers a highly interesting proposal for a theory of consciousness relying on what he calls euryphysics. Goertzel formulates euryphysics by listing 23 principles. The notions involved are certainly central to consciousness and in the following I will comment this approach from TGD point of view trying suggesting TGD counterparts for the notions introduced (this is the only manner that I can learn!). I restrict my attention to the basic principles and make only brief comments about the proposed applications involving peaked distribution and morphic resonance as key notions. Most of these notions have natural TGD counterparts. My basic criticism concerns the relational interpretation of quantum mechanics.

I have discussed non-locality in TGD framework at [L65], IIT of Tononi and Koch at [L72] and the questions raised by Lian about IIT and Eurycosm theory at [K97].

#### 19.3.1 Relational interpretation of quantum mechanics

Goertzel adopts so called relational interpretation of quantum mechanics (see <http://tinyurl.com/mo25186>).

1. The motivation comes from the fact that in special relativity time perception depend on the state of motion of  $O$  relative to  $S$  (time dilation, Lorentz contraction). Also the Unruh effect suggests that the an observer  $O$  in accelerated motion relative to  $S$  sees thermal spectrum of photons emerging from  $S$ . To my opinion this does not however serve as justification for the assumption that entanglement or lack of it is observer dependent notion.
2. Relational interpretation postulates that state function reduction is not real and that quantum state is observer dependent concept characterizing the relationship of observer  $O$  and measured system  $S$ . This interpretation is encouraged by conflict between the non-determinism of state function reduction and unitary time evolution emerging in the Copenhagen interpretation and forcing to give up ontology altogether so that wave function describes only the knowledge about the system. In this framework relational interpretation would be natural. One can however argue that this makes the notion of quantum state rather complex.
3. Since an interpretation of quantum theory is in question, consistency suggests that entire Universe obeys unitary time evolution although it is not observed at the level of  $O+S$  pairs. State function reduction effectively occurs for sub-system pairs in the sense that second member - observer - perceives itself and second system un-entangled although the external observer perceives them as unentangled system. The density matrix for entangled system pair defines a natural observable in the sense that its eigenstates define preferred state basis for  $O$  (or by symmetry for  $S$ ).
4. A third system not entangled with  $O+S$  perceives it as entangled system. One can therefore ask whether the entangled pair gives rise to a superposition of several conscious entities formed by observer-system state pairs. It is difficult to see why this would not be the case. If so, then any entangled system pair would represent superposition of parallel conscious sub-universes and there would be a close connection with Everett's interpretation.

What objections can one invent against relational interpretation?

1. Suppose that observer and system (O+S) are maximally entangled spin 1/2 systems in spin singlet state so that the density matrix is  $2 \times 2$  unit matrix. By the rotational symmetry any choice of quantization axis for spin is equally good. There is no obvious criterion making possible to choose a unique quantization axis and to decide what is the state of S perceived by O or vice versa. One can of course ask that exact rotational symmetry is impossible in practice and there is always a small mixing with spin 1 state with same spin projection implying that the density matrix deviates from identity matrix. One cannot however demand internal consistency in statistical sense only.
2. If one assumes separate unitary evolution for all O-S pairs one ends up with infinite number of consistency conditions: my guess is that they cannot be satisfied. If one that only the state of the entire universe obeying unitary evolution, one can ask whether this notion has any operational meaning. This makes the application of the theory rather difficult.

### 19.3.2 The notion of eurycosm

Eurycosm is introduced as a key notion. Its precise meaning is however left open. Eurycosm would contain space-time as we understand it as a subset. Eurycosm would be a structure possessing topology, geometry, and various order relations. On the other hand, it is noted that it probably has no dimensional structure characterizing manifolds. If I have understood correctly, the ordering relations for eurycosm would characterize various key aspects of consciousness rather than serving as mere correlates.

In TGD framework one analog of eurycosm would be the 8-D embedding space containing space-time as 4-surface, and more generally would adelic space-time as surface in adelic embedding space. World of Classical Worlds (WCW) and its adelic analog would also serve as TGD analogy for eurycosm. They would however be zombies and provide only classical correlates for various aspects of conscious experience associated with state function reductions not assumed in Goertzel's approach.

Adelic Universe means that instead of reals as basic number field one considers adeles, which are Cartesian product of reals, and finite-dimensional extensions of various p-adic number fields induced by an extension of rationals. Rationals allow both algebraic and non-algebraic extensions and there is infinite hierarchy of them so that adelic worlds at various levels (space-time, embedding space, WCW) form a hierarchy interpreted in terms of evolution.

p-Adic sectors of the adelic world correspond to space-time correlates for cognition and imagination. One can speak of p-adic space-time surfaces and they correspond rather closely to real space-time surfaces but the one can also have p-adic space-time surfaces with no real counterparts: imaginations are not always realizable. The reason is that due to the occurrence of p-adic pseudo constants p-adic partial differential equations are non-deterministic and allow much more solutions than their real counterparts. Strong form of holography (SH) allows to construct real and p-adic space-time surfaces from string world sheets and partonic 2-surfaces by algebraic continuation as preferred extremals for the basic action principle. There is strong analogy with analytic continuation in complex analysis: real function at real axis can be continued to analytic function in the entire complex plane.

### 19.3.3 Definition of consciousness

"Raw" consciousness is regarded as a property of any physical system and even of space-time and eurycosm rather than assigning it somehow to state function reduction or Zeno effect as in TGD. The identification of consciousness as a property of eurycosm identified as topological object leads to "boundary problem": where the mind begins and where the body ends?

The basic objections against the identification of consciousness as a property are same as in materialistic approach: there is no manner to distinguish between consciousness and any other physical property. Also free will suggesting that state function reduction is real would be an illusion.

Some comments are in order.

1. Relational interpretation would strongly suggest that "raw" consciousness corresponds to elementary observation identifiable in this interpretation as effective state function reduction.

If one assumes that state function reduction is real, one ends up with conflict between determinism of unitary evolution and non-determinism of state function reduction if the causality of free will is assumed to be same as that for laws of physics. One could call this problem “causality paradox”. This in turn relates to the identification of experienced time as geometric time: an assumption which can be only approximately true (second law).

2. To me quantum parallel conscious observers defined by entangled quantum state would look like a feasible notion in the framework of relational interpretation: conscious entity could correspond to this kind of system having no entanglement with environment. This interpretation would not be plagued by the “boundary problem”. This would also mean panpsychism: any entangled system could be in role of conscious observer unless one poses some additional conditions to what it is to be an observer. I however understood that this interpretation is not adopted.

In TGD framework Zero Energy Ontology (ZEO) and generalization of quantum measurement theory to a theory of observer as conscious entity leads to a resolution of “causality paradox”. Consciousness is an (only) effectively a property of systems, which are negentropically entangled to entities stable under NMP and un-entangled from the environment. Actually the self is changing in every state function reduction and only the passive boundary of CD and the states associated with it remain unaffected. Regarding consciousness as a property is strictly speaking impossible albeit very practical. This delicacy does not have great practical significance but is of fundamental since it allows to solve a bundle of difficulties plaguing consciousness theories.

### 19.3.4 The notion of observation

Observation is taken as a key notion.

1. It is noticed that observation has directedness. This is certainly true in macro scales. The first guess inspired by quantum measurement theory is that state function reduction corresponds to observation in its simplest form. This does not however conform with the complete symmetry between O and S implied by the relational interpretation. The directedness would naturally follow if O is capable of intentional actions, in particular measuring the state of S by inducing genuine state function reduction. Now this is not possible now. Note that this relates also to the directedness of attention: there is the system with directed attention and the system which is attended.

My understanding is that the perception of O+S by O as un-entangled system although it is entangled from the point of view of outside does not represent primitive observation.

2. Observations are proposed to have a hierarchical structure: observations within observations. Also the notion of complex observer is also introduced. The composition of entities is introduced as a basic principle.
3. The notions of simplicity (equivalently complexity), surprisingness, intensity, and notability as characterizers of the observations are introduced. Observations can be ordered by the degree for these attributes and allow to characterize basic notions related to consciousness. Also gradient of surprisingness is introduced as a key notion. Local time axis would be defined in terms of gradient of surprisingness.
4. Also the notions of representation and pattern are introduced. If A is intense when B is intense, A represents B. P is pattern if P represents S and is simpler than S. Pattern could be seen in terms of inclusion of hyperfinite factors with included factor defining pattern which is simpler due to the lower measurement resolution. The notions of emergence and intelligence are mentioned.
5. Goertzel introduces the notion of persistent entity and speaks of causal arrows and network of them defining space.
6. Understanding the essence of intelligence is a fascinating challenge. For instance, what problem solving could mean at quantum level? Intelligent systems certainly form “stories” as

symbolic representations/simulation of the external world in various spatial and time scales so that fractality seems to be an essential element of intelligence. The emergence of symbolic dynamics seems to be an essential element of intelligence: one can predict the behavior of person for years just by knowing his role in society. Trying to compute it from all available data at molecular level would be completely hopeless task - even in principle.

What about the situation in TGD?

1. Also in TGD this the case - strictly speaking only observations exist and observer is only a useful idealization.
2. In TGD framework state function reduction represents the core element of observation and also now the challenge is to understand the directness of observation. U-shaped magnetic flux tube loops of the magnetic body of system define a concrete realization of directed attention using "magnetic tentacles". Directing attention to another system would mean reconnection of the U-shaped loops of the two systems to a pair of flux tubes connecting the systems so that they quantum entangled or can do so. The asymmetry would be due to the fact that the more complex system - observer - can perform intentional motor actions of magnetic body that is control flux tube thickness and therefore magnetic fields and corresponding cyclotron frequencies so that for suitable frequency resonant reconnection can occur (magnetic field strengths are same for the two reconnecting U-shaped flux loops). Directedness would basically come from self hierarchy. The self directing attention would perform intentional action forcing its sub-self to reconnect with the magnetic body (MB) of the attended system.
3. Self hierarchy is analogous to the hierarchy of observations. At the level of space-time surface the counterpart is hierarchy of space-time sheets glued to larger space-time sheets by wormhole contacts glued to.... The geometric counterparts are hierarchy of causal diamonds at the level of embedding space. Self has sub-selves which it experiences as mental images. Sub-selves are experienced as kind of average. State function reductions take place as top-down cascades. A reduction of system decomposes it to two unentangled subsystems and for this NMP can force a further state function reduction and cascade stops when all resulting sub-systems are negentropically entangled.
4. In TGD framework measure of complexity for representations could be defined in terms of measurement resolution allowing definition in terms of inclusions of hyperfinite factors: included factor would have lower resolution and would be simpler. For p-adic cognition measurement resolution is unavoidable and increases as the complexity of the algebraic extension of rationals behind adeles increases.

In TGD the hierarchies of Planck constants, p-adic length scales defines, algebraic extensions of rationals define evolutionary hierarchies with increasing complexity measured also by the entanglement negentropy. NMP states that negentropy gain is maximized in state function reduction and intensity of conscious experience could be measured as negentropy gain. To my view surprisingness demands ability to predict the time evolution so that the deviation from prediction would characterize surprisingness. In ZEO zero energy states have indeed 4-D space-time surfaces as correlates and these would define the predictions. Notability would perhaps might be characterized in terms of the value of negentropy gain in state function reduction.

5. Subjective time as sequence of repeated reductions at the same boundary of causal diamond corresponds to the experienced time in TGD framework but the negentropy associated with passive boundary of CD is not changing. The drift of the active boundary of CD farther away from the passive one defines clock time giving rise to experienced flow of time. One can say that the sequence of state function reductions defining subjective time is mapped to a sequence of increasing temporal distance between the tips of CD. Same is true for sub-selves/sub-CDs.

During the period of reductions defining self sub-selves (sub-CDs) defining mental images are generated and the increase of negentropy assignable to them accompanies this flow of

time (usually thermodynamical entropy defines arrow of time). In TGD p-adic entanglement negentropies correlate very closely with real entanglement entropy and the randomness assignable to reductions at opposite boundary of CD meaning death and reincarnation of self generate thermodynamical ensemble entropy.

6. Persistent entity corresponds in TGD naturally to the negentropic subsystems at passive boundary of CD defining the unchanging part of self responsible for self identity. These can be also seen as negentropy resources of the Universe, kind of Akashic records. The network of magnetic flux tubes carrying dark matter as large  $h_{eff}$  phase define a kind of neural network giving rise to experience about space and body as something distinguishable from environment. The flux tubes would meet at nodes and there would be NE between the nodes. One must clearly distinguish between space in purely geometric sense and system able to create the experience about space as 3-D structure, biological body.
7. What about understanding of emergence and intelligence? The number theoretic evolution realized in terms of algebraic extensions of rationals suggests first principle definition of emergence of intelligence as phase transitions making the extension more complex, increasing the value of  $h_{eff}$  and thus scale of quantum coherent, increasing the p-adic length scale, etc... Negentropy Maximization Principle would be the driving force and state that state function reductions tend to increase negentropic resources of the Universe: strong form states that the negentropy gain is maximal (see <http://tinyurl.com/gwaal5l>). One can identify several ingredients of intelligence (see <http://tinyurl.com/zcwa5jj>). What seems essential is that intelligent system is able to build “stories” as p-adically scaled variants of real event sequences so that simulations can be carried out in much shorter or also longer time scale than that for the real events.

### 19.3.5 The notions of peaked distribution and morphic resonance

Many other notions are introduced and the theory is applied to Psi phenomena, morphic resonance, and other candidates for anomalous phenomena. In the following I discuss the notions of peaked distribution and morphic resonance from TGD point of view.

1. The notion of peaked distribution is introduced. In TGD framework the notion of preferred extremal of Kähler action is an analogous notion. In ordinary quantum field theory one would have path integral over all 4-surfaces connecting initial and final states. By holography one does not have path integral now. Already ordinary holography produces effectively 3-D dynamics and SH produces effectively 2-D dynamics: the data about space-time geometry is carried by 2-D surfaces (apart additional discrete degrees of freedom very probably present).

Preferred extremals satisfy powerful conditions stating that infinite number of Noether charges assignable to the symmetries of WCW vanish and guarantee that space-time sheets can be constructed from essentially 2-D data - space-time genes. These conditions leave extremely restricted set of space-time surfaces as preferred extremals representing kind of archetypal dynamical patterns. The actual space-time engineered from these and standard model + GRT limit of TGD lacks therefore this simplicity although it is topologically simple. These preferred extremals would be natural counterparts for the peaks of distribution. One might say that the space-time surface represent kind of dynamical archetypes possessing huge symmetries. EEG pattern would be a typical example.

Brain is mentioned as a key example of system in which this kind of peaking occurs. In TGD brain would be a system building standardized mental images by virtual sensory input to sensory organs as feedback and 4-D self-organization would replace zero-energy state reduction by reduction with a new one approaching asymptotic pattern defining standardized mental image.

2. Morphic resonance as mechanism for the formation of habits is emphasized. In TGD context ZEO implies that magnetic bodies define 4-D temporal patterns connecting initial and final states at the opposite boundaries of CD serving as correlates for behaviors, functions, habits, etc... The replication of 4-D magnetic bodies analogous to what occurs for the elementary particle in the decay  $A \rightarrow B+C$  could lead to the morphic resonance and establishment of a



new skill. Ordinary DNA and cell replication would be 3-D shadow of morphic resonance in this sense. The reconnection would be also basic mechanism in various remote mental interactions such as telepathy and psychokinesis. To understand precognition also ZEO (signals propagating also in non-standard time direction) is needed.

Resonance aspect is actually very concrete. Dark photons at magnetic flux tubes are characterized by cyclotron frequencies and reconnection of two flux tubes requires that the magnetic field strengths and therefore also cyclotron frequencies are identical, which means resonance in concrete sense. The establishment of a habit would be based on reconnection of the flux tubes of the MBs associated with the members of the community. Since MBs can have size of order Earth size scale or even larger, the habit could be established at different sides of globe almost instantaneously.

### 19.3.6 Space-time as a metaphorical knot

Could problem solving have space-time correlate? Goertzel talks about space-time as a metaphorical knot. Opening a knot could serve as an attractive metaphor for problem solving. I am not however quite sure whether Goertzel has exactly this in mind.

1. In TGD framework knottedness of space-time is much more than metaphor. Effectively one-dimensional (from the point of view of homology) magnetic flux tubes as basic space-time structures can get knotted in 3-space as also 1-D fermionic strings inside them. Braiding is another name for this process and defines classical counterparts of quantum computer programs. The special role of knots is solely due to the dimension  $D=4$  of space-time. Even more: also the (effectively) 2-D orbits of fermionic strings (flux tubes) can form 2-knots in 4-D space-time. This brings additional topological reactions.
2. The idea about opening a knot without cutting it temporarily as a space-time correlate for problem solving in civilized manner is very attractive. 2-knots correspond to processes in which this is carried out in Alexandrian manner by cutting the knot temporarily: the portions of knots go through each other or are split and reconnected in a new manner. Reconnection processes for magnetic body in living matter would be rebuilding of communication network based on flux tubes.
3. The vision about scattering diagrams as space-time surfaces defining geometric and topological representations for algebraic computations is central in quantum TGD. Particle reaction can be seen as an algebraic computation connecting initial and final collections of algebraic objects (particles) with vertices defining algebraic operations  $A + B \rightarrow C = A \circ B$ . There is infinite number of equivalent ways to perform the computation and the simplest computation correspond to a diagram containing no loops. This gives infinite number of dualities between different but equivalent computations very much analogous to mirror symmetry in M-theory. Could the problem solving be understood as a process in which one finds the simplest possible representation of algebraic computation in terms of space-time correlates? There is an objection: if these dualities are complete symmetries, it should not be possible to speak about solving problem in this manner. Symmetry breaking is needed to make a difference. Maybe one must give up this very nice metaphor.
4. Strong form of holography (SH) suggests however an alternative view about problem solving. Problem solving involves imagination in an essential manner and means finding an imagination, which is realizable. By SH both real and p-adic space-time surfaces are constructible from 2-D space-time genes in the intersection of reality and various p-adicities (string world sheets and partonic 2-surfaces) by algebraic continuation. Due to the inherent non-determinism of p-adic partial differential equations much larger set of continuations is possible in p-adic sectors than in real sector. p-Adic imagination need not therefore be realizable. Could the solution of the problem mean finding a p-adic imagination having also real counterpart.

## 19.4 Further notions and ideas

Goertzel introduces also the notions of peaked distribution and morphic resonance and the idea about space-time as metaphorical knot.

### 19.4.1 The notions of peaked distribution and morphic resonance

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# Chapter i

## Appendix

### A-1 Introduction

Originally this appendix was meant to be a purely technical summary of basic facts but in its recent form it tries to briefly summarize those basic visions about TGD which I dare to regard as stabilized. I have added illustrations making it easier to build mental images about what is involved and represented briefly the key arguments. This chapter is hoped to help the reader to get fast grasp about the concepts of TGD.

The basic properties of embedding space and related spaces are discussed and the relationship of  $CP_2$  to the standard model is summarized. The basic vision is simple: the geometry of the embedding space  $H = M^4 \times CP_2$  geometrizes standard model symmetries and quantum numbers. The assumption that space-time surfaces are basic objects, brings in dynamics as dynamics of 3-D surfaces based on the induced geometry. Second quantization of free spinor fields of  $H$  induces quantization at the level of  $H$ , which means a dramatic simplification.

The notions of induction of metric and spinor connection, and of spinor structure are discussed. Many-sheeted space-time and related notions such as topological field quantization and the relationship many-sheeted space-time to that of GRT space-time are discussed as well as the recent view about induced spinor fields and the emergence of fermionic strings. Also the relationship to string models is discussed briefly.

Various topics related to p-adic numbers are summarized with a brief definition of p-adic manifold and the idea about generalization of the number concept by gluing real and p-adic number fields to a larger book like structure analogous to adèle [L97, L98]. In the recent view of quantum TGD [L210], both notions reduce to physics as number theory vision, which relies on  $M^8 - H$  duality [L165, L166] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L149] [K129] 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) [L149, L197] [K129] 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 [A32] so that  $H = M^4 \times CP_2$  is twistorially unique.

One can loosely say that quantum states in a given sector of “world of classical worlds” (WCW) are superpositions of space-time surfaces inside CDs and that positive and negative energy parts of zero energy states are localized and past and future boundaries of CDs. CDs form a hierarchy. One can have CDs within CDs and CDs can also overlap. The size of CD is characterized by the proper time distance between its two tips. One can perform both translations and also Lorentz boosts of CD leaving either boundary invariant. Therefore one can assign to CDs a moduli space and speak about wave function in this moduli space.

In number theoretic approach it is natural to restrict the allowed Lorentz boosts to some discrete subgroup of Lorentz group and also the distances between the tips of CDs to multiples of  $CP_2$  radius defined by the length of its geodesic. Therefore the moduli space of CDs discretizes. The quantization of cosmic recession velocities for which there are indications, could relate to this quantization.

### A-2.1 Basic facts about $CP_2$

$CP_2$  as a four-manifold is very special. The following arguments demonstrate that it codes for the symmetries of standard models via its isometries and holonomies.

#### $CP_2$ as a manifold

$CP_2$ , the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space  $C^3$  under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) . \quad (\text{A-2.1})$$

Here  $\lambda$  is any non-zero complex number. Note that  $CP_2$  can be also regarded as the coset space  $SU(3)/U(2)$ . The pair  $z^i/z^j$  for fixed  $j$  and  $z^i \neq 0$  defines a complex coordinate chart for  $CP_2$ . As  $j$  runs from 1 to 3 one obtains an atlas of three coordinate charts covering  $CP_2$ , the charts being holomorphically related to each other (e.g.  $CP_2$  is a complex manifold). The points  $z^3 \neq 0$  form a subset of  $CP_2$  homeomorphic to  $R^4$  and the points with  $z^3 = 0$  a set homeomorphic to  $S^2$ . Therefore  $CP_2$  is obtained by “adding the 2-sphere at infinity to  $R^4$ ”.

Besides the standard complex coordinates  $\xi^i = z^i/z^3$ ,  $i = 1, 2$  the coordinates of Eguchi and Freund [A27] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it , \\ \xi^2 &= x + iy . \end{aligned} \quad (\text{A-2.2})$$

These are related to the “spherical coordinates” via the equations

$$\begin{aligned} \xi^1 &= r \exp(i \frac{(\Psi + \Phi)}{2}) \cos(\frac{\Theta}{2}) , \\ \xi^2 &= r \exp(i \frac{(\Psi - \Phi)}{2}) \sin(\frac{\Theta}{2}) . \end{aligned} \quad (\text{A-2.3})$$

The ranges of the variables  $r, \Theta, \Phi, \Psi$  are  $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$  respectively.

Considered as a real four-manifold  $CP_2$  is compact and simply connected, with Euler number 3, Pontryagin number 3 and second  $b = 1$ .

**Fig. 4.**  $CP_2$  as manifold. <http://tgdtheory.fi/appfigures/cp2.jpg>

### Metric and Kähler structure of $CP_2$

In order to obtain a natural metric for  $CP_2$ , observe that  $CP_2$  can be thought of as a set of the orbits of the isometries  $z^i \rightarrow \exp(i\alpha)z^i$  on the sphere  $S^5$ :  $\sum z^i \bar{z}^i = R^2$ . The metric of  $CP_2$  is obtained by projecting the metric of  $S^5$  orthogonally to the orbits of the isometries. Therefore the distance between the points of  $CP_2$  is that between the representative orbits on  $S^5$ .

The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b, \quad (\text{A-2.4})$$

where the Hermitian, in fact Kähler metric  $g_{a\bar{b}}$  is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K, \quad (\text{A-2.5})$$

where the function  $K$ , Kähler function, is defined as

$$\begin{aligned} K &= \log(F), \\ F &= 1 + r^2. \end{aligned} \quad (\text{A-2.6})$$

The Kähler function for  $S^2$  has the same form. It gives the  $S^2$  metric  $dzd\bar{z}/(1+r^2)^2$  related to its standard form in spherical coordinates by the coordinate transformation  $(r, \phi) = (\tan(\theta/2), \phi)$ .

The representation of the  $CP_2$  metric is deducible from  $S^5$  metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2 \sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F}, \quad (\text{A-2.7})$$

where the quantities  $\sigma_i$  are defined as

$$\begin{aligned} r^2 \sigma_1 &= \text{Im}(\xi^1 d\xi^2 - \xi^2 d\xi^1), \\ r^2 \sigma_2 &= -\text{Re}(\xi^1 d\xi^2 - \xi^2 d\xi^1), \\ r^2 \sigma_3 &= -\text{Im}(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2). \end{aligned} \quad (\text{A-2.8})$$

$R$  denotes the radius of the geodesic circle of  $CP_2$ . The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A, \quad (\text{A-2.9})$$

are given by

$$\begin{aligned} e^0 &= \frac{dr}{F}, & e^1 &= \frac{r\sigma_1}{\sqrt{F}}, \\ e^2 &= \frac{r\sigma_2}{\sqrt{F}}, & e^3 &= \frac{r\sigma_3}{F}. \end{aligned} \quad (\text{A-2.10})$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned}
e^0 &= \frac{dr}{F} , & e^1 &= \frac{r(\sin\Theta\cos\Psi d\Phi + \sin\Psi d\Theta)}{2\sqrt{F}} , \\
e^2 &= \frac{r(\sin\Theta\sin\Psi d\Phi - \cos\Psi d\Theta)}{2\sqrt{F}} , & e^3 &= \frac{r(d\Psi + \cos\Theta d\Phi)}{2F} .
\end{aligned}
\tag{A-2.11}$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + \cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + \sin^2\Theta d\Phi^2) .
\tag{A-2.12}$$

From this expression one finds that at coordinate infinity  $r = \infty$  line element reduces to  $\frac{r^2}{4F}(d\Theta^2 + \sin^2\Theta d\Phi^2)$  of  $S^2$  meaning that 3-sphere degenerates metrically to 2-sphere and one can say that  $CP_2$  is obtained by adding to  $R^4$  a 2-sphere at infinity.

The vierbein connection satisfying the defining relation

$$de^A = -V_B^A \wedge e^B ,
\tag{A-2.13}$$

is given by

$$\begin{aligned}
V_{01} &= -\frac{e^1}{r_2} , & V_{23} &= \frac{e^1}{r_2} , \\
V_{02} &= -\frac{e^2}{r} , & V_{31} &= \frac{e^2}{r} , \\
V_{03} &= (r - \frac{1}{r})e^3 , & V_{12} &= (2r + \frac{1}{r})e^3 .
\end{aligned}
\tag{A-2.14}$$

The representation of the covariantly constant curvature tensor is given by

$$\begin{aligned}
R_{01} &= e^0 \wedge e^1 - e^2 \wedge e^3 , & R_{23} &= e^0 \wedge e^1 - e^2 \wedge e^3 , \\
R_{02} &= e^0 \wedge e^2 - e^3 \wedge e^1 , & R_{31} &= -e^0 \wedge e^2 + e^3 \wedge e^1 , \\
R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 , & R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 .
\end{aligned}
\tag{A-2.15}$$

Metric defines a real, covariantly constant, and therefore closed 2-form  $J$

$$J = -is_{a\bar{b}} d\xi^a d\bar{\xi}^b ,
\tag{A-2.16}$$

the so called Kähler form. Kähler form  $J$  defines in  $CP_2$  a symplectic structure because it satisfies the condition

$$J^k_r J^{rl} = -s^{kl} .
\tag{A-2.17}$$

The condition states that  $J$  and  $g$  give representations of real unit and imaginary units related by the formula  $i^2 = -1$ .

Kähler form is expressible locally in terms of Kähler gauge potential

$$J = dB ,
\tag{A-2.18}$$

where  $B$  is the so called Kähler potential, which is not defined globally since  $J$  describes homological magnetic monopole.

$dJ = ddB = 0$  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

$$\begin{aligned} B &= 2re^3 , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = \frac{r}{F^2} dr \wedge (d\Psi + \cos\Theta d\Phi) + \frac{r^2}{2F} \sin\Theta d\Theta \wedge d\Phi . \end{aligned} \quad (\text{A-2.19})$$

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

$$\begin{aligned} B &= \sum_{k=1,2} P_k dQ_k , \\ J &= \sum_{k=1,2} dP_k \wedge dQ_k . \end{aligned} \quad (\text{A-2.20})$$

The relationship of the canonical coordinates to the “spherical” coordinates is given by the equations

$$\begin{aligned} P_1 &= -\frac{1}{1+r^2} , \\ P_2 &= -\frac{r^2 \cos\Theta}{2(1+r^2)} , \\ Q_1 &= \Psi , \\ Q_2 &= \Phi . \end{aligned} \quad (\text{A-2.21})$$

### Spinors In $CP_2$

$CP_2$  doesn't allow spinor structure in the conventional sense [A25]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of  $CP_2$  play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space  $M$ . The parallel propagation around a closed curve with a base point  $x$  leads to a rotated vierbein at  $x$ :  $e^A = R_B^A e^B$  and one can associate to each closed path an element of  $SO(4)$ .

Consider now a one-parameter family of closed curves  $\gamma(v) : v \in (0, 1)$  with the same base point  $x$  and  $\gamma(0)$  and  $\gamma(1)$  trivial paths. Clearly these paths define a sphere  $S^2$  in  $M$  and the element  $R_B^A(v)$  defines a closed path in  $SO(4)$ . When the sphere  $S^2$  is contractible to a point e.g., homologically trivial, the path in  $SO(4)$  is also contractible to a point and therefore represents a trivial element of the homotopy group  $\Pi_1(SO(4)) = Z_2$ .

For a homologically nontrivial 2-surface  $S^2$  the associated path in  $SO(4)$  can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group  $\text{Spin}(4)$  (leading from the matrix 1 to -1 in the matrix representation). Assume this is the case.

Assume now that the space allows spinor structure. Then one can parallel propagate also spinors and by the above construction associate a closed path of  $\text{Spin}(4)$  to the surface  $S^2$ . Now, however this path corresponds to a lift of the corresponding  $SO(4)$  path and cannot be closed. Thus one ends up with a contradiction.

From the preceding argument it is clear that one could compensate the non-allowed  $-1$ -factor associated with the parallel transport of the spinor around the sphere  $S^2$  by coupling it to a gauge potential in such a way that in the parallel transport the gauge potential introduces a compensating  $-1$ -factor. For a  $U(1)$  gauge potential this factor is given by the exponential



$\exp(i2\Phi)$ , where  $\Phi$  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  $h_\alpha^k$  (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 [A41] a general characterization of the geodesic sub-manifolds for an arbitrary symmetric space  $G/H$  is given. Geodesic sub-manifolds are in 1-1-correspondence with the so called Lie triple systems of the Lie-algebra  $g$  of the group  $G$ . The Lie triple system  $t$  is defined as a subspace of  $g$  characterized by the closedness property with respect to double commutation

$$[X, [Y, Z]] \in t \text{ for } X, Y, Z \in t . \quad (\text{A-2.22})$$

$SU(3)$  allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that  $SU(3)$  allows two nonequivalent  $SU(2)$  algebras corresponding to subgroups  $SO(3)$  (orthogonal  $3 \times 3$  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 [B14] and in particular that the right handed neutrinos decouple completely from the electro-weak interactions.

To begin with, recall that the space  $H$  allows to define three different chiralities for spinors. Spinors with fixed  $H$ -chirality  $e = \pm 1$ ,  $CP_2$ -chirality  $l, r$  and  $M^4$ -chirality  $L, R$  are defined by the condition

$$\begin{aligned} \Gamma\Psi &= e\Psi , \\ e &= \pm 1 , \end{aligned} \quad (\text{A-2.23})$$

where  $\Gamma$  denotes the matrix  $\Gamma_9 = \gamma_5 \otimes \gamma_5$ ,  $1 \otimes \gamma_5$  and  $\gamma_5 \otimes 1$  respectively. Clearly, for a fixed  $H$ -chirality  $CP_2$ - and  $M^4$ -chiralities are correlated.

The spinors with  $H$ -chirality  $e = \pm 1$  can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite  $H$ -chirality one can identify the vielbein group of  $CP_2$  as the electro-weak group:  $SO(4)$  having as its covering group  $SU(2)_L \times SU(2)_R$ .

The covariant derivatives are defined by the spinorial connection

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) . \quad (\text{A-2.24})$$

Here  $V$  and  $B$  denote the projections of the vielbein and Kähler gauge potentials respectively and  $1_{+(-)}$  projects to the spinor  $H$ -chirality  $+(-)$ . The integers  $n_{\pm}$  are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection  $V$  and of  $B$  are given by the equations

$$\begin{aligned} V_{01} &= -\frac{e^1}{r_2} , & V_{23} &= \frac{e^1}{r_2} , \\ V_{02} &= -\frac{e^2}{r} , & V_{31} &= \frac{e^2}{r} , \\ V_{03} &= (r - \frac{1}{r})e^3 , & V_{12} &= (2r + \frac{1}{r})e^3 , \end{aligned} \quad (\text{A-2.25})$$

and

$$B = 2re^3 , \quad (\text{A-2.26})$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying  $\Sigma_3^0$  and  $\Sigma_2^1$  as the diagonal (neutral) Lie-algebra generators of  $SO(4)$ , one finds that the charged part of the spinor connection is given by

$$A_{ch} = 2V_{23}I_L^1 + 2V_{13}I_L^2 , \quad (\text{A-2.27})$$

where one have defined

$$\begin{aligned} I_L^1 &= \frac{(\Sigma_{01} - \Sigma_{23})}{2} , \\ I_L^2 &= \frac{(\Sigma_{02} - \Sigma_{13})}{2} . \end{aligned} \quad (\text{A-2.28})$$

$A_{ch}$  is clearly left handed so that one can perform the identification of the gauge potential as

$$W^{\pm} = \frac{2(e^1 \pm ie^2)}{r} , \quad (\text{A-2.29})$$

where  $W^{\pm}$  denotes the charged intermediate vector boson.

The covariantly constant curvature tensor is given by

$$\begin{aligned} R_{01} &= -R_{23} = e^0 \wedge e^1 - e^2 \wedge e^3 , \\ R_{02} &= -R_{31} = e^0 \wedge e^2 - e^3 \wedge e^1 , \\ R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 , \\ R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 . \end{aligned} \quad (\text{A-2.30})$$

The charged part of the curvature tensor is left handed.

This is to be compared with the Weyl tensor, which defines a representation of quaternionic imaginary units.

$$\begin{aligned}
W_{03} = W_{12} &\equiv 2I_3 = 2(e^0 \wedge e^3 + e^1 \wedge e^2) , \\
W_{01} = W_{23} &\equiv I_1 = -e^0 \wedge e^1 - e^2 \wedge e^3 , \\
W_{02} = W_{31} &\equiv I_2 = -e^0 \wedge e^2 - e^3 \wedge e^1 .
\end{aligned} \tag{A-2.31}$$

The charged part of the Weyl tensor is right-handed and that the relative sign of the two terms in the curvature tensor and Weyl tensor are opposite.

Consider next the identification of the neutral gauge bosons  $\gamma$  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  $\gamma$  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  $\Sigma_{12}$  and  $\Sigma_{03} = 1 \times \gamma_5 \Sigma_{12}$  as vectorial and axial Lie-algebra generators, respectively, the requirement that  $\gamma$  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  $\gamma$  and  $Z^0$  are defined via the relations

$$\begin{aligned}
\gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) , \\
Z^0 &= 4(a+b)\bar{Z}^0 = 4(X - Y) .
\end{aligned} \tag{A-2.38}$$

The value of the Weinberg angle is given by

$$\sin^2 \theta_W = \frac{3b}{2(a+b)} , \quad (\text{A-2.39})$$

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  $\gamma Z^0$ . This leads to a definite value for the Weinberg angle.

One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle. As a matter fact, color gauge action identifying color gauge field as proportional to  $H^A J_{\alpha\beta}$  is proportional to Kähler action. A possible interpretation would be as a sum of electroweak and color gauge interactions.

To evaluate the value of the Weinberg angle one can express the neutral part  $F_{nc}$  of the induced gauge field as

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) , \quad (\text{A-2.40})$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) , \\ R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) , \end{aligned} \quad (\text{A-2.41})$$

in terms of the fields  $\gamma$  and  $Z^0$  (photon and  $Z$ - boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - \sin^2 \theta_W Q_{em}) . \quad (\text{A-2.42})$$

Evaluating the expressions above, one obtains for  $\gamma$  and  $Z^0$  the expressions

$$\begin{aligned} \gamma &= 3J - \sin^2 \theta_W R_{12} , \\ Z^0 &= 2R_{03} . \end{aligned} \quad (\text{A-2.43})$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + \sin^2 \theta_W Z^0) . \quad (\text{A-2.44})$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + f J^{\alpha\beta} J_{\alpha\beta} , \\ L_{sym} &= \frac{1}{4g^2} \text{Tr}(F^{\alpha\beta} F_{\alpha\beta}) , \end{aligned} \quad (\text{A-2.45})$$

where the trace is taken in spinor representation, in terms of  $\gamma$  and  $Z^0$  one obtains for the coefficient  $X$  of the  $\gamma Z^0$  cross term (this coefficient must vanish) the expression

$$\begin{aligned}
X &= -\frac{K}{2g^2} + \frac{fp}{18} , \\
K &= Tr [Q_{em}(I_L^3 - \sin^2\theta_W Q_{em})] ,
\end{aligned}
\tag{A-2.46}$$

This parameter can be calculated by substituting the values of quark and lepton charges and weak isospins.

In the general case the value of the coefficient  $K$  is given by

$$K = \sum_i \left[ -\frac{(18 + 2n_i^2)\sin^2\theta_W}{9} \right] , \tag{A-2.47}$$

where the sum is over the spinor chiralities, which appear as elementary fermions and  $n_i$  is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i (18 + n_i^2))} . \tag{A-2.48}$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$\sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} . \tag{A-2.49}$$

The bare value of the Weinberg angle is  $9/28$  in this scenario, which is not far from the typical value  $9/24$  of GUTs at high energies [B2]. The experimental value at the scale length scale of the electron can be deduced from the ratio of W and Z boson masses as  $\sin^2\theta_W = 1 - (m_W/m_Z)^2 \simeq .22290$ . This ratio and also the weak boson masses depend on the length scale.

If one interprets the additional term proportional to  $J$  as color action, one could perhaps interpret the value of Weinberg angle as expressing a connection between strong and weak coupling constant evolution. The limit  $f \rightarrow 0$  should correspond to an infinite value of color coupling strength and at this limit one would have  $\sin^2\theta_W = \frac{9}{28}$  for  $f/g^2 \rightarrow 0$ . This does not make sense since the Weinberg angle is in the standard model much smaller in QCD scale  $\Lambda$  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 [L216] 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

$$\begin{aligned}
 R_{03} &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = J + 2e^0 \wedge e^3 , \\
 J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) , \\
 R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) = 3J - 2e^0 \wedge e^3 , 
 \end{aligned} \tag{A-2.50}$$

2. The induced fields  $\gamma$  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  $\gamma$  would be

$$\langle \gamma \rangle = (3 - 4\sin^2 \theta_W)J .$$

For  $\sin^2 \theta_W = 3/4$   $\langle \gamma \rangle$  would vanish.

The quantum averages of classical weak fields quite generally vanish. What about correlation functions?

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  $\hbar_{eff}$  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  $\hbar_{eff}$  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 [B3] .

The action of the reflection  $P$  on spinors of is given by

$$\Psi \rightarrow P\Psi = \gamma^0 \otimes \gamma^0 \Psi . \quad (\text{A-2.53})$$

in the representation of the gamma matrices for which  $\gamma^0$  is diagonal. It should be noticed that  $W$  and  $Z^0$  bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of  $P$ .

The guess that a complex conjugation in  $CP_2$  is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$\begin{aligned} m^k &\rightarrow T(M^k) , \\ \xi^k &\rightarrow \bar{\xi}^k , \\ \Psi &\rightarrow \gamma^1 \gamma^3 \otimes 1 \Psi . \end{aligned} \quad (\text{A-2.54})$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in  $CP_2$ :

$$\begin{aligned} \xi^k &\rightarrow \bar{\xi}^k , \\ \Psi &\rightarrow \Psi^\dagger \gamma^2 \gamma^0 \otimes 1 . \end{aligned} \quad (\text{A-2.55})$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

### A-3 Induction procedure and many-sheeted space-time

Since the classical gauge fields are closely related in TGD framework, it is not possible to have space-time sheets carrying only single kind of gauge field. For instance, em fields are accompanied by  $Z^0$  fields for extremals of Kähler action.

Classical em fields are always accompanied by  $Z^0$  field and some components of color gauge field. For extremals having homologically non-trivial sphere as a  $CP_2$  projection em and  $Z^0$  fields are the only non-vanishing electroweak gauge fields. For homologically trivial sphere only  $W$  fields are non-vanishing. Color rotations does not affect the situation.

For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has  $U(1)$  holonomy by 2-dimensionality of the  $CP_2$  projection. Color gauge field has  $U(1)$  holonomy for all space-time surfaces and quantum classical correspondence suggest a weak form of color confinement meaning that physical states correspond to color neutral members of color multiplets.

#### A-3.1 Induction procedure for gauge fields and spinor connection

Induction procedure for gauge potentials and spinor structure is a standard procedure of bundle theory. If one has embedding of some manifold to the base space of a bundle, the bundle structure can be induced so that it has as a base space the imbedded manifold, whose points have as fiber the fiber 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  $\gamma$  and  $Z^0$ . This can be verified by explicit examples.

$r = \infty$  surface gives rise to a homologically non-trivial geodesic sphere for which  $e_0$  and  $e_3$  vanish imply the vanishing of  $W$  field. For space-time sheets for which  $CP_2$  projection is  $r = \infty$  homologically non-trivial geodesic sphere of  $CP_2$  one has

$$\gamma = \left(\frac{3}{4} - \frac{\sin^2(\theta_W)}{2}\right)Z^0 \simeq \frac{5Z^0}{8}.$$

The induced  $W$  fields vanish in this case and they vanish also for all geodesic sphere obtained by  $SU(3)$  rotation.

$Im(\xi^1) = Im(\xi^2) = 0$  corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex  $CP_2$  coordinates constant values. In this case  $e^1$  and  $e^3$  vanish so that the induced em,  $Z^0$ , and Kähler fields vanish but induced  $W$  fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D  $CP_2$  projection color rotations and weak symmetries commute.



### A-3.3 Many-sheeted space-time

TGD space-time is many-sheeted: in other words, there are in general several space-sheets which have projection to the same  $M^4$  region. Second manner to say this is that  $CP_2$  coordinates are many-valued functions of  $M^4$  coordinates. The original physical interpretation of many-sheeted space-time was not correct: it was assumed that single sheet corresponds to GRT space-time and this obviously leads to difficulties since the induced gauge fields are expressible in terms of only four embedding space coordinates.

**Fig. 10.** Illustration of many-sheeted space-time of TGD. <http://tgdtheory.fi/appfigures/manysheeted.jpg>

#### Superposition of effects instead of superposition of fields

The first objection against TGD is that superposition is not possible for induced gauge fields and induced metric. The resolution of the problem is that it is effects which need to superpose, not the fields.

Test particle topologically condenses simultaneously to all space-time sheets having a projection to same region of  $M^4$  (that is touches them). The superposition of effects of fields at various space-time sheets replaces the superposition of fields. This is crucial for the understanding also how GRT space-time relates to TGD space-time, which is also in the appendix of this book).

#### Wormhole contacts

Wormhole contacts are key element of many-sheeted space-time. One does not expect them to be stable unless there is non-trivial Kähler magnetic flux flowing through them so that the throats look like Kähler magnetic monopoles.

**Fig. 11.** Wormhole contact. <http://tgdtheory.fi/appfigures/wormholecontact.jpg>

Since the flow lines of Kähler magnetic field must be closed this requires the presence of another wormhole contact so that one obtains closed monopole flux tube decomposing to two Minkowskian pieces at the two space-time sheets involved and two wormhole contacts with Euclidian signature of the induced metric. These objects are identified as space-time correlates of elementary particles and are clearly analogous to string like objects.

#### The relationship between the many-sheeted space-time of TGD and of GRT space-time

The space-time of general relativity is single-sheeted and there is no need to regard it as surface in  $H$  although the assumption about representability as vacuum extremal gives very powerful constraints in cosmology and astrophysics and might make sense in simple situations.

The space-time of GRT can be regarded as a long length scale approximation obtained by lumping together the sheets of the many-sheeted space-time to a region of  $M^4$  and providing it with an effective metric obtained as sum of  $M^4$  metric and deviations of the induced metrics of various space-time sheets from  $M^4$  metric. Also induced gauge potentials sum up in the similar manner so that also the gauge fields of gauge theories would not be fundamental fields.

**Fig. 12.** The superposition of fields is replaced with the superposition of their effects in many-sheeted space-time. <http://tgdtheory.fi/appfigures/fieldsuperpose.jpg>

Space-time surfaces of TGD are considerably simpler objects than the space-times of general relativity and relate to GRT space-time like elementary particles to systems of condensed matter physics. Same can be said about fields since all fields are expressible in terms of embedding space coordinates and their gradients, and general coordinate invariance means that the number of bosonic field degrees is reduced locally to 4. TGD space-time can be said to be a microscopic description whereas GRT space-time a macroscopic description. In TGD complexity of space-time topology replaces the complexity due to large number of fields in quantum field theory.

#### Topological field quantization and the notion of magnetic body

Topological field quantization also TGD from Maxwell's theory. TGD predicts topological light rays ("massless extremals (MEs)") as space-time sheets carrying waves or arbitrary shape propagating

with maximal signal velocity in single direction only and analogous to laser beams and carrying light-like gauge currents in the generic 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 of these states must be those of standard model. For instance, the color quantum numbers of fundamental left-hand neutrino and lepton can compensate each other for the physical lepton. For fundamental quark-lepton pair they could sum up to those of physical quark.

The well-definedness of em charge is crucial condition.

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  $(r, \Theta, \Psi, \Phi)$  for  $CP_2$ , the expression of Kähler form reads as

$$\begin{aligned} J &= \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + \frac{r^2}{2F} \sin(\Theta) d\Theta \wedge d\Phi , \\ F &= 1 + r^2 . \end{aligned} \quad (\text{A-3.1})$$

The general expression of electromagnetic field reads as

$$\begin{aligned} F_{em} &= (3 + 2p) \frac{r}{F^2} dr \wedge (d\Psi + \cos(\Theta)d\Phi) + (3 + p) \frac{r^2}{2F} \sin(\Theta) d\Theta \wedge d\Phi , \\ p &= \sin^2(\Theta_W) , \end{aligned} \quad (\text{A-3.2})$$

where  $\Theta_W$  denotes Weinberg angle.

1. The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$\begin{aligned} \Psi &= k\Phi , \\ (3 + 2p) \frac{1}{r^2 F} (d(r^2)/d\Theta)(k + \cos(\Theta)) + (3 + p) \sin(\Theta) &= 0 , \end{aligned} \quad (\text{A-3.3})$$

hold true. The conditions imply that  $CP_2$  projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned}
r &= \sqrt{\frac{X}{1-X}} , \\
X &= D \left[ \left| \frac{k+u}{C} \right| \right]^\epsilon , \\
u &\equiv \cos(\Theta) , \quad C = k + \cos(\Theta_0) , \quad D = \frac{r_0^2}{1+r_0^2} , \quad \epsilon = \frac{3+p}{3+2p} ,
\end{aligned} \tag{A-3.4}$$

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

$$\text{sign}(u+k) \times \left[ \frac{1+r_0^2}{r_0^2} \right]^{\frac{3+2p}{3+p}} \leq k+1 ,$$

where  $\text{sign}(x)$  denotes the sign of  $x$ .

The expressions for Kähler form and  $Z^0$  field are given by

$$\begin{aligned}
J &= -\frac{p}{3+2p} X du \wedge d\Phi , \\
Z^0 &= -\frac{6}{p} J .
\end{aligned} \tag{A-3.5}$$

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  $\epsilon$  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:

$$\begin{aligned}
Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2} (k+u) \frac{\partial r}{\partial u} du \wedge d\Phi = (k+u) du \wedge d\Phi , \\
r &= \sqrt{\frac{X}{1-X}} , \quad X = D|k+u| , \\
\gamma &= -\frac{p}{2} Z^0 .
\end{aligned} \tag{A-3.6}$$

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

$$\begin{aligned} ds_{eff}^2 &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s_{\Theta\Theta}^{eff}d\Theta^2 + s_{\Phi\Phi}^{eff}d\Phi^2] , \\ s_{\Theta\Theta}^{eff} &= X \times \left[ \frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X \right] , \\ s_{\Phi\Phi}^{eff} &= X \times [(1-X)(k+u)^2 + 1 - u^2] , \end{aligned} \quad (A-3.7)$$

and is useful in the construction of vacuum embedding of, say Schwarzschild metric.

### Topological quantum numbers

Space-times for which either  $em, Z^0$ , or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers ( $\omega_1$  and  $\omega_2$ ) 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  $\omega_i$  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  $\Psi$  and  $\Phi$  can be written in the form

$$\begin{aligned} \Psi &= \omega_2 m^0 + k_2 m^3 + n_2 \phi + \text{Fourier expansion} , \\ \Phi &= \omega_1 m^0 + k_1 m^3 + n_1 \phi + \text{Fourier expansion} . \end{aligned} \quad (A-3.8)$$

$m^0, m^3$  and  $\phi$  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  $\omega_i, k_i$  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  $\Theta_0$ . At  $r = \infty$  surfaces  $n_2, \omega_2$  and  $m$  can change since all values of  $\Psi$  correspond to the same point of  $CP_2$ : at  $r = 0$  surfaces also  $n_1$  and  $\omega_1$  can change since all values of  $\Phi$  correspond to same point of  $CP_2$ , too. If  $r = 0$  or  $r = \infty$  is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global embedding for, say a constant magnetic field. Although global embedding exists it decomposes into regions with different values of the vacuum parameters and the coordinate  $u$  in general possesses discontinuous derivative at  $r = 0$  and  $r = \infty$  surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteeing the absence of edges are satisfied.

For instance, the vanishing of the electromagnetic fields implies that the condition

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 , \quad (A-3.9)$$

is satisfied. In particular, the ratio  $\omega_2/\omega_1$  is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter  $n_1$  and  $n_2$  ( $\omega_1$  and  $\omega_2$ ) 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 "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 [K50, K28, K93] [L199, L210].

**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  $\delta M_+^4$  plays the role of complex string coordinate in string models. These symmetries are assumed to act as isometries of WCW.

### A-4.3 String-like objects and strings

String like objects obtained as deformations of cosmic strings  $X^2 \times Y^2$ , where  $X^2$  is minimal surface in  $M^4$  and  $Y^2$  a holomorphic surface of  $CP_2$  are fundamental extremals of Kähler action having string world sheet as  $M^4$  projections. Cosmic strings dominate the primordial cosmology of the TGD Universe and the inflationary period corresponds to the transition to radiation dominated cosmology for which space-time sheets with 4-D  $M^4$  projection dominate.

Also genuine string-like objects emerge from TGD. The conditions that the em charge of modes of induced spinor fields is well-defined requires in the generic case the localization of the modes at 2-D surfaces -string world sheets and possibly also partonic 2-surfaces. This in Minkowskian space-time regions.

**Fig. 6.** Well-definedness of em charge forces the localization of induced spinor modes to 2-D surfaces in generic situations in Minkowskian regions of space-time surface. <http://tgdtheory.fi/appfigures/fermistring.jpg>

### A-4.4 TGD view of elementary particles

The TGD based view about elementary particles has two key aspects.

1. The space-time correlates of elementary particles are identified as pairs of wormhole contacts with Euclidean signature of metric and having 4-D  $CP_2$  projection. Their throats behave effectively as Kähler magnetic monopoles so that wormhole throats must be connected by Kähler magnetic flux tubes with monopole flux so that closed flux tubes are obtained.
2. At the level of  $H$  Fermion number is carried by the modes of the induced spinor field. In space-time regions with Minkowski signature the modes are localized at string world sheets connecting the wormhole contacts.

**Fig. 7.** TGD view about elementary particles. a) Particle orbit corresponds to a 4-D generalization of a world line or b) with its light-like 3-D boundary (holography). c) Particle world lines have Euclidean signature of the induced metric. d) They can be identified as wormhole contacts. e) The throats of wormhole contacts carry effective Kähler magnetic charges so that wormhole contacts must appear as pairs in order to obtain closed flux tubes. f) Wormhole contacts are accompanied by fermionic strings connecting the throats at the same sheet: the strings do not extend inside the wormhole contacts. <http://tgdtheory.fi/appfigures/elparticletgd.jpg>

Particle interactions involve both stringy and QFT aspects.

1. The boundaries of string world sheets correspond to fundamental fermions. This gives rise to massless propagator lines in generalized Feynman diagrammatics. One can speak of "long" string connecting wormhole contacts and having a hadronic string as a physical counterpart. Long strings should be distinguished from wormhole contacts which due to their superconformal invariance behave like "short" strings with length scale given by  $CP_2$  size, which is  $10^4$  times longer than Planck scale characterizing strings in string models.
2. Wormhole contact defines basic stringy interaction vertex for fermion-fermion scattering. The propagator is essentially the inverse of the superconformal scaling generator  $L_0$ . Wormhole contacts containing fermion and antifermion at its opposite throats behave like virtual bosons so that one has BFF type vertices typically.
3. In topological sense one has 3-vertices serving as generalizations of 3-vertices of Feynman diagrams. In these vertices 4-D "lines" of generalized Feynman diagrams meet along their 3-D ends. One obtains also the analogs of stringy diagrams but stringy vertices do not have the usual interpretation in terms of particle decays but in terms of propagation of particles along two different routes.

**Fig. 8.** a) TGD analogs of Feynman and string diagrammatics at the level of 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 [K50, K93].

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 [L99] [L199, L202, L203] 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 [A32] 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  $\Omega$  depending on zero modes. This cannot be true: galaxy and elementary particle cannot correspond to the same Kähler metric.

Number theoretical vision and the hierarchy of inclusions of HFFs associated with supersymplectic algebra acting as isometries of WCW provide equivalent realizations of the measurement resolution. This solves these paradoxes and predicts that WCW decomposes into sectors for which Kähler metrics of WCW differ in a natural way.

#### **The hierarchy subalgebras of supersymplectic algebra implies the decomposition of WCW into sectors with different actions**

Supersymplectic algebra of  $\delta M_+^4 \times CP_2$  is assumed to act as isometries of WCW [L210]. 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 [L210] 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 [L210] 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 [L210] 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 [L205] 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 [K62, K63]). 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 differentials and reduces to a polynomial of the  $n$  coefficients of  $P$ . Ramified primes define p-adic length scales assignable to the particles in the amplitudes scattering amplitudes defined by zero energy states.

$P$  would represent the space-time surface defining an interaction region in  $N$ -particle scattering. The  $N$  ramified primes dividing  $D(P)$  would characterize the p-adic length scales assignable to these particles. If  $D(P)$  reduces to a single ramified prime, one has elementary particle [L205], 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 [L205], 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 [L205].

3. p-Adic length scale hypothesis [L211] 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 [L210] 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  $\delta M_+^4 \times CP_2$  [K50, K28]. 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 [L208].

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 [K67, K57, K26]. The fusion of the various p-adic physics leads to what I call adelic physics [L97, L98]. 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 [L165, L166] 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 [L205, L208]. Also the ordinary  $3 \rightarrow 4$  holography is needed to assign 4-surfaces with these 3-D mass shells. The number theoretic dynamics is based on the condition that the normal space of the 4-surface in  $M^8$  is associative (quaternionic) and contains a commutative complex sub-space. This makes it possible to assign to this surface space-time surface in  $H = M^4 \times CP_2$ .

At the level of  $H$  the space-time surfaces are by holography preferred extremals and are assumed to be determined by the twistor lift of TGD [L99] 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 [A22]. p-Adic numbers are representable as power expansion of the prime number  $p$  of form

$$x = \sum_{k \geq k_0} x(k)p^k, \quad x(k) = 0, \dots, p-1. \quad (\text{A-6.1})$$

The norm of a p-adic number is given by

$$|x| = p^{-k_0(x)} . \quad (\text{A-6.2})$$

Here  $k_0(x)$  is the lowest power in the expansion of the p-adic number. The norm differs drastically from the norm of the ordinary real numbers since it depends on the lowest pinary digit of the p-adic number only. Arbitrarily high powers in the expansion are possible since the norm of the p-adic number is finite also for numbers, which are infinite with respect to the ordinary norm. A convenient representation for p-adic numbers is in the form

$$x = p^{k_0} \varepsilon(x) , \quad (\text{A-6.3})$$

where  $\varepsilon(x) = k + \dots$  with  $0 < k < p$ , is p-adic number with unit norm and analogous to the phase factor  $\exp(i\phi)$  of a complex number.

The distance function  $d(x, y) = |x - y|_p$  defined by the p-adic norm possesses a very general property called ultra-metricity:

$$d(x, z) \leq \max\{d(x, y), d(y, z)\} . \quad (\text{A-6.4})$$

The properties of the distance function make it possible to decompose  $R_p$  into a union of disjoint sets using the criterion that  $x$  and  $y$  belong to same class if the distance between  $x$  and  $y$  satisfies the condition

$$d(x, y) \leq D . \quad (\text{A-6.5})$$

This division of the metric space into classes has following properties:

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 [B11]. The emergence of p-adic topology as the topology of the effective space-time would make ultra-metricity property basic feature of physics.

### Canonical correspondence between p-adic and real numbers

The basic challenge encountered by p-adic physicist is how to map the predictions of the p-adic physics to real numbers. p-Adic probabilities provide a basic example in this respect. Identification via common rationals and canonical identification and its variants have turned out to play a key role in this respect.

#### 1. Basic form of the canonical identification

There exists a natural continuous map  $I : R_p \rightarrow R_+$  from p-adic numbers to non-negative real numbers given by the “pinary” expansion of the real number for  $x \in R$  and  $y \in R_p$  this correspondence reads

$$\begin{aligned} y &= \sum_{k > N} y_k p^k \rightarrow x = \sum_{k < N} y_k p^{-k} , \\ y_k &\in \{0, 1, \dots, p-1\} . \end{aligned} \quad (\text{A-6.6})$$

This map is continuous as one easily finds out. There is however a little difficulty associated with the definition of the inverse map since the pinary expansion like also decimal expansion is not unique ( $1 = 0.999\dots$ ) for the real numbers  $x$ , which allow pinary expansion with finite number of pinary digits

$$\begin{aligned} x &= \sum_{k=N_0}^N x_k p^{-k} , \\ x &= \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1)p^{-N} + (p - 1)p^{-N-1} \sum_{k=0, \dots} p^{-k} . \end{aligned} \quad (\text{A-6.7})$$

The p-adic images associated with these expansions are different

$$\begin{aligned} y_1 &= \sum_{k=N_0}^N x_k p^k , \\ y_2 &= \sum_{k=N_0}^{N-1} x_k p^k + (x_N - 1)p^N + (p - 1)p^{N+1} \sum_{k=0, \dots} p^k \\ &= y_1 + (x_N - 1)p^N - p^{N+1} , \end{aligned} \quad (\text{A-6.8})$$

so that the inverse map is either two-valued for p-adic numbers having expansion with finite pinary digits or single valued and discontinuous and non-surjective if one makes pinary expansion unique by choosing the one with finite pinary digits. The finite pinary digit expansion is a natural choice since in the numerical work one always must use a pinary cutoff on the real axis.

## 2. The topology induced by canonical identification

The topology induced by the canonical identification in the set of positive real numbers differs from the ordinary topology. The difference is easily understood by interpreting the p-adic norm as a norm in the set of the real numbers. The norm is constant in each interval  $[p^k, p^{k+1})$  (see **Fig. A-6.1**) and is equal to the usual real norm at the points  $x = p^k$ : the usual linear norm is replaced with a piecewise constant norm. This means that p-adic topology is coarser than the usual real topology and the higher the value of  $p$  is, the coarser the resulting topology is above a given length scale. This hierarchical ordering of the p-adic topologies will be a central feature as far as the proposed applications of the p-adic numbers are considered.

Ordinary continuity implies p-adic continuity since the norm induced from the p-adic topology is rougher than the ordinary norm. p-Adic continuity implies ordinary continuity from right as is clear already from the properties of the p-adic norm (the graph of the norm is indeed continuous from right). This feature is one clear signature of the p-adic topology.

**Fig. 14.** The real norm induced by canonical identification from 2-adic norm. <http://tgdtheory.fi/appfigures/norm.png>

The linear structure of the p-adic numbers induces a corresponding structure in the set of the non-negative real numbers and p-adic linearity in general differs from the ordinary concept of linearity. For example, p-adic sum is equal to real sum only provided the summands have no common pinary digits. Furthermore, the condition  $x +_p y < \max\{x, y\}$  holds in general for the p-adic sum of the real numbers. p-Adic multiplication is equivalent with the ordinary multiplication only provided that either of the members of the product is power of  $p$ . Moreover one has  $x \times_p y < x \times y$  in general. The p-Adic negative  $-1_p$  associated with p-adic unit 1 is given by  $(-1)_p = \sum_k (p - 1)p^k$  and defines p-adic negative for each real number  $x$ . An interesting possibility is that p-adic linearity might replace the ordinary linearity in some strongly nonlinear systems so these systems would look simple in the p-adic topology.

These results suggest that canonical identification is involved with some deeper mathematical structure. The following inequalities hold true:

$$\begin{aligned} (x+y)_R &\leq x_R + y_R , \\ |x|_p |y|_R \leq (xy)_R &\leq x_R y_R , \end{aligned} \quad (\text{A-6.9})$$

where  $|x|_p$  denotes p-adic norm. These inequalities can be generalized to the case of  $(R_p)^n$  (a linear vector space over the p-adic numbers).

$$\begin{aligned} (x+y)_R &\leq x_R + y_R , \\ |\lambda|_p |y|_R \leq (\lambda y)_R &\leq \lambda_R y_R , \end{aligned} \quad (\text{A-6.10})$$

where the norm of the vector  $x \in T_p^n$  is defined in some manner. The case of Euclidian space suggests the definition

$$(x_R)^2 = \left( \sum_n x_n^2 \right)_R . \quad (\text{A-6.11})$$

These inequalities resemble those satisfied by the vector norm. The only difference is the failure of linearity in the sense that the norm of a scaled vector is not obtained by scaling the norm of the original vector. Ordinary situation prevails only if the scaling corresponds to a power of  $p$ .

These observations suggests that the concept of a normed space or Banach space might have a generalization and physically the generalization might apply to the description of some non-linear systems. The nonlinearity would be concentrated in the nonlinear behavior of the norm under scaling.

### 3. Modified form of the canonical identification

The original form of the canonical identification is continuous but does not respect symmetries even approximately. This led to a search of variants which would do better in this respect. The modification of the canonical identification applying to rationals only and given by

$$I_Q(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)} \quad (\text{A-6.12})$$

is uniquely defined for rationals, maps rationals to rationals, has also a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for  $0 \leq r < p$  and  $0 \leq s < p$ . It has turned out that it is this map which most naturally appears in the applications. The map is obviously continuous locally since p-adically small modifications of  $r$  and  $s$  mean small modifications of the real counterparts.

Canonical identification is in a key role in the successful predictions of the elementary particle masses. The predictions for the light elementary particle masses are within extreme accuracy same for  $I$  and  $I_Q$  but  $I_Q$  is theoretically preferred since the real probabilities obtained from p-adic ones by  $I_Q$  sum up to one in p-adic thermodynamics.

### 4. Generalization of number concept and notion of embedding space

TGD forces an extension of number concept: roughly a fusion of reals and various p-adic number fields along common rationals is in question. This induces a similar fusion of real and p-adic embedding spaces. Since finite p-adic numbers correspond always to non-negative reals  $n$ -dimensional space  $R^n$  must be covered by  $2^n$  copies of the p-adic variant  $R_p^n$  of  $R^n$  each of which projects to a copy of  $R_+^n$  (four quadrants in the case of plane). The common points of p-adic and real embedding spaces are rational points and most p-adic points are at real infinity.

Real numbers and various algebraic extensions of p-adic number fields are thus glued together along common rationals and also numbers in algebraic extension of rationals whose number belong to the algebraic extension of p-adic numbers. This gives rise to a book like structure with rationals and various algebraic extensions of rationals taking the role of the back of the book. Note that Neper number is exceptional in the sense that it is algebraic number in p-adic number field  $Q_p$  satisfying  $e^p \bmod p = 1$ .

**Fig. 15.** Various number fields combine to form a book like structure. <http://tgdtheory.fi/appfigures/book.jpg>

For a given p-adic space-time sheet most points are literally infinite as real points and the projection to the real embedding space consists of a discrete set of rational points: the interpretation in terms of the unavoidable discreteness of the physical representations of cognition is natural. Purely local p-adic physics implies real p-adic fractality and thus long range correlations for the real space-time surfaces having enough common points with this projection.

p-Adic fractality means that  $M^4$  projections for the rational points of space-time surface  $X^4$  are related by a direct identification whereas  $CP_2$  coordinates of  $X^4$  at these points are related by  $I$ ,  $I_Q$  or some of its variants implying long range correlates for  $CP_2$  coordinates. Since only a discrete set of points are related in this manner, both real and p-adic field equations can be satisfied and there are no problems with symmetries. p-Adic effective topology is expected to be a good approximation only within some length scale range which means infrared and UV cutoffs. Also multi-p-fractality is possible.

### The notion of p-adic manifold

The notion of p-adic manifold is needed in order to fuse real physics and various p-adic physics to a larger structure which suggests that real and p-adic number fields should be glued together along common rationals bringing in mind adeles. The notion is problematic because p-adic topology is totally disconnected implying that p-adic balls are either disjoint or nested so that ordinary definition of manifold using p-adic chart maps fails. A cure is suggested to be based on chart maps from p-adics to reals rather than to p-adics (see the appendix of the book)

The chart maps are interpreted as cognitive maps, “thought bubbles”.

**Fig. 16.** The basic idea between p-adic manifold. <http://tgdtheory.fi/appfigures/padmanifold.jpg>

There are some problems.

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 might be understood as Bohr orbits for a gigantic gravitational Planck constant.

Hierarchy of Planck constant would mean that the values of Planck constant come as integer multiples of ordinary Planck constant:  $h_{eff} = n \times h$ . The particles at magnetic flux tubes characterized by  $h_{eff}$  would correspond to dark matter which would be invisible in the sense that only particle with same value of  $h_{eff}$  appear in the same vertex of Feynman diagram.



Hierarchy of Planck constants would be due to the non-determinism of the Kähler action predicting huge vacuum degeneracy allowing all space-time surfaces which are sub-manifolds of any  $M^4 \times Y^2$ , where  $Y^2$  is Lagrangian sub-manifold of  $CP_2$ . For a given  $Y^2$  one obtains new manifolds  $Y^2$  by applying symplectic transformations of  $CP_2$ .

Non-determinism would mean that the 3-surface at the ends of causal diamond (CD) can be connected by several space-time surfaces carrying same conserved Kähler charges and having same values of Kähler action. Conformal symmetries defined by Kac-Moody algebra associated with the embedding space isometries could act as gauge transformations and respect the light-likeness property of partonic orbits at which the signature of the induced metric changes from Minkowskian to Euclidian (Minkowskian space-time region transforms to wormhole contact say). The number of conformal equivalence classes of these surfaces could be finite number  $n$  and define discrete physical degree of freedom and one would have  $\hbar_{eff} = n \times \hbar$ . This degeneracy would mean “second quantization” for the sheets of n-furcation: not only one but several sheets can be realized.

This relates also to quantum criticality postulated to be the basic characteristics of the dynamics of quantum TGD. Quantum criticalities would correspond to an infinite fractal hierarchy of broken conformal symmetries defined by sub-algebras of conformal algebra with conformal weights coming as integer multiples of  $n$ . This leads also to connections with quantum criticality and hierarchy of broken conformal symmetries, p-adicity, and negentropic entanglement which by consistency with standard quantum measurement theory would be described in terms of density matrix proportional  $n \times n$  identity matrix and being due to unitary entanglement coefficients (typical for quantum computing systems).

Formally the situation could be described by regarding space-time surfaces as surfaces in singular n-fold singular coverings of embedding space. A stronger assumption would be that they are expressible as products of  $n_1$ -fold covering of  $M^4$  and  $n_2$ -fold covering of  $CP_2$  meaning analogy with multi-sheeted Riemann surfaces and that  $M^4$  coordinates are  $n_1$ -valued functions and  $CP_2$  coordinates  $n_2$ -valued functions of space-time coordinates for  $n = n_1 \times n_2$ . These singular coverings of embedding space form a book like structure with singularities of the coverings localizable at the boundaries of causal diamonds defining the back of the book like structure.

**Fig. 17.** Hierarchy of Planck constants. <http://tgdtheory.fi/appfigures/planckhierarchy.jpg>

### A-6.3 $M^8 - H$ duality as it is towards the end of 2021

The view of  $M^8 - H$  duality (see Appendix ??) has changed considerably towards the end 2021 [L199] after the realization that this duality is the TGD counterpart of momentum position duality of wave mechanics, which is lost in QFTs. Therefore  $M^8$  and also space-time surface is analogous to momentum space. This forced us to give up the original simple identification of the points  $M^4 \subset M^4 \times E^4 = M^8$  and of  $M^4 \times CP_2$  so that it respects Uncertainty Principle (UP).

The first improved guess for the duality map was the replacement with the inversion  $p^k \rightarrow m^k = \hbar_{eff} p^k / p^2$  conforming in spirit with UP but turned out to be too naive.

The improved form [L199] 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 [L199] 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 [L165, L166].  $E_n$  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  $X^4 \subset M^8$  [L145]. 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 [L199]. 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 [L189] 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  $P$  [L199]. 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 [L149] [K129].

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 [L149].

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 Mineev et al [L141] in atomic scale can be explained by the same mechanism [L141]. 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 [J31] 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 [L142]. 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 [L147, L221]).

### 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 [L147, L221]. 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 from the Maxwellian view. Magnetic body brings in third level

to the description of living system as a system interacting strongly with environment. Magnetic body would serve as an intentional agent using biological body as a motor instrument and sensory receptor. EEG would communicate the information from biological body to magnetic body and Libet's findings from time delays of consciousness support this view.

The following pictures illustrate the notion of magnetic body and its dynamics relevant for quantum biology in TGD Universe.

**Fig. 18.** Magnetic body associated with dipole field. <http://tgdtheory.fi/appfigures/fluxquant.jpg>

**Fig. 19.** Illustration of the reconnection by magnetic flux loops. <http://tgdtheory.fi/appfigures/reconnect1.jpg>

**Fig. 20.** Illustration of the reconnection by flux tubes connecting pairs of molecules. <http://tgdtheory.fi/appfigures/reconnect2.jpg>

**Fig. 21.** Flux tube dynamics. a) Reconnection making possible magnetic body to “recognize” the presence of another magnetic body, b) braiding, knotting and linking of flux tubes making possible topological quantum computation, c) contraction of flux tube in phase transition reducing the value of  $h_{eff}$  allowing two molecules to find each other in dense molecular soup. <http://tgdtheory.fi/appfigures/fluxtubedynamics.jpg>

## A-8.2 Number theoretic entropy and negentropic entanglement

TGD inspired theory of consciousness relies heavily p-Adic norm allows an to define the notion of Shannon entropy for rational probabilities (and even those in algebraic extension of rationals) by replacing the argument of logarithm of probability with its p-adic norm. The resulting entropy can be negative and the interpretation is that number theoretic entanglement entropy defined by this formula for the p-adic prime minimizing its value serves as a measure for conscious information. This negentropy characterizes two-particle system and has nothing to do with the formal negative negentropy assignable to thermodynamic entropy characterizing single particle. Negentropy Maximization Principle (NMP) implies that number theoretic negentropy increases during evolution by quantum jumps. The condition that NMP is consistent with the standard quantum measurement theory requires that negentropic entanglement has a density matrix proportional to unit matrix so that in 2-particle case the entanglement matrix is unitary.

**Fig. 22.** Schrödinger cat is neither dead or alive. For negentropic entanglement this state would be stable. <http://tgdtheory.fi/appfigures/cat.jpg>

## A-8.3 Life as something residing in the intersection of reality and p-adicities

In TGD inspired theory of consciousness p-adic space-time sheets correspond to space-time correlates for thoughts and intentions. The intersections of real and p-adic preferred extremals consist of points whose coordinates are rational or belong to some extension of rational numbers in preferred embedding space coordinates. They would correspond to the intersection of reality and various p-adicities representing the “mind stuff” of Descartes. There is temptation to assign life to the intersection of realities and p-adicities. The discretization of the chart map assigning to real space-time surface its p-adic counterpart would reflect finite cognitive resolution.

At the level of “world of classical worlds” (WCW) the intersection of reality and various p-adicities would correspond to space-time surfaces (or possibly partonic 2-surfaces) representable in terms of rational functions with polynomial coefficients which are rational or belong to algebraic extension of rationals.

The quantum jump replacing real space-time sheet with p-adic one (vice versa) would correspond to a buildup of cognitive representation (realization of intentional action).

**Fig. 23.** The quantum jump replacing real space-time surface with corresponding p-adic manifold can be interpreted as formation of thought, cognitive representation. Its reversal

would correspond to a transformation of intention to action. <http://tgdtheory.fi/appfigures/padictoreal.jpg>

#### A-8.4 Sharing of mental images

The 3-surfaces serving as correlates for sub-selves can topologically condense to disjoint large space-time sheets representing selves. These 3-surfaces can also have flux tube connections and this makes possible entanglement of sub-selves, which unentangled in the resolution defined by the size of sub-selves. The interpretation for this negentropic entanglement would be in terms of sharing of mental images. This would mean that contents of consciousness are not completely private as assumed in neuroscience.

**Fig. 24.** Sharing of mental images by entanglement of subselves made possible by flux tube connections between topologically condensed space-time sheets associated with mental images. <http://tgdtheory.fi/appfigures/sharing.jpg>

#### A-8.5 Time mirror mechanism

Zero energy ontology (ZEO) is crucial part of both TGD and TGD inspired consciousness and leads to the understanding of the relationship between geometric time and experience time and how the arrow of psychological time emerges. One of the basic predictions is the possibility of negative energy signals propagating backwards in geometric time and having the property that entropy basically associated with subjective time grows in reversed direction of geometric time. Negative energy signals inspire time mirror mechanism (see **Fig. 24** in the appendix of this book) providing mechanisms of both memory recall, realization of intentional action initiating action already in geometric past, and remote metabolism. What happens that negative energy signal travels to past and is reflected as positive energy signal and returns to the sender. This process works also in the reverse time direction.

**Fig. 25.** Zero energy ontology allows time mirror mechanism as a mechanism of memory recall. Essentially “seeing” in time direction is in question. <http://tgdtheory.fi/appfigures/timemirror.jpg>

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