TGD INSPIRED THEORY OF CONSCIOUSNESS

Matti Pitkänen

Rinnekatu 2-4 A 8, Karkkila, 03620, Finland

April 29, 2024

0.1 PREFACE

Brief summary of TGD

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

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

The basic ideas of TGD

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

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

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

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

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

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

Physics as geometry

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

- Standard model symmetries uniquely fix the choice of 8-D space in which space-time surfaces live to $H = M^4 \times CP_2$ [L85]. 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 [L38, L48](see **Fig. 13**). The geometrization applies even to the quantum theory itself and the space of space-time surfaces - "world of classical worlds" (WCW) - becomes the basic object endowed with Kähler geometry (see **Fig. 14**). The mere mathematical existence of WCW geometry requires that it has maximal isometries, which together twistor lift and number theoretic vision fixes it uniquely [L86].

- 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 [K124, L58].

- 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 [K23, K52] [L81].

- 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 [L83]. Space-time surfaces correspond to holomorphic imbeddings of the space-time surface to H with a generalized complex structure defined by the vanishing of 2 analytic functions of 4 generalized complex coordinates of H. These surfaces are automatically minimal surfaces. This is true for any geneneral coordinate invariant action constructed in terms of the induced geometric structures so that the dynamics is universal. Different actions differ only in the sense that singularities at which the minimal surface property fails depend on the action. This affects the scattering amplitudes, which can be constructed in terms of the data related to the singularities [L88].

- Generalized conformal symmetries define an extension of conformal symmetries and one can assign to them Noether charges. Besides this the so called super-symplectic symmetries associated with $\delta M_+^4 \times CP_2$ define isometries of the "world of classical worlds" (WCW), which by holography is essentially the space of Bohr orbits of 3-surfaces as particles so that quantum TGD is expected to reduce to a generalization of wave mechanics.

Physics as number theory

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

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

Adelic physics [L36, L37] fusing real and various p-adic physics is part of the number theoretic vision, which provides a kind of dual description for the description based on space-time geometry and the geometry of "world of classical words". Adelic physics predicts two fractal length scale hierarchies: p-adic length scale hierarchy and the hierarchy of dark length scales labelled by $h_{eff} = nh_0$, where n is the dimension of extension of rational. The interpretation of the latter hierarchy is as phases of ordinary matter behaving like dark matter. Quantum coherence is possible in arbitarily long scales. These two hierarchies are closely related. p-Adic primes correspond to ramified primes for a polynomial, whose roots define the extension of rationals: for a given extension this polynomial is not unique.

$M^8 - H$ duality

The concrete realization of the number theoretic vision is based on $M^8 - H$ duality (see **Fig. 15**). What the precise form is this duality is, has been far from clear but the recent form is the simplest one and corresponds to the original view [L87]. M^8 corresponds to octonions O but with the number theoretic metric defined by $Re(o^2)$ rather than the standard norm and giving Minkowskian signature.

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

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

p-Adic physics

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

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

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

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

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

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

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

TGD as an analog of topological QFT

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

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

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

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

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

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

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

Equivalence Principle in TGD framework

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

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

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

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

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

could say that at the quantum level gravitational and gauge interactions are eliminated everywhere except at the singularities identifiable as defects of the ordinary smooth structure. The exotic smooth structures [L78], possible only in dimension 4, are ordinary smooth structures apart from these defects serving as vertex representing a creation of a fermion-antifermion pair in the induced gauge potentials. The vertex is universal and essentially the trace of the second fundamental form as an analog of the Higgs field and the gravitational constant is proportional to the square of CP_2 radius.

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

Quantum TGD as a generalization of Einstein's geometrization program

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

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

- If one assumes Bohr orbitology, then strong correlations between the 3-surfaces at the ends of CD follow and mean holography. It is natural to identify the quantum states of the Universe (and sub-Univeverses) as modes of a formally classical spinor field in WCW. WCW gamma matrices are expressible in terms of oscillator operators of free second quantized spinor fields of H. The induced spinor fields identified projections of H spinor fields to the space-time surfaces satisfy modified Dirac equation for the modified Dirac equation. Only quantum jump remains the genuinely quantal aspect of quantum physics.

- Quantum TGD can be seen as a theory for free spinor fields in WCW having maximal isometries and the generalization of the Super Virasoro conditions gives rise to the analog massless Dirac equation at the level of WCW.

The world of classical worlds and its symmetries

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

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

WCW geometry exists only if it has maximal isometries: this statement is a generalization of the discovery of Freed for loop space geometries [A19]. I have proposed [K44, K26, K121, K88, L86] that WCW could be regarded as a union of generalized symmetric spaces labelled by zero modes which do not contribute to the metric. The induced Kähler field is invariant under symplectic transformations of CP_2 and would therefore define zero mode degrees of freedom if one assumes

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

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

- A weaker proposal is that the symplectomorphisms of H define only symplectomorphisms of WCW. Extended conformal symmetries define also a candidate for isometry group. Remarkably, light-like boundary has an infinite-dimensional group of isometries which are in 1-1 correspondence with conformal symmetries of $S^2 \subset S^2 \times R_+ = \delta M_+^4$.

- Extended Kac Moody symmetries induced by isometries of δM_+^4 are also natural candidates for isometries. The motivation for the proposal comes from physical intuition deriving from string models. Note they do not include Poincare symmetries, which act naturally as isometries in the moduli space of causal diamonds (CDs) forming the "spine" of WCW.

- The light-like orbits of partonic 2-surfaces might allow separate symmetry algebras. One must however notice that there is exchange of charges between interior degrees of freedom and partonic 2-surfaces. The essential point is that one can assign to these surface conserved charges when the dual light-like coordinate defines time coordinate. This picture also assumes a slicing of space-time surface by by the partonic orbits for which partonic orbits associated with wormrhole throats and boundaries of the space-time surface would be special. This slicing would correspond to Hamilton-Jacobi structure.

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

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

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

About the construction of scattering amplitudes

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

- In ZEO [K124, L58] 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 [L84]. 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 [L75, L76] led to a stringy variant of the twistor diagrammatics.

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

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

The twistorial approach is however extremely abstract and lacks a concrete physical interpretation. The holography=holomorphy vision led to a breakthough in the construction of the scattering amplitudes by solving the problem of identifying interaction vertices [L88].

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

2. The minimal surface property expressess masslessness for both fields and particles as 3-surfaces. At singularities masslessness property fails and singularities can be said to serve as sources which also in QFT define scattering amplitudes.

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

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

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

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

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

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

  Note that also the notion of electric body makes sense [L82]. Quite generally, long range classical gravitational, electric and magnetic fields give rise to very large values of effective Planckl constants. The Nottale's hypothesis of gravitational Planck constant generalizes to electric interactions.
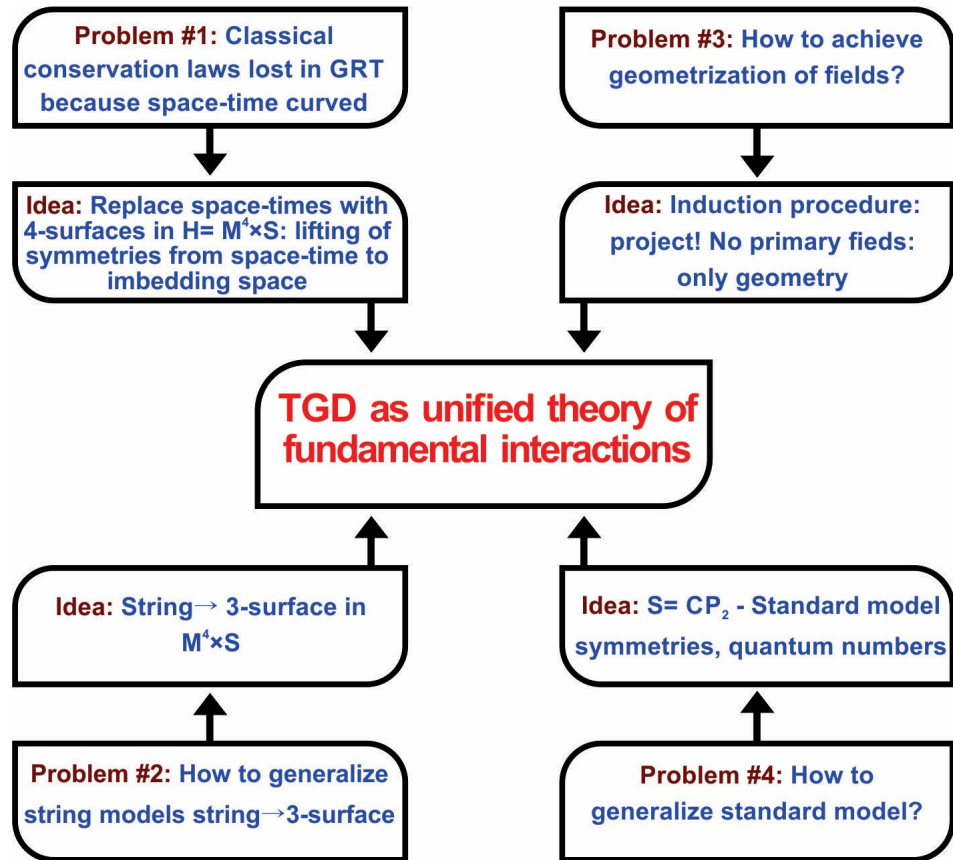
Figure 1: The problems leading to TGD as their solution.

- 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 then.

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

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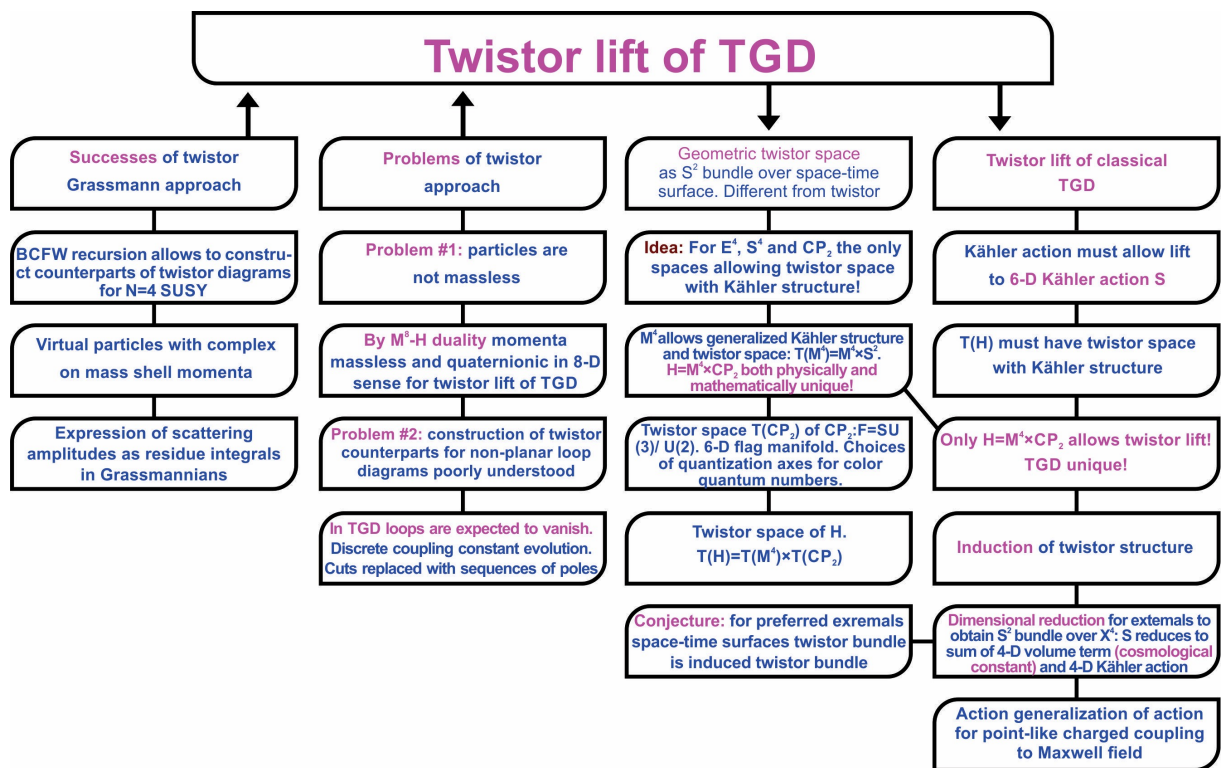
Twistor lift of TGD
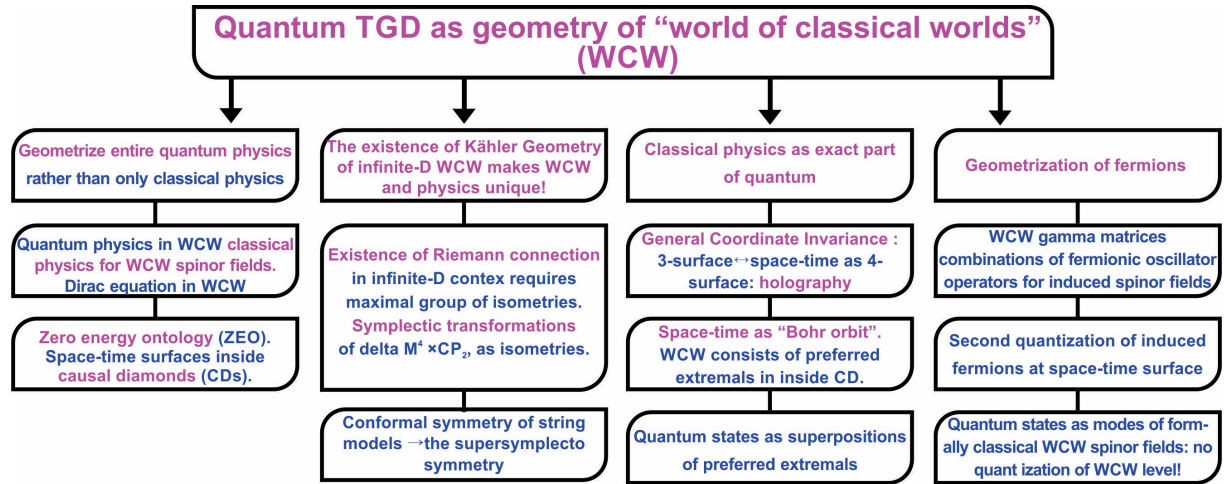
Successes of twistor Grassmann approach

Problems of twistor approach

Geometric twistor space as S^2 bundle over space-time surface. Different from twistor

Twistor lift of classical TGD

BCFW recursion allows to construct counterparts of twistor diagrams for N=4 SUSY

Problem #1: particles are not massless

Idea: For E^4, S^4 and CP_2 the only spaces allowing twistor space with Kähler structure!

Kähler action must allow lift to 6-D Kähler action S

Virtual particles with complex on mass shell momenta

By M^8-H duality momenta massless and quaternionic in 8-D sense for twistor lift of TGD

M^4 allows generalized Kähler structure and twistor space: $T(M^4)=M^4 \times S^2$. $H=M^4 \times CP_2$ both physically and mathematically unique!

T(H) must have twistor space with Kähler structure

Expression of scattering amplitudes as residue integrals in Grassmannians

Problem #2: construction of twistor counterparts for non-planar loop diagrams poorly understood

Twistor space $T(CP_2)$ of CP_2:F=SU (3)/ U(2). 6-D flag manifold. Choices of quantization axes for color quantum numbers.

Only $H=M^4 \times CP_2$ allows twistor lift! TGD unique!

In TGD loops are expected to vanish. Discrete coupling constant evolution. Cuts replaced with sequences of poles

Twistor space of H. $T(H)=T(M^4) \times T(CP_2)$

Induction of twistor structure

Conjecture: for preferred exremals space-time surfaces twistor bundle is induced twistor bundle

Dimensional reduction for extermals to obtain S^2 bundle over X^4: S reduces to sum of 4-D volume term (cosmological constant) and 4-D Kähler action

Action generalization of action for point-like charged coupling to Maxwell field
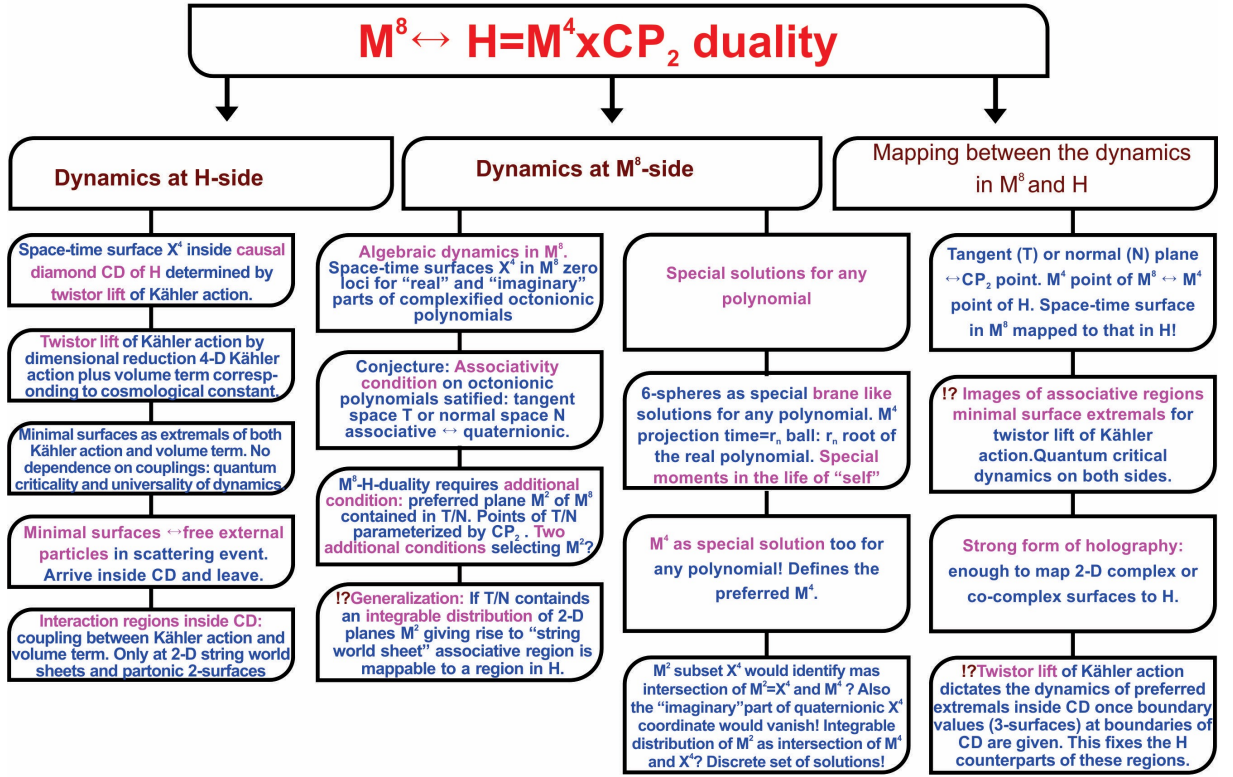
Figure 2: Twistor lift

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

M⁸ ↔ H=M⁴xCP₂ duality

Dynamics at H-side

- Space-time surface X⁴ inside causal diamond CD of H determined by twistor lift of Kähler action.
- Twistor lift of Kähler action by dimensional reduction 4-D Kähler action plus volume term corresponding to cosmological constant.
- Minimal surfaces as extremals of both Kähler action and volume term. No dependence on couplings: quantum criticality and universality of dynamics.
- Minimal surfaces ↔free external particles in scattering event. Arrive inside CD and leave.
- Interaction regions inside CD: coupling between Kähler action and volume term. Only at 2-D string world sheets and partonic 2-surfaces

Dynamics at M⁸-side

- Algebraic dynamics in M⁸. Space-time surfaces X⁴ in M⁸ zero loci for "real" and "imaginary" parts of complexified octonionic polynomials
- Conjecture: Associativity condition on octonionic polynomials satified: tangent space T or normal space N associative ↔ quaternionic.
- M⁸-H-duality requires additional condition: preferred plane M² of M⁸ contained in T/N. Points of T/N parameterized by CP₂. Two additional conditions selecting M²?
- !?Generalization: If T/N containds an integrable distribution of 2-D planes M² giving rise to "string world sheet" associative region is mappable to a region in H.

- Special solutions for any polynomial
- 6-spheres as special brane like solutions for any polynomial. M⁴ projection time=rₙ ball: rₙ root of the real polynomial. Special moments in the life of "self"
- M⁴ as special solution too for any polynomial! Defines the preferred M⁴.
- M² subset X⁴ would identify mas intersection of M²=X⁴ and M⁴ ? Also the "imaginary"part of quaternionic X⁴ coordinate would vanish! Integrable distribution of M² as intersection of M⁴ and X⁴? Discrete set of solutions!

Mapping between the dynamics in M⁸ and H

- Tangent (T) or normal (N) plane ↔CP₂ point. M⁴ point of M⁸ ↔ M⁴ point of H. Space-time surface in M⁸ mapped to that in H!
- !? Images of associative regions minimal surface extremals for twistor lift of Kähler action.Quantum critical dynamics on both sides.
- Strong form of holography: enough to map 2-D complex or co-complex surfaces to H.
- !?Twistor lift of Kähler action dictates the dynamics of preferred extremals inside CD once boundary values (3-surfaces) at boundaries of CD are given. This fixes the H counterparts of these regions.

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
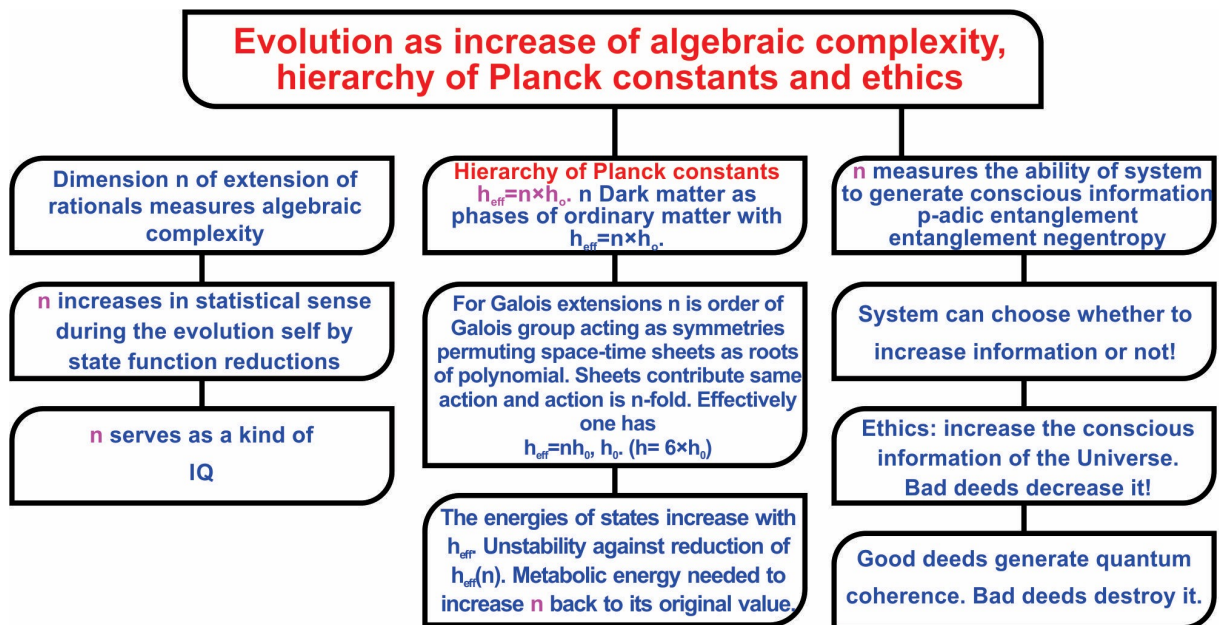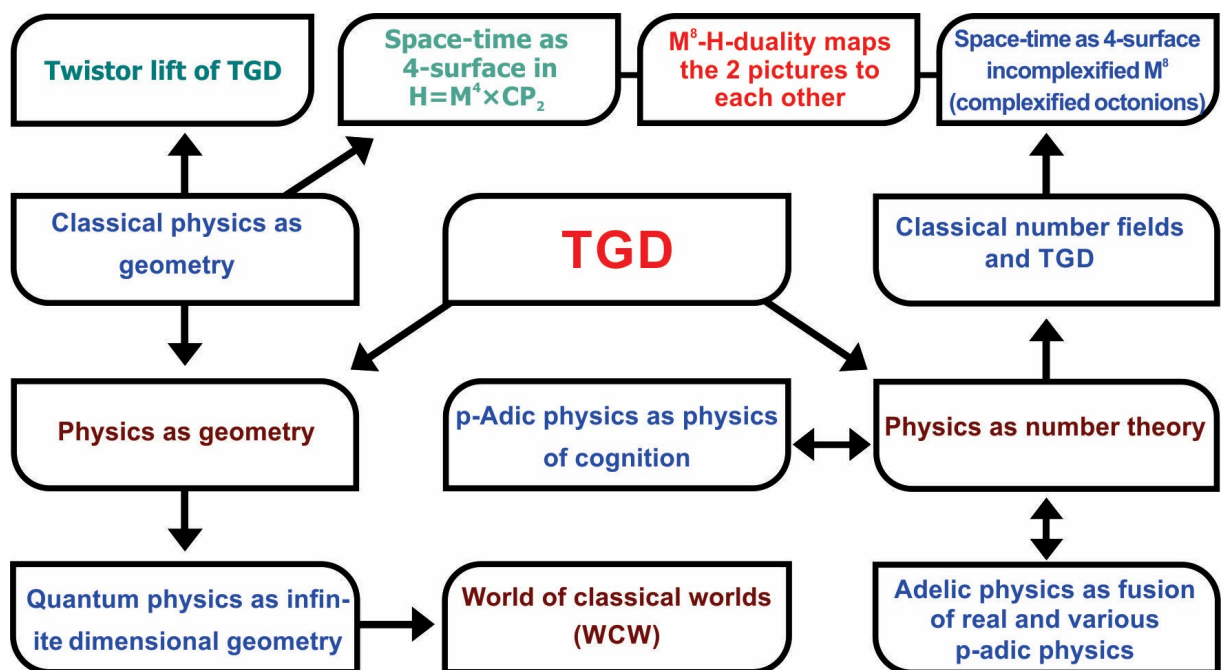
Figure 5: Number theoretic view of evolution

Figure 6: TGD is based on two complementary visions: physics as geometry and physics as number theory.
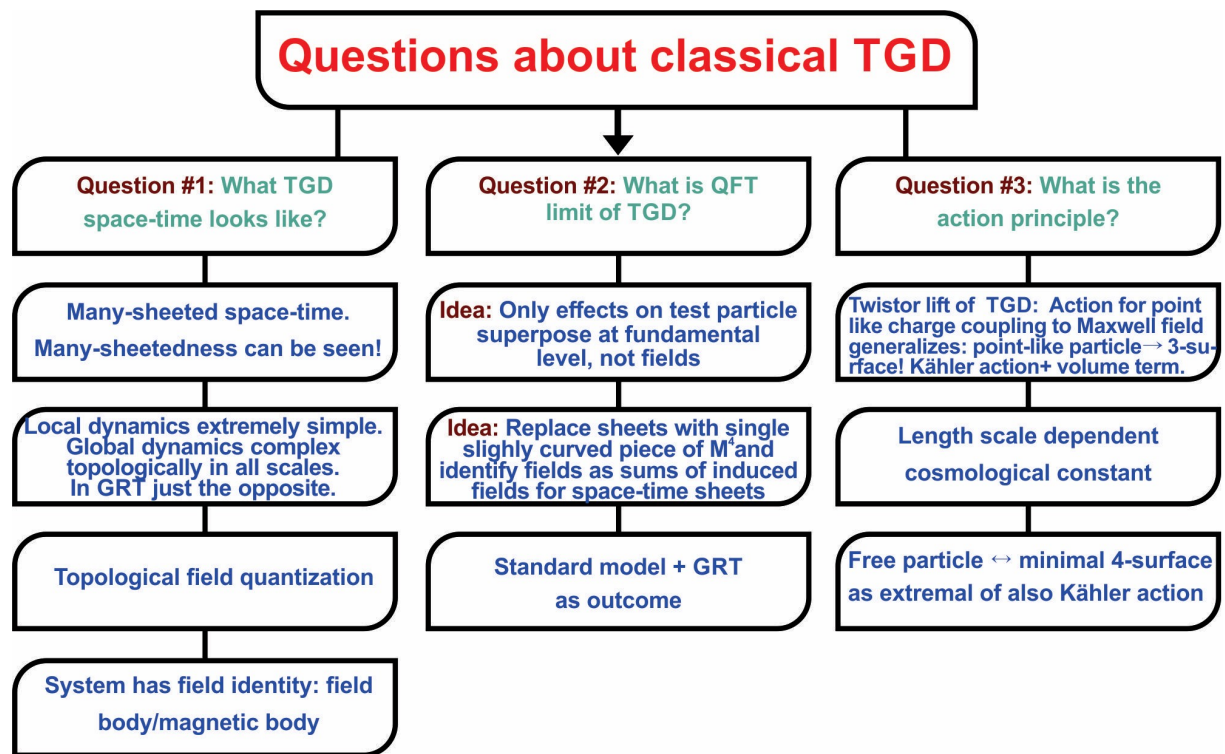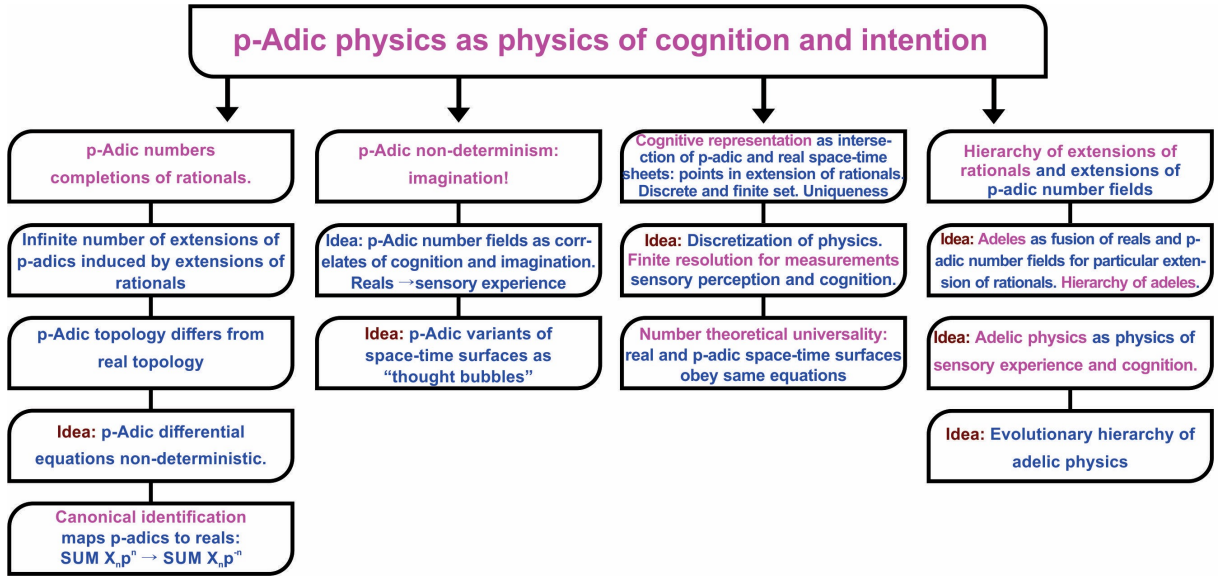
Figure 7: Questions about classical TGD.

p-Adic physics as physics of cognition and intention

p-Adic numbers completions of rationals.

Infinite number of extensions of p-adics induced by extensions of rationals

p-Adic topology differs from real topology

Idea: p-Adic differential equations non-deterministic.

Canonical identification maps p-adics to reals: SUM $X_n p^n$ → SUM $X_n p^{-n}$

p-Adic non-determinism: imagination!

Idea: p-Adic number fields as correlates of cognition and imagination. Reals → sensory experience
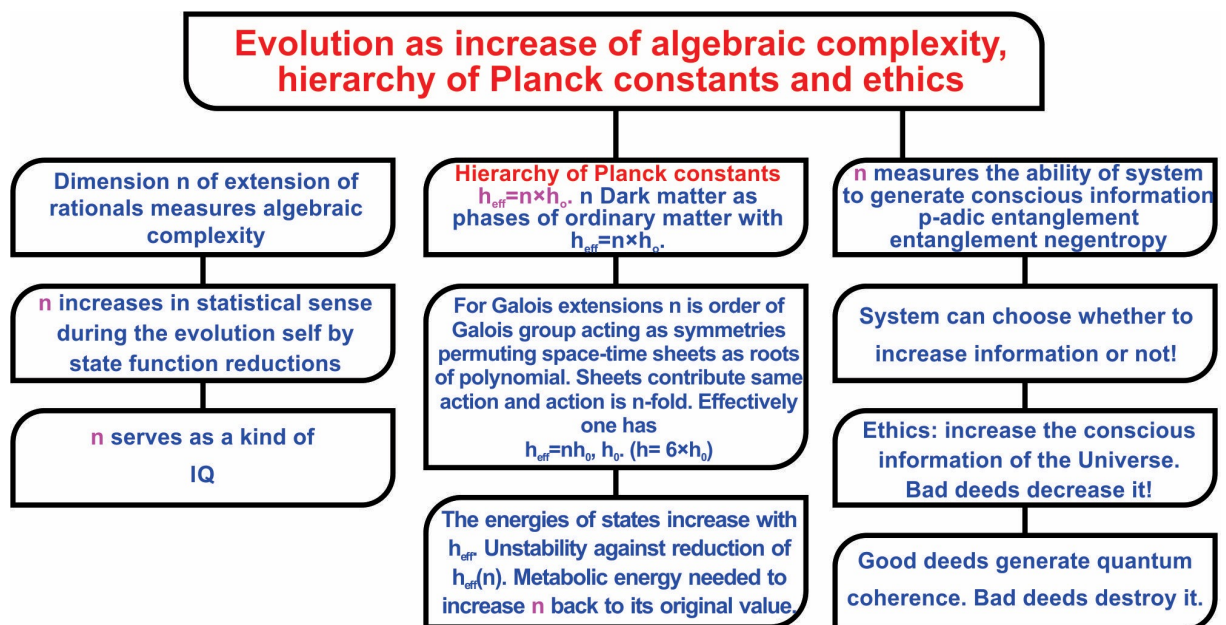
Idea: p-Adic variants of space-time surfaces as "thought bubbles"

Cognitive representation as intersection of p-adic and real space-time sheets: points in extension of rationals. Discrete and finite set. Uniqueness

Idea: Discretization of physics. Finite resolution for measurements sensory perception and cognition.

Number theoretical universality: real and p-adic space-time surfaces obey same equations

Hierarchy of extensions of rationals and extensions of p-adic number fields

Idea: Adeles as fusion of reals and p-adic number fields for particular extension of rationals. Hierarchy of adeles.

Idea: Adelic physics as physics of sensory experience and cognition.

Idea: Evolutionary hierarchy of adelic physics

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, aninoacids and even tRNA are in one-one correspondence with the resulting 3-quark states and that vertebrate genetic code emerges naturally. This leads to a vision about water as primordial lifeform still playing a vital role in living organisms. The model of water memory and homeopathy in turn generalizes to a vision about how immune system might have evolved.

- Metabolic energy is necessary for conscious information processing in living matter. This suggests that metabolism should be basically tranfer of negentropic entanglement from nutrients to the organism. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would make possible the transfer of negentropy.

- Pollack effect and its generalizations are in a central role in the TGD inspire quantum biology. In the Pollack effect, the feed of energy allows to increase the value of effective Planck constant so that an ordinary charged particle transforms to its dark variant, being kicked to, say, the gravitational magnetic body of the system itself or some other system such as the Earth or Sun. Charge separation takes place between ordinary biomatter and its magnetic body. Dissipation is extremely small at the magnetic /field body so that Pollack effect makes it possible to realize various biological functions at the magnetic/field body. Photons, in particular solar photons, can provide the energy needed to increase the value of h_{eff} but there are many other possibilities. For instance, the formation of molecular bound states of atoms liberates energy which can be used in the Pollack effect and this process could generate dark matter at the magnetic and more general field bodies.

xx
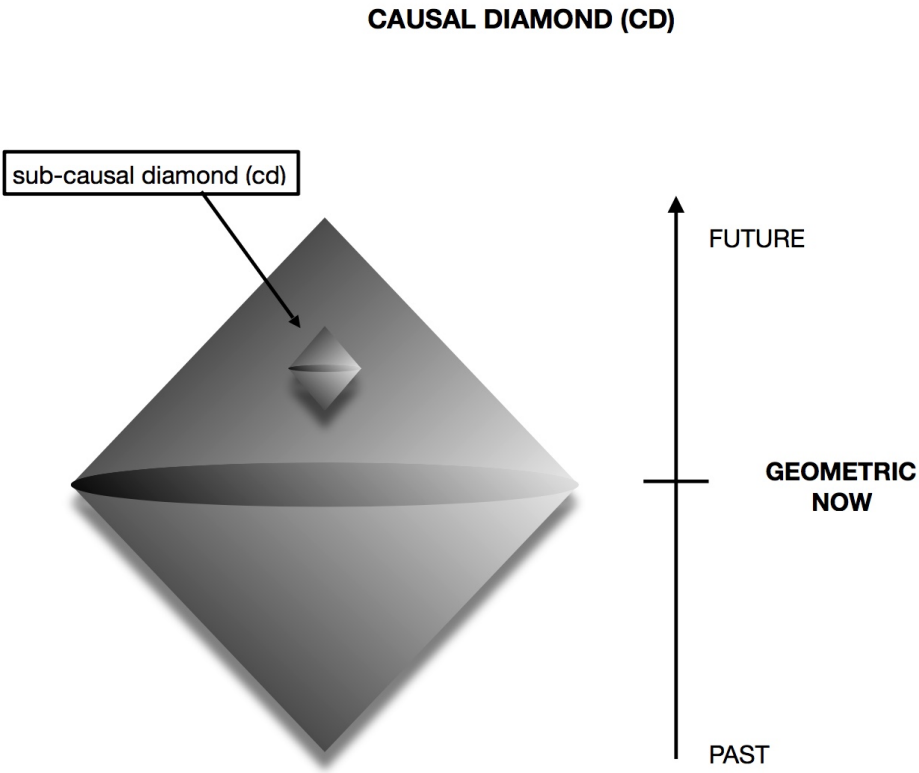
CAUSAL DIAMOND (CD)

Figure 9: Causal diamond
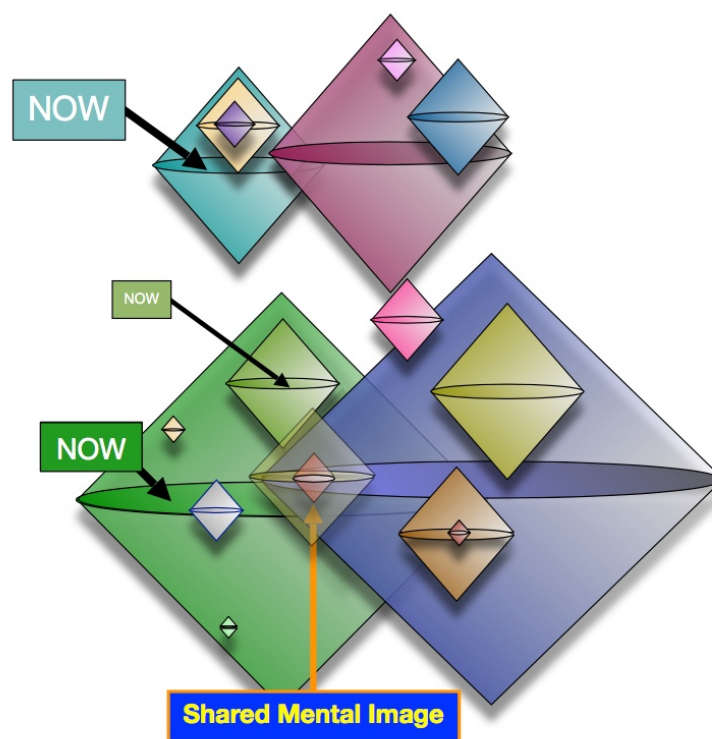
Figure 10: CDs define a fractal "conscious atlas"
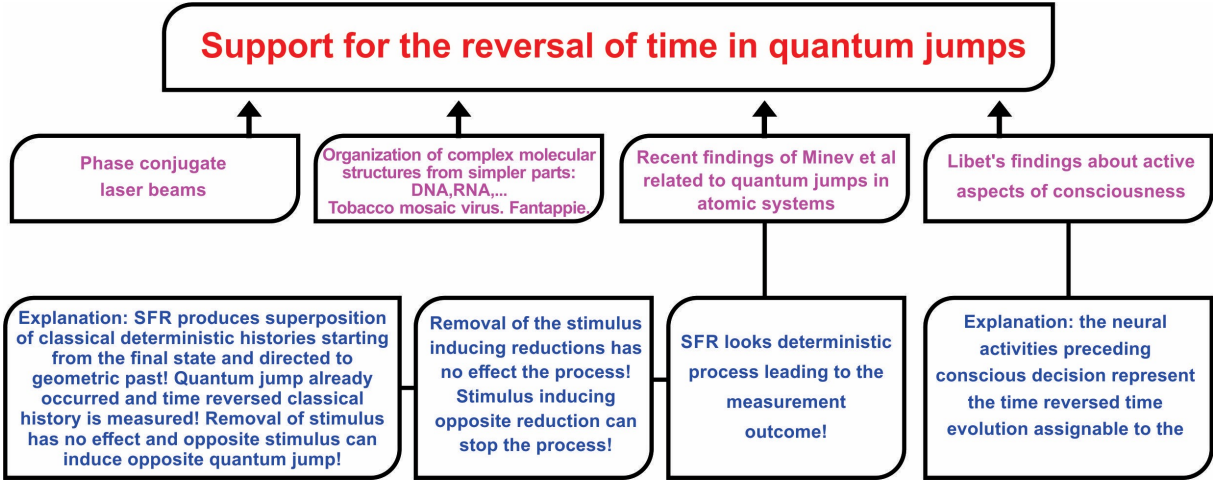
Figure 11: Time reversal occurs in BSFR

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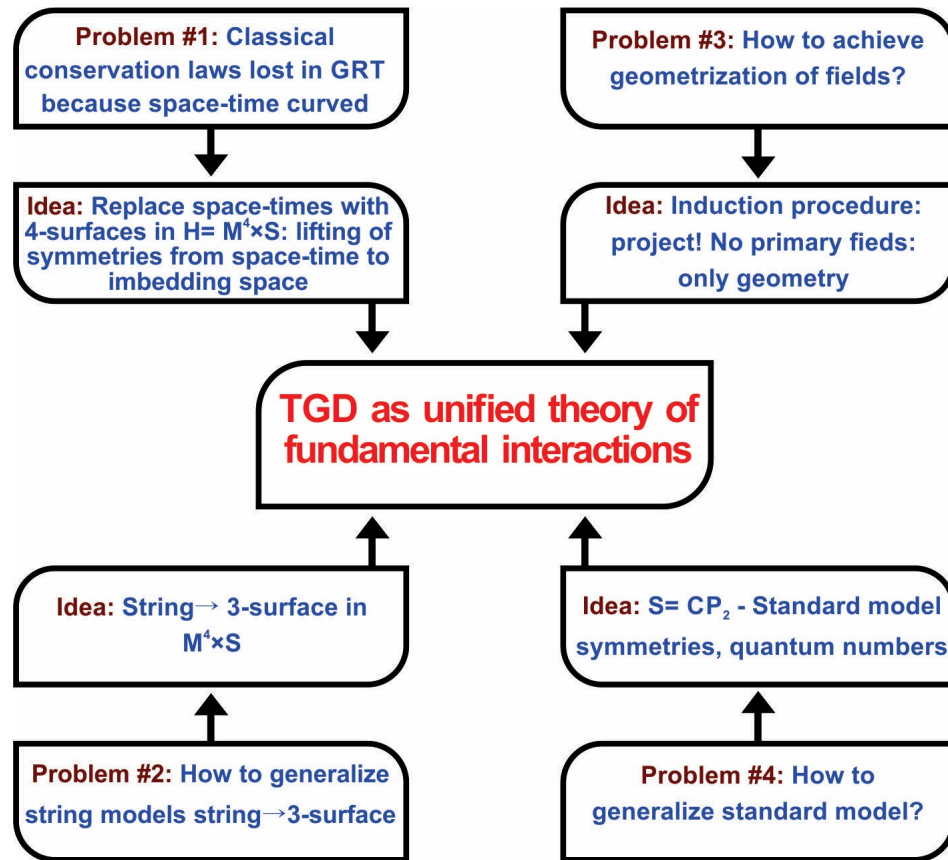
Figure 12: The problems leading to TGD as their solution.

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

**Quantum TGD as geometry of "world of classical worlds"
(WCW)**

Geometrize entire quantum physics
rather than only classical physics

The existence of Kähler Geometry
of infinite-D WCW makes WCW
and physics unique!

Classical physics as exact part
of quantum

Geometrization of fermions

Quantum physics in WCW classical
physics for WCW spinor fields.
Dirac equation in WCW

Existence of Riemann connection
in infinite-D contex requires
maximal group of isometries.
Symplectic transformations
of delta $M^4 \times CP_2$, as isometries.

General Coordinate Invariance :
3-surface$\leftrightarrow$space-time as 4-
surface: holography

WCW gamma matrices
combinations of fermionic oscillator
operators for induced spinor fields

Zero energy ontology (ZEO).
Space-time surfaces inside
causal diamonds (CDs).

Conformal symmetry of string
models $\rightarrow$the supersymplecto
symmetry

Space-time as "Bohr orbit".
WCW consists of preferred
extremals in inside CD.

Second quantization of induced
fermions at space-time surface

Quantum states as superpositions
of preferred extremals

Quantum states as modes of form-
ally classical WCW spinor fields: no
quant ization of WCW level!

Figure 14: Geometrization of quantum physics in terms of WCW
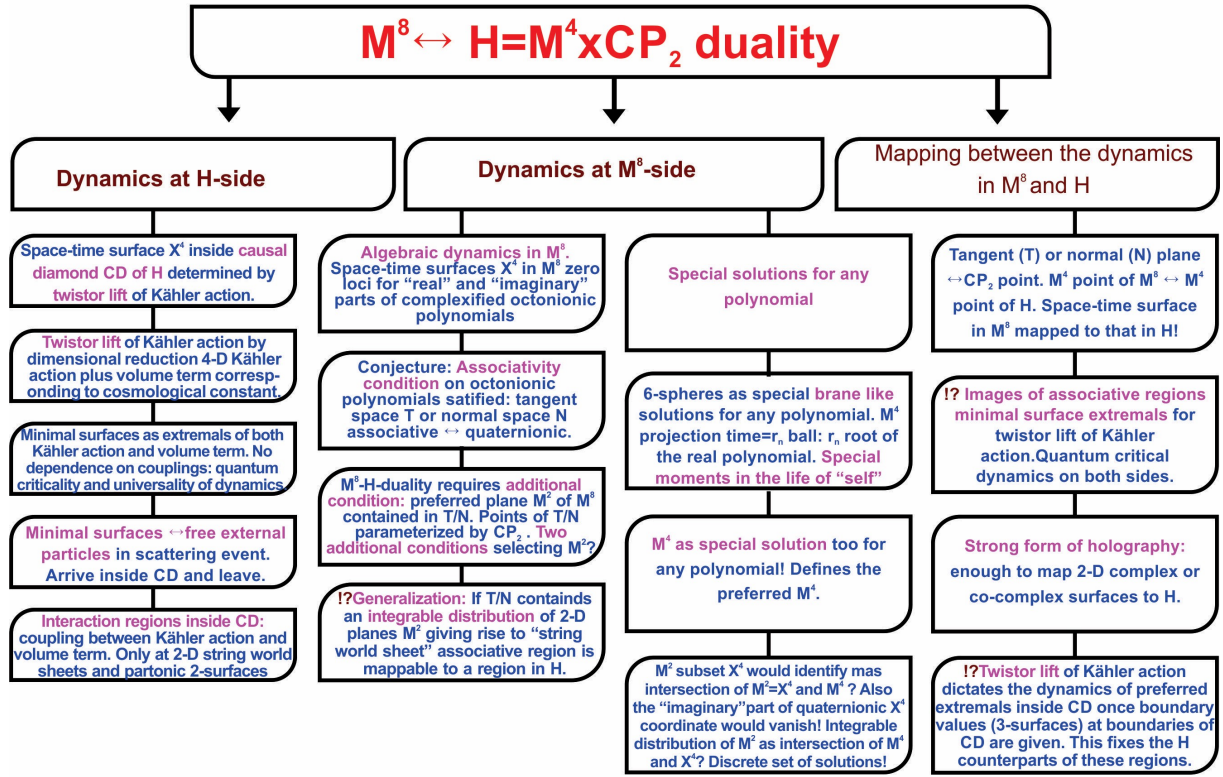
Figure 15: $M^8 - H$ duality

Figure 16: Number theoretic view of evolution
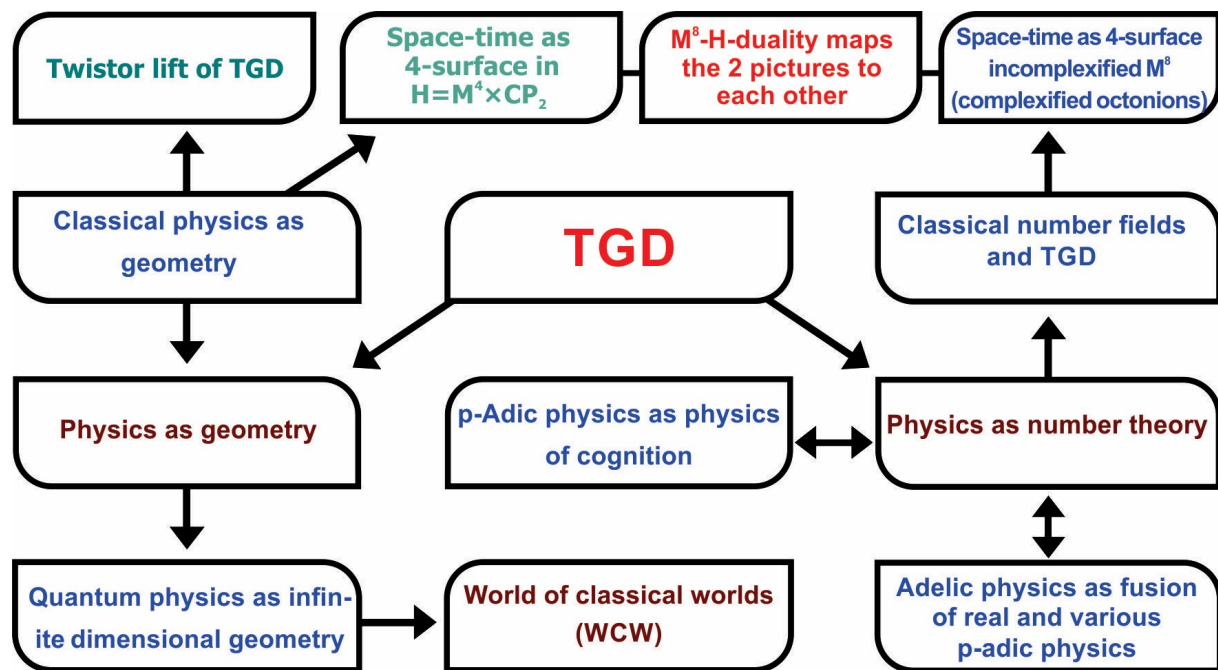
Figure 17: TGD is based on two complementary visions: physics as geometry and physics as number theory.
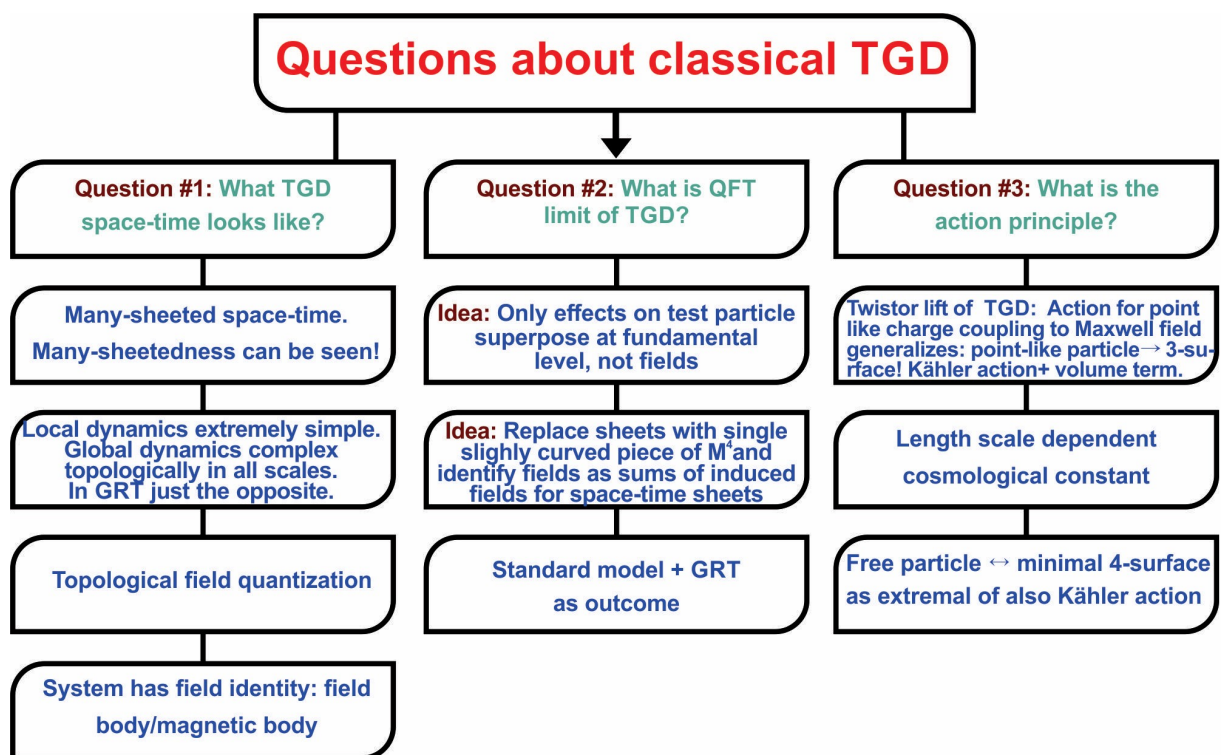
Figure 18: Questions about classical TGD.
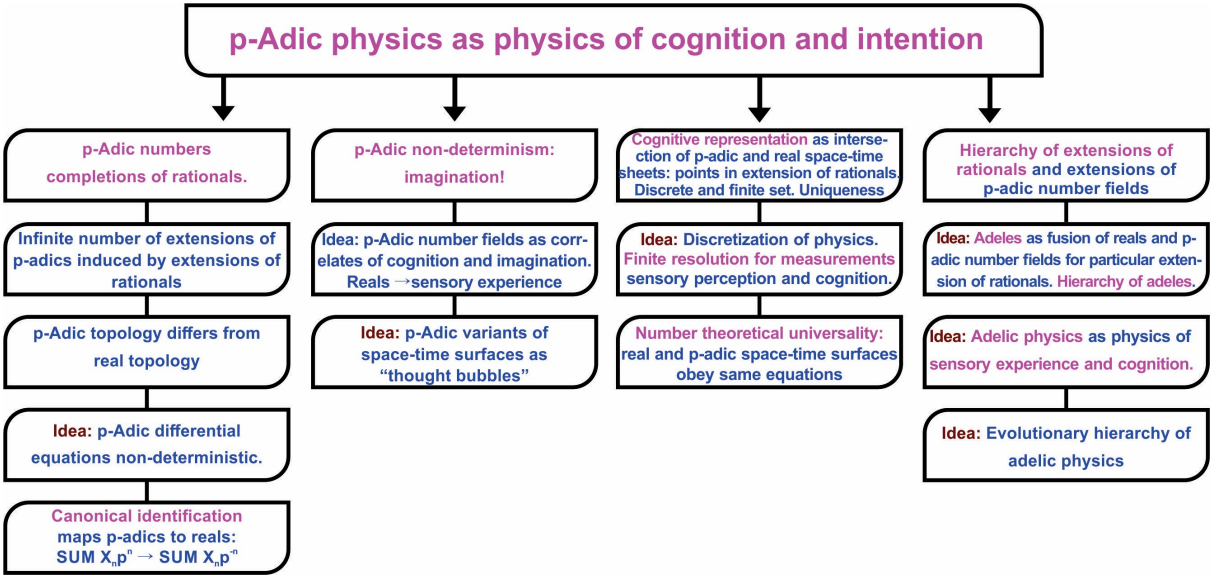
Figure 19: p-Adic physics as physics of cognition and imagination.
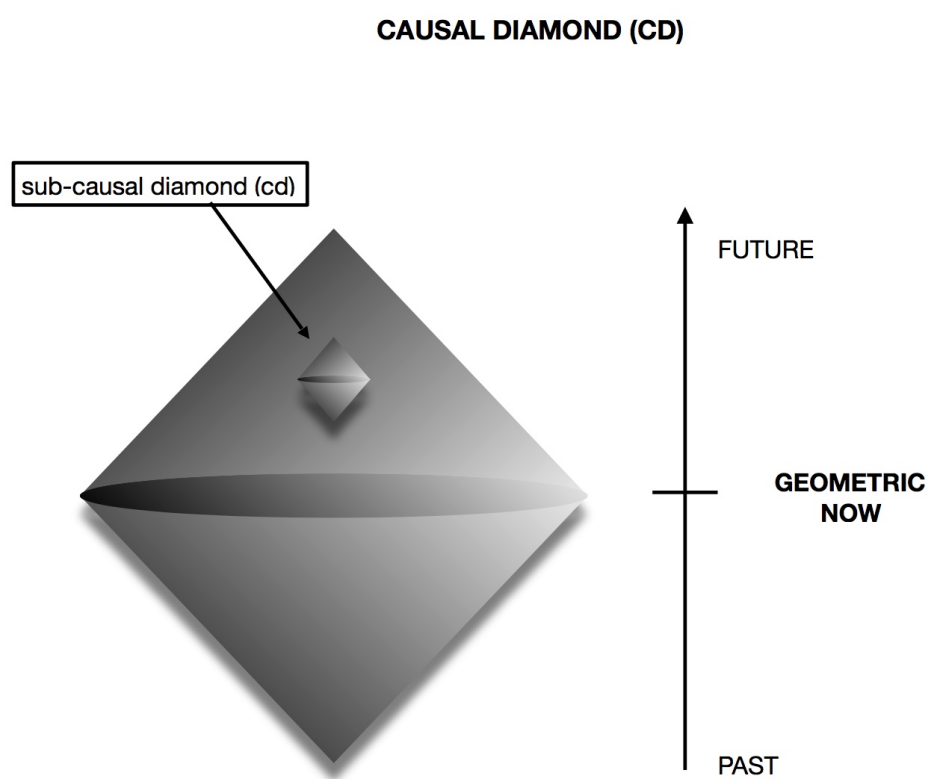
CAUSAL DIAMOND (CD)

Figure 20: Causal diamond
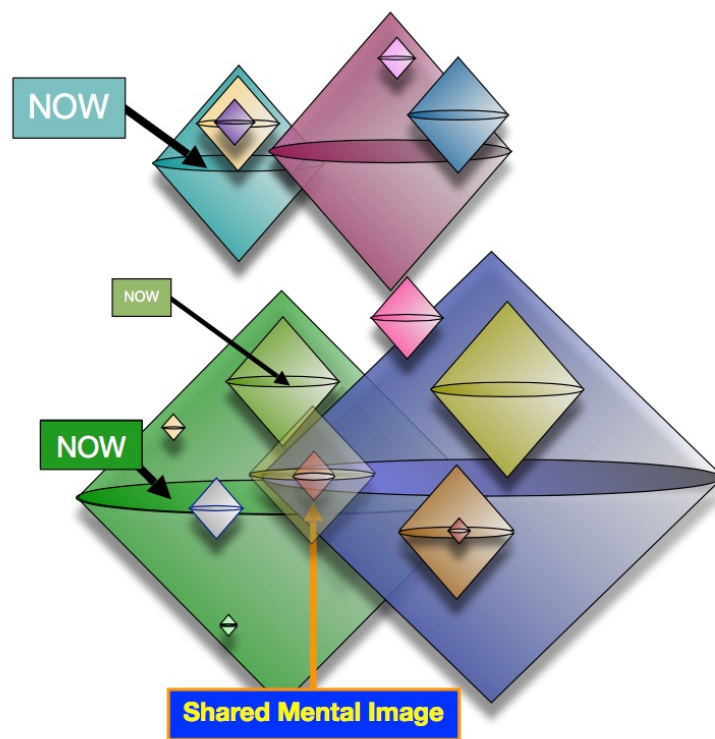
Figure 21: CDs define a fractal "conscious atlas"
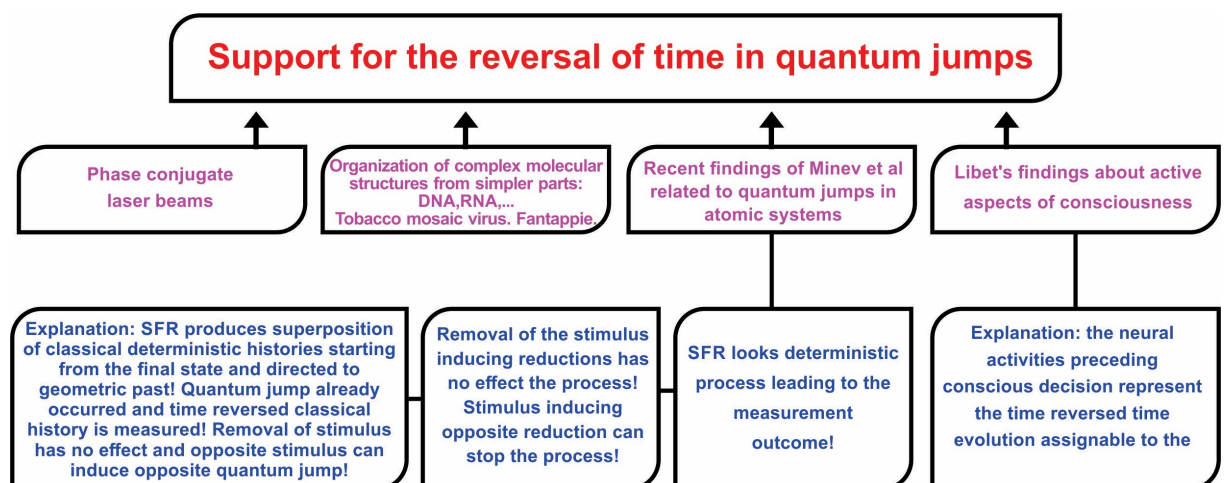
Figure 22: Time reversal occurs in BSFR

ACKNOWLEDGEMENTS

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

Contents

List of Figures

Chapter 1

Introduction

1.1   Basic Ideas of Topological Geometrodynamics (TGD)

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

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

1.1.1   Geometric Vision Very Briefly

T(opological) G(eometro)D(ynamics)   is one of the many attempts to find a unified description of basic interactions. The development of the basic ideas of TGD to a relatively stable form took time of about half decade [K1].

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

1. Space-times are representable as 4-surfaces in the 8-dimensional embedding space $H = M^4 \times CP_2$, where M^4 is 4-dimensional (4-D) Minkowski space and CP_2 is 4-D complex projective space (see Appendix).

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

Twistor lift of TGD means that one can lift space-time surfaces in H to 6-D surfaces a analogs of twistor space of space-time surface in the Cartesian product of the twistor spaces of M^4 and CP_2, which are the only 4-manifolds allowing twistor space with Kähler structure [A29]. The twistor structure would be induced in some sense, and should coincide with that associated with the induced metric. Clearly, the 2-spheres defining the fibers of twistor spaces of M^4 and CP_2 must allow identification: this 2-sphere defines the S^2 fiber of the twistor space of the space-time surface. This poses a constraint on the embedding of the twistor space of space-time surfaces as sub-manifold in the Cartesian product of twistor spaces. The existence of Kähler structure allows to lift 4-D Kähler action to its 6-D counterparts and the 6-D counterpart of twistor space is obtained by its dimensional reduction so that one obtains a sphere bundle. This makes possible twistorialization for all space-time surfaces: in general relativity the general metric does not allow this.

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

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

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

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

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

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

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

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

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

7. A string model-like picture emerges from TGD and one ends up with a rather concrete view about the topological counterpart of Feynman diagrammatics. The natural stringy action would be given by the string world sheet area, which is present only in the space-time regions with Minkowskian signature. Gravitational constant could be present as a fundamental constant in string action and the ratio $\hbar/G/R^2$ would be determined by quantum criticality conditions. The hierarchy of Planck constants $h_{eff}/h = n$ assigned to dark matter in TGD framework would allow to circumvent the objection that only objects of length of order Planck length are possible since string tension given by $T = 1/\hbar_{eff}G$ apart from numerical factor could be arbitrary small. This would make possible gravitational bound states as partonic 2-surfaces as structures connected by strings and solve the basic problem of superstring theories. This option allows the natural interpretation of M^4 type vacuum extremals with CP_2 projection, which is Lagrange manifold as good approximations for space-time sheets at macroscopic length scales. String area does not contribute to the Kähler function at all.

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

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

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

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

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

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

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

3. TGD is *not* a gauge theory. In TGD framework the counterparts of also ordinary gauge symmetries are assigned to super-symplectic algebra (and its Yangian [A7] [B11, B9, B10]), which is a generalization of Kac-Moody algebras rather than gauge algebra and suffers a fractal hierarchy of symmetry breakings defining hierarchy of criticalities. TGD is *not* one more quantum field theory like structure based on path integral formalism: path integral is replaced with functional integral over 3-surfaces, and the notion of classical space-time becomes an exact part of the theory. Quantum theory becomes formally a purely classical theory of WCW spinor fields: only state function reduction is something genuinely quantal.

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

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

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

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

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

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

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

TGD as a Poincare Invariant Theory of Gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space $H = M_\times^4 CP_2$, where M^4 denotes Minkowski space and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [A22, A28, A18, A27].

The identification of the space-time as a sub-manifold [A24, A33] of $M^4 \times CP_2$ leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity.

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

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

TGD as a Generalization of the Hadronic String Model

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

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

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

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

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

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

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

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

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

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

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

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

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

1.1.3 Basic Objections

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

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

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

Topological Field Quantization

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

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

1.1.4   Quantum TGD as Spinor Geometry of World of Classical Worlds

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

World of Classical Worlds

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

1. Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude identified as WCW spinor in the configuration space CH ("world of classical worlds", WCW) consisting of all possible 3-surfaces in H. "All possible" means that surfaces with arbitrary many disjoint components and with arbitrary internal topology and also singular surfaces topologically intermediate between two different manifold topologies are included.

2. 4-D general coordinate invariance forces holography and replaces the ill-defined path integral over all space-time surfaces with a discrete sum over 4-D analogs of Bohr orbits for particles identified as 3-surfaces. Holography means that basic objects are these analogs of Bohr orbits. Since there is no quantization at the level of WCW, one has an analog of wave mechanics with point-like particles replaced with 4-D Bohr orbits.

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

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

Identification of Kähler function

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

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

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

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

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

WCW spinor fields

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

---

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

1. The WCW metric is given by anticommutators of WCW gamma matrices which also have interpretation as supercharges assignable to the generators of WCW isometries and allowing expression as non-conserved Noether charges. Holography implies zero energy ontology (ZEO) meaning that zero energy states are superpositions of Bohr orbits connecting boundaries of causal diamond (CD). CDs form a fractal hierarchy and their space forming the spine of WCW is finite-dimensional and can be geometrized. The alternative interpretation is as a superposition of pairs of ordinary 3-D fermionic states assignable to the ends of the space-time surfaces.

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

The role of modified Dirac action

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

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

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

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

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

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

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

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

1.1.5 Construction of scattering amplitudes

Reduction of particle reactions to space-time topology

Particle reactions are identified as topology changes [A32, A35, A41]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay $A \to B + C$. Classically this corresponds to a path of WCW leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.

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

Construction of the counterparts of S-matrices

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

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

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

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

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

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

The notion of M-matrix

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

2. If one allows entanglement between positive and energy parts of the zero energy state but assumes that the states at the passive boundary are fixed, one must introduce the counterpart of the density matrix, or rather its square root. This classical free field theory would dictate what I have called M-matrices defined between positive and negative energy parts of zero energy states which form orthonormal rows of what I call U-matrix as a matrix defined between zero energy states. A biven M-matrix in turn would decompose to a product of a hermitian square root of density matrix and unitary S-matrix.

3. M-matrix would define time-like entanglement coefficients between positive and negative energy parts of zero energy states (all net quantum numbers vanish for them) and can be regarded as a hermitian square root of density matrix multiplied by a unitary S-matrix. Quantum theory would be in a well-defined sense a square root of thermodynamics. The orthogonality and hermiticity of the M-matrices commuting with S-matrix means that they span infinite-dimensional Lie algebras acting as symmetries of the S-matrix. Therefore quantum TGD would reduce to group theory in a well-defined sense.

4. In fact the Lie algebra of Hermitian M-matrices extends to Kac-Moody type algebra obtained by multiplying hermitian square roots of density matrices with powers of the S-matrix. Also the analog of Yangian algebra involving only non-negative powers of S-matrix is possible and would correspond to a hierarchy of CDs with the temporal distances between tips coming as integer multiples of the CP_2 time.

   The M-matrices associated with CDs are obtained by a discrete scaling from the minimal CD and characterized by integer n are naturally proportional to a representation matrix of scaling: $S(n) = S^n$, where S is unitary S-matrix associated with the minimal CD [K61]. This conforms with the idea about unitary time evolution as exponent of Hamiltonian discretized to integer power of S and represented as scaling with respect to the logarithm of the proper time distance between the tips of CD.

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

1.1.6   TGD as a generalized number theory

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

The Threads in the Development of Quantum TGD

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

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

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

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

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

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

Number theoretic vision very briefly

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

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

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

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

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

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

4. Number theoretical universality requires that space-time surfaces or at least their $M^8 - H$ duals in M_c^8 are defined for both reals and various p-adic number fields. This is true if they are defined by polynomials with integer coefficients as surfaces in M^8 obeying number theoretic holography realized as associativity of the normal space of 4-D surface using as holographic data 3-surfaces at mass shells identified in terms of roots of a polynomial. A physically motivated additional condition is that the coefficients of the polynomials are smaller than their degrees.

5. Galois confinement is a key piece of the number theoretic vision. It states that the momenta of physical states are algebraic integers in the extensions of rationals assignable to the space-time region considered. These numbers are in general complex and are not consistent with particle in box quantization. The proposal is that physical states satisfy Galois confinement being thus Galois singlets and having therefore total momenta, whose components are ordinary integers, when momentum unit defined by the scale of causal diamond (CD) is used.

6. The notion of p-adic prime was introduced in p-adic mass calculations that started the developments around 1995. p-Adic length scale hypothesis states that p-adic primes near powers of 2 have a special physical role (as possibly also the powers of other small primes such as $p = 3$).

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

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

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

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

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

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

1. What is the relationship of p-adic non-determinism to the classical non-determinism of the basic field equations of TGD? Are the p-adic space-time region genuinely p-adic or does p-adic topology only serve as an effective topology? If p-adic physics is direct image of real physics, how the mapping relating them is constructed so that it respects various symmetries? Is the basic physics p-adic or real (also real TGD seems to be free of divergences) or both? If it is both, how should one glue the physics in different number field together to get *the* Physics? Should one perform p-adicization also at the level of the WCW? Certainly the p-adicization at the level of super-conformal representation is necessary for the p-adic mass calculations.

2. Perhaps the most basic and most irritating technical problem was how to precisely define p-adic definite integral which is a crucial element of any variational principle based formulation of the field equations. Here the frustration was not due to the lack of solution but due to the too large number of solutions to the problem, a clear symptom for the sad fact that clever inventions rather than real discoveries might be in question. Quite recently I however learned that the problem of making sense about p-adic integration has been for decades central problem in the frontier of mathematics and a lot of profound work has been done along same intuitive lines as I have proceeded in TGD framework. The basic idea is certainly the notion of algebraic continuation from the world of rationals belonging to the intersection of real world and various p-adic worlds.

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

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

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

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

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

emerge as so called ramified primes of algebraic extension of rationals in question and characterizing string world sheets and partonic 2-surfaces. Preferred p-adic primes would be ramified primes for extensions for which the number of p-adic continuations of two-surfaces to space-time surfaces (imaginations) allowing also real continuation (realization of imagination) would be especially large. These ramifications would be winners in the fight for number theoretical survival. Also a generalization of p-adic length scale hypothesis emerges from NMP [K56].

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

Infinite primes

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

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

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

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

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

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

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

Holography in H

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

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

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

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

Number theoretic holography in M_c^8

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

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

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

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

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

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

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

1. The interpretation is that $g(y)$ at given point y of Y^4 relates the normal space at y to a fixed quaternionic/associative normal space at point y_0, which corresponds is fixed by some subgroup $U(2)_0 \subset SU(3)$. The automorphism property of g guarantees that the normal space is quaternionic/associative at y. This simplifies the construction dramatically.

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

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

3. The real part $Re(g(y))$ defines a point of $SU(3)$ and the bundle projection $SU(3) \rightarrow CP_2$ in turn defines a point of $CP_2 = SU(3)/U(2)$. Hence one can assign to g a point of CP_2 as $M^8 - H$ duality requires and deduce an explicit formula for the point. This means a realization of the dream.

4. The construction requires a fixing of a quaternionic normal space N_0 at y_0 containing a preferred complex subspace at a single point of Y^4 plus a selection of the function g. If M^4 coordinates are possible for Y^4, the first guess is that g as a function of complexified M^4 coordinates obeys generalized holomorphy with respect to complexified M^4 coordinates in the same sense and in the case of X^4. This might guarantee that the $M^8 - H$ image of Y^4 satisfies the generalized holomorphy.

5. Also space-time surfaces X^4 with M^4 projection having a dimension smaller than 4 are allowed. I have proposed that they might correspond to singular cases for the above formula: a kind of blow-up would be involved.   One can also consider a more general definition of Y^4 allowing it to have a M^4 projection with dimension smaller than 4 (say cosmic strings). Could one have implicit equations for the surface Y^4 in terms of the complex coordinates of $SU(3)_c$ and M^4? Could this give for instance cosmic strings with a 2-D M^4 projection and CP_2 type extremals with 4-D CP_2 projection and 1-D light-like M^4 projection?

What could the number theoretic holography mean physically?

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

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

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

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

Twistor lift of the holography

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

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

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

1. The selection of $SU(3) \subset G_2$ for ordinary $M^8 - H$ duality means that the $G_{2,c}$ gauge field vanishes everywhere and the choice of color quantization axis is the same at all points of the 4-surface. The fixing of the CP_2 point to be constant at H^3 implies that the color gauge field at $H^3 \subset M_c^8$ and its image $H^3 \subset H$ vanish. One would have color confinement at the mass shells H_i^3, where the observations are made. Is this condition too strong?

2. The constancy of the G_2 element at mass shells makes sense physically and means a fixed color quantization axis. The selection of a fixed $SU(3) \subset G_2$ for entire space-time surface is in conflict with the non-constancy of G_2 element unless G_2 element differs at different points of 4-surface only by a multiplication of a local $SU(3)_0$ element, that is local $SU(3)$ transformation. This kind of variation of the G_2 element would mean a fixed color group but varying choice of color quantization axis.

3. Could one consider the possibility that the local $G_{2,c}$ element is free and defines the twistor lift of $M^8 - H$ duality as something more fundamental than the ordinary $M^8 - H$ duality based on $SU(3)_c$. This duality would make sense only at the mass shells so that only the spaces $H^3 \times CP_2$ assignable to mass shells would make sense physically? In the interior CP_2 would be replaced with the twistor space $SU(3)/U(1) \times U(1)$. Color gauge fields would be non-vanishing at the mass shells but outside the mass shells one would have G_2 gauge fields.

   There is also a physical objection against the G_2 option. The 14-D Lie algebra representation of G_2 acts on the imaginary octonions which decompose with respect to the color group to $1 \oplus 3 \oplus \bar{3}$. 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 h_{gr}. Equivalence Principle and the independence of gravitational Compton length on mass m implies however that one can restrict the values of mass m to masses of microscopic objects so that h_{gr} would be much smaller. Large h_{gr} could provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [K97].

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

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

Hierarchy of Planck Constants from the Anomalies of Neuroscience and Biology

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

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

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

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

Also the anomalies of biology (see for instance [K78, K79, K76]) 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 [K110]. 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 [A29]. 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 [L46].

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 [L37]. Similar discretization would take place for momenta. Loops would vanish at the level of discretization but what would happen at the possibly existing continuum limit: does the sequence of poles integrate to cuts? Or is representation as sum of resonances something much deeper?

3. Maybe it is! The basic idea of behind the original Veneziano amplitudes (see `http://tinyurl.com/yyhwvbqb`) was Veneziano duality. This 4-particle amplitude was generalized by Yoshiro Nambu, Holber-Beck Nielsen, and Leonard Susskind to N-particle amplitude (see `http://tinyurl.com/yyvkx7as`) based on string picture, and the resulting model was called dual resonance model. The model was forgotten as QCD emerged. Later came superstring models and led to M-theory. Now it has become clear that something went wrong, and it seems that one must return to the roots. Could the return to the roots mean a careful reconsideration of the dual resonance model?

4. Recall that Veneziano duality (1968) was deduced by assuming that scattering amplitude can be described as sum over s-channel resonances or t-channel Regge exchanges and Veneziano duality stated that hadronic scattering amplitudes have representation as sums over s- or t-channel resonance poles identified as excitations of strings. The sum over exchanges defined by t-channel resonances indeed reduces at larger values of s to Regge form.

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

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

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

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

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

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

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

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

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

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

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

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

1.2   TGD As A Generalization Of Physics To A Theory Consciousness

General Coordinate Invariance forces the identification of quantum jump as quantum jump between entire deterministic quantum histories rather than time=constant snapshots of single history. The new view about quantum jump forces a generalization of quantum measurement theory such that observer becomes part of the physical system. The basic idea is that quantum jump can be identified as momentum of consciousness. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [K108, K16, K75, K14, K40, K49, K53, K99, K106].

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

1. What does one mean with quantum jump? Can one overcome the basic problem of the standard quantum measurement theory, that which forcing Bohr to give up totally the idea about objective reality?

2. How do the experienced time and geometric time relate in this framework? How the arrow of subjective time translates to that of geometric time?

3. How to define conscious information? Is it conserved or even increased during time evolution as biological evolution suggests? How does this increase relate to second law implied basically by the randomness of state function reduction?

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

1.2.1 Quantum Jump As A Moment Of Consciousness

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

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

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

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

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

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

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

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

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

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

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

1. The basic objection is that the arrow of geometric time alternates at embedding space level but we know that arrow of time looks the same in the part of the Universe we live. Possible exceptions however exist, for instance phase conjugate laser beams seem to obey opposite arrow of time. Also biological phenomena might involve non-standard arrow of time at some levels. This led Fantappie [J97] to introduce the notion of syntropy. This suggests that the arrow of time depends on the size scale of CD and of space-time sheet.

2. It took some time to realize that the solution of the problem is trivial in ZEO. In the ordinary quantum measurement theory one must assume that state function reduction can occur repeatedly: the assumption is that nothing happens to the state during repeated reductions. The outcome is Zeno effect: the watched pot does not boil.

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

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

4. Contrary to original working hypothesis, state function reduction in the usual sense does not solely determine the ordinary conscious experience. It can however contribute to conscious experience and the act of free will is a good candidate in this respect. TGD view about realization of intentional action assumes that intentional actions involve negative energy signals propagating backwards in geometric time. This would mean that at some level of CD hierarchy the arrow of geometric time indeed changes and the reduction start to occur at opposite boundary of CD at some level of length scale hierarchy.

1.2.2   Negentropy Maximization Principle (NMP)

Information is the basic aspect of consciousness and this motivates the introduction of Negentropy Maximization Principle (NMP) [K56] as the fundamental variational principle of consciousness theory. The amount of negentropy of zero energy state should increase in each quantum jump. The ordinary entanglement entropy is also non-negative so that negentropy could be at best zero. Since p-adic physics is assumed to be a correlate of cognition, it is natural to generalizes Shannon entropy to its number theoretic variant by replacing the probabilities appearing as arguments of logarithms of probabilities with their p-adic norms. This gives negentropy which can be positive so that NMP can generates entanglement.

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

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

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

1.2.3   The Notion Of Self

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

1. The original view was that self corresponds to a subsystem able to remain un-entangled under the sequential informational "time evolutions" U. It is however unclear how it could be possible to avoid generation of entanglement.

2. In ZEO the situation changes. Self corresponds to a sequence of quantum jumps for which the parts of zero energy states at either boundary of CD remaim unchanged. Therefore one can say that self defined in terms of parts of states assignable to this boundary remains unaffected as sub-system and does not generate entanglement. At the other boundary changes occur and give rise to the experience of time flow and arrow of time since the average temporal distance between the tips of CD tends to increase.

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

3. It looks natural to assume that the experiences of the self after the last "wake-up" sum up to single average experience. This means that subjective memory is identifiable as conscious, immediate short term memory. Selves form an infinite hierarchy with the entire Universe at the top. Self can be also interpreted as mental images: our mental images are selves having mental images and also we represent mental images of a higher level self. A natural hypothesis is that self S experiences the experiences of its sub-selves as kind of abstracted experience: the experiences of sub-selves S_i are not experienced as such but represent kind of averages $\langle S_{ij} \rangle$ of sub-sub-selves S_{ij}. Entanglement between selves, most naturally realized by the formation of flux tube bonds between cognitive or material space-time sheets, provides a possible a mechanism for the fusion of selves to larger selves (for instance, the fusion of the mental images representing separate right and left visual fields to single visual field) and forms wholes from parts at the level of mental images.

4. Self corresponds in neuro science to self model defining a model for organism and for the external world. Information or negentropy seems to be necessary for understanding self. Negentropically entangled states - Akashic records - are excellent candidates for selves and would thus correspond to dark matter in TGD sense since the number of states in superposition corresponds to the integer n defining h_{eff}. It is enough that self is potentially conscious: this could mean that it conscious experience about self is generated only in interaction free measurement. Repeated state function reductions to given boundary of CD is second possibility. This would assign irreversibility and definite arrow of time and experience of time flow with self.

5. CDs would serve as embedding space correlates of selves and quantum jumps would be followed by cascades of state function reductions beginning from given CD and proceeding downwards to the smaller scales (smaller CDs). At space-time level space-time sheets in given p-adic length scale would be the natural correlates of selves. One ends also ends up with concrete ideas about how the localization of the contents of sensory experience and cognition to the "upper" (changing) boundary of CD could take place. One cannot exclude the possibility that state function reduction cascades could also take place in parallel branches of the quantum state.

1.2.4   Relationship To Quantum Measurement Theory

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

1. The standard quantum measurement theory a la von Neumann involves the interaction of brain with the measurement apparatus. If this interaction corresponds to entanglement between microscopic degrees of freedom m with the macroscopic effectively classical degrees of freedom M characterizing the reading of the measurement apparatus coded to brain state, then the reduction of this entanglement in quantum jump reproduces standard quantum measurement theory provide the unitary time evolution operator U acts as flow in zero mode degrees of freedom and correlates completely some orthonormal basis of WCW spinor fields in non-zero modes with the values of the zero modes. The flow property guarantees that the localization is consistent with unitarity: it also means 1-1 mapping of quantum state basis to classical variables (say, spin direction of the electron to its orbit in the external magnetic field).

2. The assumption that localization occurs in zero modes in each quantum jump implies that the world of conscious experience looks classical. It is also consistent with the state function reduction of the standard quantum measurement theory as the following arguments demonstrate (it took incredibly long time to realize this almost obvious fact!).

3. Since zero modes represent classical information about the geometry of space-time surface (shape, size, classical Kähler field, ...), they have interpretation as effectively classical degrees of freedom and are the TGD counterpart of the degrees of freedom M representing the reading of the measurement apparatus. The entanglement between quantum fluctuating non-zero modes and zero modes is the TGD counterpart for the $m - M$ entanglement. Therefore the localization in zero modes is equivalent with a quantum jump leading to a final state where the measurement apparatus gives a definite reading.

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

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

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

1.2.5   Selves Self-Organize

The fourth basic element is quantum theory of self-organization based on the identification of quantum jump as the basic step of self-organization [K87]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization. Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken's classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the "energy" landscape.

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

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

1.2.6   Classical Non-Determinism Of Kähler Action

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

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

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

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

1.2.7   P-Adic Physics As Physics Of Cognition

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

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

A more precise formulation of this vision requires a generalization of the number concept obtained by fusing reals and p-adic number fields along common rationals (in the case of algebraic extensions among common algebraic numbers). This picture is discussed in [K103] . The application this notion at the level of the embedding space implies that embedding space has a book like structure with various variants of the embedding space glued together along common rationals (algebraics, see **Fig. `http://tgdtheory.fi/appfigures/book.jpg`** or **Fig. ??** in the appendix of this book). The implication is that genuinely p-adic numbers (non-rationals) are strictly infinite as real numbers so that most points of p-adic space-time sheets are at real infinity, outside the cosmos, and that the projection to the real embedding space is discrete set of rationals (algebraics). Hence cognition and intentionality are almost completely outside the real cosmos and touch it at a discrete set of points only.

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

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

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

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

1. Macroscopic quantum coherence can be understood since a particle with a given mass can in principle appear as arbitrarily large scaled up copies (Compton length scales as $\hbar$). The phase transition to this kind of phase implies that space-time sheets of particles overlap and this makes possible macroscopic quantum coherence.

2. The space-time sheets with large Planck constant can be in thermal equilibrium with ordinary ones without the loss of quantum coherence. For instance, the cyclotron energy scale associated with EEG turns out to be above thermal energy at room temperature for the level of dark matter hierarchy corresponding to magnetic flux quanta of the Earth's magnetic field with the size scale of Earth and a successful quantitative model for EEG results [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 [K51, 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 experiencse subselves as separate mental images. Averaging over experiences of sub-selves of sub-self would however occur.

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

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

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

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

Higher levels of dark matter hierarchy provide a neat quantitative view about self hierarchy and its evolution. Various levels of dark matter hierarchy would naturally correspond to higher levels in the hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question. The level would determine also the time span of long term memories as discussed in [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 [K51, 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 inspire quantum biology.

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

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

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

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

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

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

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

5. p-Adic physics can be identified as physics of cognition and intentionality. The hierarchy of p-adic length scales predicts a hierarchy of universal metabolic quanta as increments of zero point kinetic energies. Negentropic entanglement (see **Fig. http://tgdtheory.fi/ appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) possible for number theoretic entanglement entropy makes sense for rational (and even algebraic) entanglement and leads to the identification of life as something residing in the intersection of real and p-adic worlds. NMP respects negentropic entanglement and the attractive idea is that the experience of understanding and positively colored emotions relate to negentropic entanglement.

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

1.3.2   Brain In TGD Universe

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

1. An attractive idea is that the negentropic entanglement can be assigned with magnetic flux tubes somehow and that ATP serves as a correlate for negentropic entanglement. This leads to a rather detailed ideas about the role of phosphate bond and provides interpretation for the fact that the number of valence bonds tend to be maximized in living matter. In a loose sense one could even call ATP a consciousness molecule. The latest view encourages to consider the possibility that negentropic entanglement with what might be called Mother Gaia is what is transferred in metabolism.

2. The view about the function of brain differs from the standard view. The simplest option is that brain is a builder of symbolic representations building percepts and giving them names rather than the seat of primary qualia relevant to our conscious experience. Sensory organs

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

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

1.3.3   Anomalies

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

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

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

3. Metabolic energy is necessary for conscious information processing in living matter. This suggests that metabolism should be basically transfer of negentropic entanglement from nutrients to the organism. ATP could be seen as a molecule of consciousness in this picture and high energy phosphate bond would make possible the transfer of negentropy.

1.4   Bird's Eye of View about the Topics of the Book

This book tries to give an overall view about TGD inspired theory of consciousness as it stands now. In nutshell TGD based view about consciousness relies following ideas and concepts.

1. The basic notions TGD inspired theory of consciousness are quantum jump identified as a moment of consciousness, self identified as sequence of quantum jumps analogous to bound state of particles, self hierarchy with sub-selves experienced by self as mental images, and sharing and fusion of mental images by quantum entanglement.

2. Dark matter hierarchy, the levels of which are labeled by increasing quantized value of Planck constant, suggests that the geometric durations for the moments of consciousness form defined as the scale of the space-time volume from which conscious experience is about, form an increasing hierarchy so that the highest level associated with a given self would correspond to single moment of consciousness. This would actually eliminate the notion of self and self hierarchy would correspond to a fractal hierarchy of quantum jumps.

3. The anatomy of quantum jumps must be consistent with the notions of state preparation, state function reduction, and unitary evolution and this leads to a detailed view what quantum jump means for quantum states of the Universe identified as classical spinor fields in configuration space, the "world of classical worlds". The zero modes of the configuration space geometry which do not contribute to its metric and thus do not quantum fluctuate, correspond to classical observables. A direct connection with quantum measurement theory emerges.

4. Negentropy Maximization Principle (NMP) defines the basic variational principle of TGD inspired theory of consciousness. NMP states that the negentropy gain in quantum jump is maximal. The allowance of a number theoretic variant of Shannon entropy making sense for rational or algebraic entanglement probabilities implies that quantum jump can also generate or increase the amount of entanglement. A possible interpretation is in terms of bound state entanglement to which conscious information can be assigned.

5. A natural characterization of the fundamental qualia is in terms of quantum number increments associated with the quantum jump. The classical non-determinism of Kähler action (in the usual sense of the world) means that the contents of the conscious experience of a given self comes from a 4-dimensional space-time region rather than representing 3-D snapshot of space-time. This together with the new view about energy and time (negative energies and communications to the geometric past are predicted) leads to a new vision about memory, intentional action, and also metabolism.

6. p-Adic physics as physics of cognition is a genuinely new element as compared to the existing theories of consciousness and forces to give up the view that cognition is localized in the sense of real physics. Indeed, p-adic space-time sheets representing intentions have literally infinite size since most p-adic integers, in particular those which are infinitesimally small, have infinitely large as real numbers. Cognition would quite literally see the real cosmos from outside. The transformations of p-adic space-time sheets to real ones in quantum jump define an attractive view about what happens when intention transforms to an action and is consistent with TGD based view about energy (also negative inertial energies are possible and the density of inertial energy vanishes in cosmological length scales). The discrete rational projection of p-adic space-time sheets to the real embedding space is excellent candidate for the realization of cognitive representations at the level of space-time since p-adic numbers define very naturally a generalization of binary logic and for primes satisfying p-adic length scale hypothesis the resulting logic has also Boolean interpretation as a logic in which certain number of statements are taboos so that the number of allowed statements is reduced from 2^k to $p = 2^k - n$.

7. The new view about the relationship between experienced and geometric time inspires a general model of memory, intentional action, and metabolism. In this model time mirror mechanism meaning communications with geometric past using negative energy (phase conjugate photons) is in central role. Also time-like entanglement plays a key role in the model of memories. A precise conceptualization for this vision is provided by zero energy ontology in which M-matrix generalizes S-matrix. M-matrix is identifiable as the "square" root of density matrix defines time like entanglement coefficients between positive and negative energy parts of the zero energy state located at past and future boundaries of the causal diamond defined by the intersection of future and past directed light-cones.

1.4.1 The organization of "TGD Inspired Theory of Consciousness"

The topics of the book are organized in the following manner.

1. In the 1st part of the book TGD inspired theory of consciousness is discussed at general level. There are three summarizing chapters give a view about how ideas have evolved. Besides this there are chapters devoted to Negentropy Maximization Principle (NMP), to a detailed exposition of the notion of self, and to a model of sensory representations.

   The views about what NMP really states have fluctuated during years and in the recent number theoretical vision NMP follows as almost trivial consequence and applies only in

statistical sense. What is however essential that any system pair can experience what can called quantum measurement of the density matrix describing their mutual entanglement.

In zero energy ontology (ZEO) second important aspect is that there are two kinds of quantum measurements: "big" state function reductions which correspond to state function reductions in the ordinary sense - in these the arrow of time is changed - and "small" state function reductions which would correspond to so called weak measurements. ZEO energy ontology can be said to lift quantum measurement theory to a theory of consciousness by making observer a part of the physical system.

2. 2nd part of the book contains three chapters about the relationship between experienced and geometric time. The first one is more than decade old. The second one - inspired by zero energy ontology and written quite recently - provides a rather detailed vision about how the arrow of geometric time correlating with the arrow of experienced time and the localization of the contents of sensory experience to a narrow time interval emerge. The chapter explaining TGD based view about long term memory is also included.

3. The 3rd part of the book summarizes roughly decade old view about intelligence and cognition. p-Adic physics as physics of cognition and intentionality and many-fermion states as representations of Boolean statements are the key notions. In zero energy ontology also quantal versions of logical rules $A \to B$ realized as quantum variants of Boolean functions emerge at the fundamental level.

A chapter about the role of dark matter hierarchy, in particular about topological quantum computation as a universal information processing tool, and a chapter about adelic physics as a mathematical description of physics of both sensory experience and cognition, would be needed to make the picture correspond to the recent understanding.

4. The 4th part is devoted to remote mental interactions. The theoretical motivation for taking remote mental interactions seriously is that exactly the same mechanisms which are involved with the interaction between magnetic body and biological body apply also to remote mental interactions in TGD Universe. One could also understand why these phenomena are rare: a kind of immune system making it impossible for foreign magnetic bodies to control and communicate with the biological body possessed by a particular magnetic body would be a highly probable (but perhaps not unavoidable) outcome of evolutionary process.

1.5   Sources

The eight online books about TGD [K117, K111, K86, K66, K21, K62, K43, K100] and nine online books about TGD inspired theory of consciousness and quantum biology [K108, K16, K75, K14, K40, K49, K53, K99, K106] are warmly recommended for the reader willing to get overall view about what is involved.

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

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

1.6   The contents of the book

1.6.1   PART I: BASIC IDEAS OF TGD INSPIRED THEORY OF CON-SCIOUSNESS

Matter, Mind, Quantum

This chapter is devoted to the TGD inspired theory of consciousness. TGD inspired theory of consciousness could be seen as a generalization of quantum measurement theory to make observer, which in standard quantum measurement theory remains an outsider, a genuine part of physical system subject to laws of quantum physics. The basic notions are quantum jump identified as moment of consciousness and the notion of self: zero energy ontology (ZEO) is essential for the notion of self. Negentropy Maximization Principle (NMP) defines the dynamics of consciousness and as a special case reproduces standard quantum measurement theory.

1. Quantum jump as moment of consciousness

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

This means that subjective time evolution corresponds to the sequence of quantum jumps $\Psi_i \to U\Psi_i \to \Psi_f$ consisting of unitary process followed by state function process. In zero energy ontology (ZEO) U defines a unitary matrix between zero energy states and is naturally assignable to intentional actions whereas the ordinary S-matrix telling what happens in particle physics experiment (for instance) generalizes to M-matrix defining time-like entanglement between positive and negative energy parts of zero energy states. One might say that U process corresponds to a fundamental act of creation creating a quantum superposition of possibilities and the remaining steps generalizing state function reduction process select between them.

2. Negentropy Maximization Principle and the notion of self

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

The original definition of self was as a subsystem able to remain unentangled under state function reductions associated with subsequent quantum jumps. Everything is consciousness but consciousness can be lost. Second aspect of self was assumed to be the integration of subsequent quantum jumps to coherent whole giving rise to the experienced flow of time.

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

p-Adic physics as correlate for cognition and intention leads to the notion of negentropic entanglement possible in the intersection of real and p-adic worlds involves experience about expansion of consciousness. Consistency with standard quantum measurement theory forces negentropic entanglement to correspond to density matrix proportional to unit matrix. Unitary entanglement

typical for quantum computing systems gives rise to unitary entanglement.

The first state function reduction - wake-up of self- at given boundary of CD is a hierarchical cascade proceeding from long to short scales. The reduction process can stop also if the self in question allows only decompositions to pairs systems with negentropic entanglement. This does not require that that the system forms a bound state for any pair of subsystems so that the systems decomposing it can be free (no binding energy). This defines a new kind of bound state not describable as a jail defined by the bottom of a potential well. Subsystems are free but remain correlated by negentropic entanglement.

Ordinary state function reductions imply dissipation crucial for self organization and quantum jump could be regarded as the basic step of an iteration like process leading to the asymptotic self-organization patterns. One could regard dissipation as a Darwinian selector as in standard theories of self-organization. NMP predicts that self organization and hence presumably also fractalization can occur inside selves. NMP would favor the generation of negentropic entanglement. This notion is highly attractive since it could allow to understand how quantum self-organization generates larger coherent structures. Note that state function reduction for negentropic entanglement is highly deterministic since the number of degenerate states with same negative entanglement entropy is expected to be small. This could allow to understand how living matter is able to develop almost deterministic cellular automaton like behaviors. In ZEO this self-organization is for 4-D spatio-temporal patterns since 3-surfaces are pairs of space-like surfaces at the boundaries of CD and maxima of Kähler function are selected in the process. These temporal patterns correspond to behaviors and functions in living matter.

The chapter is devoted to the discussion of detailed implications of these general ideas. The topics to be discussed include following basic questions.

1. How the general structure for the contents of consciousness of self are determined? The basic assumption is that self hierarchy in which subselves define mental images of self is responsible for the general structure of conscious experience. ZEO allows to derive the space-time correlates of selves.

2. How the physical realization of the hardware of consciousness differs from that assumed in neuroscience? Here the notion of magnetic body as intentional agent using biological body as motor instrument and sensory receptor is central.

3. What is the precise relationship between the geometric time of physicist and subjective time identified in terms of a sequence of quantum jumps? ZEO gives the most convincing answer to this question found hitherto.

4. What can one one say about various types of conscious experience in the proposed framework. This includes p-adic description of cognition and intentional action, model for sensory experience and sensory qualia, model for Boolean mind in terms of fermions, a model for directed attention, ideas about emotions, and also a general interpretation for altered states of consciousness based on the special features of negentgropic entanglement.

5. Can one provide solutions to the paradoxes of quantum physics, theories of consciousness, and logic in the proposed conceptual framework?

The discussion differs considerably from the earlier one. The reason is that the developments occurred during period 2005-2010 (ZEO, hierarchy of Planck constants assigned to dark matter, hyper-finite factors of type II_1, the implications of the number theoretical negentropies) are introduced from the beginning to the formulation of the theory rather than as additions to the existing text so that the representation is more coherent and the number of internal inconsistencies is minimized. The latest progress relates to the understanding of the notions of psychological time and self (2012-2014).

Negentropy Maximization Principle

In TGD Universe the moments of consciousness are associated with quantum jumps between quantum histories. The proposal is that the dynamics of consciousness is governed by Negentropy

Maximization Principle (NMP), which states the information content of conscious experience is maximal. The formulation of NMP is the basic topic of this chapter.

NMP codes for the dynamics of standard state function reduction and states that the state function reduction process following U-process gives rise to a maximal reduction of entanglement entropy at each step. In the generic case this implies at each step a decomposition of the system to unique unentangled subsystems and the process repeats itself for these subsystems. The process stops when the resulting subsystem cannot be decomposed to a pair of free systems since energy conservation makes the reduction of entanglement kinematically impossible in the case of bound states. The natural assumption is that self loses consciousness when it entangles via bound state entanglement.

There is an important exception to this vision based on ordinary Shannon entropy. There exists an infinite hierarchy of number theoretical entropies making sense for rational or even algebraic entanglement probabilities. In this case the entanglement negentropy can be negative so that NMP favors the generation of negentropic entanglement (NE), which is not bound state entanglement in standard sense since the condition that state function reduction leads to an eigenstate of density matrix requires the final state density matrix to be a projection operator.

NE might serve as a correlate for emotions like love and experience of understanding. The reduction of ordinary entanglement entropy to random final state implies second law at the level of ensemble. For the generation of NE the outcome of the reduction is not random: the prediction is that second law is not a universal truth holding true in all scales. Since number theoretic entropies are natural in the intersection of real and p-adic worlds, this suggests that life resides in this intersection. The existence effectively bound states with no binding energy might have important implications for the understanding the stability of basic bio-polymers and the key aspects of metabolism. A natural assumption is that self experiences expansion of consciousness as it entangles in this manner. Quite generally, an infinite self hierarchy with the entire Universe at the top is predicted.

There are two options to consider. Strong form of NMP, which would demand maximal negentropy gain: this would not allow morally responsible free will if ethics is defined in terms of evolution as increase of NE resources. Weak form of NMP would allow self to choose also lower-dimensional sub-space of the projector defining the final state sub-space for strong form of NMP. Weak form turns out to have several highly desirable consequences: it favours dimensions of final state space coming as powers of prime, and in particular dimensions which are primes near powers of prime: as a special case, p-adic length scale hypothesis follows. Weak form of NMP allows also quantum computations, which halt unlike strong form of NMP.

Besides number theoretic negentropies there are also other new elements as compared to the earlier formulation of NMP.

1. ZEO modifies dramatically the formulation of NMP since U-matrix acts between zero energy states and can be regarded as a collection of orthonormal M-matrices, which generalize the ordinary S-matrix and define what might be called a complex square root of density matrix so that kind of a square root of thermodynamics at single particle level justifying also p-adic mass calculations based on p-adic thermodynamics is in question.

2. The hierarchy of Planck constants labelling a hierarchy of quantum criticalities is a further new element having important implications for conciousness and biology.

3. Hyper-finite factors of type II_1 represent an additional technical complication requiring separate treatment of NMP taking into account finite measurement resolution realized in terms of inclusions of these factors.

   NMP has wide range of important implications.

1. In particular, one must give up the standard view about second law and replace it with NMP taking into account the hierarchy of CDs assigned with ZEO and dark matter hierarchy labelled by the values of Planck constants, as well as the effects due to NE. The breaking of second law in standard sense is expected to take place and be crucial for the understanding of evolution.

2. Self hierarchy having the hierarchy of CDs as embedding space correlate leads naturally to a description of the contents of consciousness analogous to thermodynamics except that the entropy is replaced with negentropy.

3. In the case of living matter NMP allows to understand the origin of metabolism. NMP demands that self generates somehow negentropy: otherwise a state function reduction to tjhe opposite boundary of CD takes place and means death and re-incarnation of self. Metabolism as gathering of nutrients, which by definition carry NE is the manner to avoid this fate. This leads to a vision about the role of NE in the generation of sensory qualia and a connection with metabolism. Metabolites would carry NE and each metabolite would correspond to a particular qualia (not only energy but also other quantum numbers would correspond to metabolites). That primary qualia would be associated with nutrient flow is not actually surprising!

4. NE leads to a vision about cognition. Negentropically entangled state consisting of a superposition of pairs can be interpreted as a conscious abstraction or rule: negentropically entangled Schrödinger cat knows that it is better to keep the bottle closed.

5. NMP implies continual generation of NE. One might refer to this ever expanding universal library as "Akashic records". NE could be experienced directly during the repeated state function reductions to the passive boundary of CD - that is during the life cycle of sub-self defining the mental image. Another, less feasible option is that interaction free measurement is required to assign to NE conscious experience. As mentioned, qualia characterizing the metabolite carrying the NE could characterize this conscious experience.

6. A connection with fuzzy qubits and quantum groups with NE is highly suggestive. The implications are highly non-trivial also for quantum computation allowed by weak form of NMP since NE is by definition stable and lasts the lifetime of self in question.

Self and Binding: Part I

This chapter is the first part of a representation devoted to the notion of self. The original definition of self was as a subsystem able to remain unentangled under state function reductions associated with subsequent quantum jumps. Everything is consciousness but consciousness can be lost if self develops bound state entanglement during U process so that state function reduction to smaller un-entangled pieces is impossible. A second aspect of self was assumed to be the integration of subsequent quantum jumps to coherent whole giving rise to the experienced flow of time. This view had however problems, which are rather obvious and it seems that new physics is needed.

The TGD based notion of self involves several new physics ingredients. These include Zero Energy Ontology (ZEO), hierarchy of Planck constants labelling a fractal hierarchy of quantum critical systems, and adelic view about quantum physics fusing real and various p-adic physics serving as correlates of cognition to single coherent whole.

Negentropic entanglement is a crucial notion. There exists an infinite hierarchy of number theoretical entropies making sense for rational or even algebraic entanglement probabilities. In this case the entanglement negentropy can be negative so that Negentropy Maximization Principle (NMP) favors generation of negentropic entanglement, which need not be bound state entanglement in standard sense. This leads to the vision that negentropic entanglement defines kind of Akashic records, kind of library storing potentially conscious information becoming conscious in interaction free measurement. Akashic records could define self model as opposed to self. Consistency with standard quantum measurement theory requires that density matrix for negentropic entanglement is projector and thus proportional to unit matrix associated to entanglement matrix characterized by a unitary matrix associated with quantum computation.

What is the precise identification of self allowing to understand both of the above mentioned aspects turned out to be difficult problem. I became aware the solution of the problem in terms of ZEO only rather recently (2014). Self indeed corresponds to a sequence of quantum jumps integrating to single unit, but these quantum jumps correspond to state function reductions to a fixed boundary of CD leaving the corresponding parts of zero energy states invariant. In positive energy ontology these repeated state function reductions would have no effect on the state but in

TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and gives rise to self. The first quantum jump to the opposite boundary corresponds to the act of free will and death of self and its re-incarnation at the opposite boundary CD. Also the arrow of geometric time is changed.

Self is assumed to experience sub-selves as mental images identifiable as "averages" of their mental images. This implies the notion of ageing of mental images as being due to the growth of ensemble entropy as the ensemble sub-sub-selves increases.

The sub-selves of two unentangled selves can entangle although selves remain unentangled. This is possible by the modification of the subsystem concept forced by the p-adic length scale cutoff. The entanglement of sub-selves means fusion and sharing of mental images providing a universal telepathy like quantum communication mechanism and presumably making possible both molecular, cellular, and human societies.

Self and Binding: Part II

This chapter is second part of a representation devoted to the notion of self as it is understood in TGD framework.

The possibility of negentropic entanglement has profound implications. It leads to a vision about learning as a basic quantum process possible in the intersection of real and p-adic worlds and made possible because state function reduction ceases to be a random process for negentropically quantum states. Quite concrete ideas about the role of synaptic transmission and neural transmitters for consciousness emerge. Music experience provides an especially interesting application for the vision about consciousness and zero energy ontology together with number theoretical vision inspires several concrete interpretations. Synchronous firing of neurons- in particular at 40 Hz frequency- is an attractive correlate for the negentropic entanglement and synesthesia can be interpreted as a particular manifestations of negentropic entanglement.

In TGD framework it is not at all obvious that the highest levels of our personal self hierarchy should correspond to the size of the physical body. Various empirical facts, in particular the observations related to the special effects of excitations of geomagnetic fields and ELF em fields in EEG frequency range on brain, inspire the hypothesis that our selves correspond to topological field quanta of em fields associated with EEG frequencies and thus by Uncertainty Principle have size scale of Earth. Indeed, the notion of magnetic body as a space-time correlate of self has become a key concept in TGD inspired biology. Magnetic body carrying dark matter identified as lare h_{eff} phases can be seen as intentional agent using biological body as motor instrument and sensory receptor.

Quantum Model for Sensory Representations

One of the toughest challenges of quantum theories of consciousness is to understand how sensory representations are constructed at quantum level. It became as a surprise that the vision about sensory representation which resulted from a long lasting thought experimentation is actually very much what the original experience about myself as a computer sitting at its own terminal, when taken very literally in some aspects, actually suggests. This vision adds to the standard view about brain an additional layer responsible for the sensory representations and brings in the quantum level of control so that nerve pulse patterns are only part of the control loop. In fact, it has turned out that the same basic theory applies to both geometric memories, precognition, sensory perception, and motor actions. The vision goes as follows.

1. As far as our consciousness is considered, primary sensory organs are the seats of sensory qualia and brain only constructs cognitive and symbolic representations. Various objections against this hypothesis can be circumvented by assuming that sensory organs entangle with the brain. The question how imagination differs from the sensory experience becomes trivial, and dreams and hallucinations can be understood as resulting via the back-projection of the imagined mental images to the primary sensory organs.

2. Libet's findings about passive aspects of consciousness lead to the view that sensory percept can be regarded as a geometric memory in time scale of .5 seconds involving entanglement with the geometric past mediated by negative energy MEs. Libet's experiments about the

active aspects of consciousness in turn lead to realization that motor actions and sensory perceptions are in a well-defined sense time-reversals of each other: pre-cognition is a definite aspect of motor action. One can say that motor action at the level of negative energy MEs is initiated from the level of muscles rather than brain and motor imagination is just a motor action starting from some level higher than muscles. The transformation of a p-adic ME to negative energy ME realizes the transformation of intention to action in a precisely targeted manner and the emission of negative energy makes possible extreme flexibility by buy now-let others pay mechanism of remote metabolism. This process is the basic step initiating motor action, neural activity leading to imagery, and active memory recall. This picture also explains why geometric memories occur more or less spontaneously whereas precognition is a rare phenomenon (pre-cognizer must *receive* negative energy MEs). Zero energy ontology (ZEO) provides a firm theoretical justification for the notion of negative energy signal to past obeying reversed arrow of time.

3. In TGD framework one can assign to any material structure a magnetic body having much large size. The closed flux loops composing magnetic bodies allow an elegant realization of the long term memories in terms of negative and positive energy MEs. A stronger hypothesis is that various magnetic bodies define sensory canvases at which various sensory representations are realized. Motor action can be seen as a geometric time reversal of sensory perception. Cortex can be seen as a collection of pre-existing symbolic and cognitive features possibly entangled with sensory mental images at sensory organs, and activated when they appear in the perceptive field or form a part of motor action. The basic task of the central nervous system is to identify these features from the sensory input. The mental images associated with various parts of the physical body are entangled with the points of the correspondin magnetic bodies representing objects of the perceptive field by sharing of mental images and in this manner define attributes of these objects. There is an entire hierarchy of representations corresponding to the hierarchy of magnetic bodies, and also sensory perception involves active selections by entangling a sequences of mental images defining paths along the tree-like structure defined by the hierarchy of magnetic bodies beginning from the personal magnetic body and ending at the roots defined by magnetic bodies of sensory organs. This explains phenomena like sensory rivalry.

4. The decomposition of the perceptive field to objects is one of the basic aspects of sensory experiencing and TGD provides a mechanism generating these objects as space-time sheets: the boundaries of these objects correspond to regions of strong Kähler electric field whose strength is assumed to correlate with the intensity of the neural input. It might be that even the objects of perceptive field or thoughts could be regarded as features. In zero energy ontology causal diamonds become the embedding space correlates of mental images and one can ask whether Negentropy Maximization Principle -perhaps suitably generalized- could force their generation.

5. The computational activities associated with the construction of the sensory representations (say estimating distances and directions of the objects of perceptive field) and virtual sensory representations representing the goals of motor action are presumably realized as iterated processes in which virtual sensory inputs characterizing the expected experiences are compared with the real world sensory input. In a similar manner the goal of the motor action is compared with the sensory representation resulting from effect of a virtual motor action on the representation of the recent state of world and body. This comparison does not necessarily require sensory representation at any level of the self hierarchy and could be based on comparison circuits defined by parallel supra currents in which the inputs which are sufficiently near to each other generate constructive interference giving rise to a large Josephson current.

6. Zero energy ontology together with the notion of causal diamond (CD) identified as embedding space correlate of self and the moduli space of CDs, the description of dark matter in terms of a hierarchy of Planck constants implying a generalization of the notion of the imbedding space, and the vision about living matter as something residing in the intersection of real and p-adic worlds and carrying positive entanglement negentropy allow to make this

vision more detailed and lead to surprisingly precise quantitative predictions and connect the basic biological time scales to those assignable to elementary particles in zero energy ontology. The notion of spectroscopy of consciousness can be formulated for the geometric aspects of conscious experience in terms of the moduli space of causal diamonds and the frequencies of the generalized EEG.

1.6.2 PART II: TIME AND CONSCIOUSNESS

Time and Consciousness

This chapter as also other chapters about the notion of time appearing in books about TGD inspired theory of consciousness should be taken as stories about how ideas developed through many tortuous twists and turns. In this abstract I only summarize the outcome and leave the description of the tortuous path to the chapter.

If one accepts the identification of moment of consciousness as quantum jump between quantum histories, the basic challenge is to explain how psychological time arises: why the contents of at least sensory experiences are concentrated around definite value of geometric time and what is the origin of the arrow of psychological time. It has become gradually clear that TGD cannot reproduce the common sense conception of time as such and that one can only require that the generalized view is consistent with our restricted conscious experiences and shows our position in the hierarchy of consciousness.

The understanding of the notion of psychological time and its arrow - or equivalently, the relationship between subjective and geometric time - turned out to be quite difficult challenge and led to a handful of proposals based on the identification of space-time sheet as a correlate of self and the idea that the experienced flow of geometric correspond to some kind of motion in space-time or in embedding space. These identifications did not lead to anything practical and generated paradoxes. Also the notion of self turned to be problematic.

The most recent proposal involves no ad hoc assumptions and relies on the recent formulation of quantum TGD using zero energy ontology (ZEO) and the understanding of both nature of time and self reduces to a more precise view about what happens in state function reduction in ZEO.

1. The embedding space correlate of self is so called causal diamond (pair of future and past directed light-cones) which is 8-D sub-manifold of the embedding space rather than space-time sheet.

2. In ZEO state function reduction can occur at both boundaries of CD but can occur repeatedly at given CD boundary. In the repeated reduction the already reduced positive/negative energy state remains the same just as the state function remains invariant in ordinary repeated state function reduction. Second boundary of CD corresponds to a wave function in the moduli space of CDs and changes: since the distance between the tips of CD is one particular modular degree of freedom, the average value of this distance tends to increase just as the distance of particle diffusing inside cone increases during diffusion. This gives rise to the experience flow of geometric time identified this temporal distance.

3. Self can be understood as a sequence of repeated state functions at the same boundary - the original identification was as sequence of all quantum jumps. The arrow of geometric time changes at some level of self hierarchy when quantum jump takes at the second boundary of CD and could correspond to volition, act of free will.

4. The notion of negentropic entanglement also leads to a model for self model to be carefully distinguished from self.

The concept of self led to the understanding of the subjective memory as an average over experiences of self experienced after its "wake-up". Subjective memories are always about past. Geometric memories are predictions for the future/past assuming that no quantum jumps would occur after/had occurred before the one giving rise to the geometric memory. Pre-cognitions can be seen as geometric memories about future. Intentions are p-adic variants of precognitions. It seems that long term memories must correspond to geometric memories: this hypothesis, when combined with the spin glass model of brain, the notion of quantum self-organization, and some key

aspects of many-sheeted physics, allows to understand the basic aspects of the long term memory and avoids the basic difficulties of the neural net models.

About the Nature of Time

This chapter as also other chapters about the notion of time appearing in books about TGD inspired theory of consciousness should be taken as stories about how ideas developed through many tortuous twists and turns. In this abstract I only summarize the outcome and leave the description of the tortuous path to the chapter.

The identification of the experienced time t_e and geometric time t_g involves well-known problems. Physicist is troubled by the reversibility of t_g contra irreversibility of t_e, by the conflict between determinism of Schrödinger equation and the non-determinism of state function reduction, and by the poorly understood the origin of the arrow of t_g. In biology the second law of thermodynamics might be violated in its standard form for short time intervals. Neuroscientist knows that the moment of sensory experience has a finite duration, does not understand what memories really are, and is bothered by the Libet's puzzling finding that neural activity seems to precede conscious decision.

These problems are discussed in the framework of Topological Geometrodynamics (TGD) and TGD inspired theory of consciousness constructed as a generalization of quantum measurement theory. In TGD space-times are regarded as 4-dimensional surfaces of 8-dimensional space-time $H = M^4 \times CP_2$ and obey classical field equations.

The basic notions of consciousness theory are quantum jump and self. Subjective timew as originally identified as a sequence of quantum jumps, which somehow integrate to form single coherent entity, self. Self has as a geometric correlate a fixed volume of H- "causal diamond"- defining the perceptive field of self. This picture leaves however open two key questions. How the arrow of time and localization of contents of sensory experience emerge and what self do really mean? This chapter discusses several approaches to the problem.

The most recent and one might hope also the final proposal involves no ad hoc assumptions and relies on the recent formulation of quantum TGD using zero energy ontology (ZEO) and the understanding of both nature of time and self reduces to a more precise view about what happens in state function reduction in ZEO.

1. The embedding space correlate of self is so called causal diamond (pair of future and past directed light-cones) which is 8-D sub-manifold of the embedding space rather than space-time sheet.

2. In ZEO state function reduction can occur at both boundaries of CD but can occur repeatedly at given CD boundary. In the repeated reduction the already reduced positive/negative energy state remains the same just as the state function remains invariant in ordinary repeated state function reduction. Second boundary of CD corresponds to a wave function in the moduli space of CDs and changes: since the distance between the tips of CD is one particular modular degree of freedom, the average value of this distance tends to increase just as the distance of particle diffusing inside cone increases during diffusion. This gives rise to the experience flow of geometric time identified this temporal distance.

3. Self can be understood as a sequence of repeated state functions at the same boundary - the original identification was as sequence of all quantum jumps. The arrow of geometric time changes at some level of self hierarchy when quantum jump takes at the second boundary of CD and could correspond to volition, act of free will.

4. The notion of negentropic entanglement also leads to a model for self model to be carefully distinguished from self.

Quantum Model of Memory

The neural realization of long term memories has remained to a high extent a mystery in the framework of the standard brain science. The TGD based quantum model for memory have developed gradually from the basic realization that in TGD framework the identification of quantum states

as quantum histories makes it un-necessary to store information about the geometric past to the geometric now. This has deep implications.

1. It is possible to separate genuine geometric memory recall from apparent memory recalls such as feature recognition, associations, and implicit and procedural memories. There are no memory storages in brain and only memory representations abstracting the essential aspects of experience are needed.

2. The models of long term memory based on the assumption that information about the geometric past is stored in the recent state of the system predict that the new memories should mask the old ones. It is however known that childhood memories are the stablest ones. In TGD framework this ceases to be a problem.

   Mirror mechanism provides a very general mechanism of long term memory. To remember something at a temporal distance T in the geometric past is to look at a mirror at a distance $cT/2$. If the mirror is quantum mirror only a timelike entanglement (allowed by the non-determinism of Kähler action) of the mental image of the geometric past with a mental image in brain now is needed. The un-necessity to communicate memories classically implies extreme generality of the mechanism: all kinds of memories: sensory, cognitive, verbal,.... can be recalled in this manner. Even the mechanism of memory recall by cue can be generalized since the notion of tele association makes in principle sense.

   The basic objections against this over-simplified picture is that there is no guarantee that the reflected ME returns to the brain and that there is no control over the time span of long term memories. The notion of magnetic body allows a more realistic formulation.

3. Zero energy ontology (ZEO) brings in the possibility of temporary change of the arrow of geometric time at some level of the hierarchy of space-time sheets. This provides a justification for the notion of negative energy signals. Brain or the personal magnetic body generates spontaneously negative energy MEs with all fundamental frequencies. These MEs can be also curved and are parallel to the closed flux tubes defining the personal magnetic body and connect geometric now with the brain of the geometric past: multiple reflections are probably required to achieve this. The length of the closed magnetic loop defines the time span of the corresponding long term memory. The sharing of mental images by timelike entanglement allows to communicate the desire to remember to the geometric past, and gives rise to the memory recall in the case of episodal memories. In the case of non-episodal/declarative memories the memory is communicated from the brain of the geometric past by classical communications using positive positive energy MEs which propagate with an effective phase velocity much lower than light velocity along closed magnetic flux tubes and generate in the receiving end symbolic representation of the memory.

   Macrotemporal quantum coherence is a further important piece of the model. The understanding of how macrotemporal quantum coherence is made possible by the spin glass degeneracy led to a concrete realization of the mirror model and also provided a connection with the ideas of Hameroff and Penrose. When a bound state is formed the zero modes of the bound state entangled subsystems become quantum fluctuating degrees of freedom. This means that state function reduction and state preparation cease to occur in these degrees of freedom. The bound state is in a kind of long-lasting multiverse state, or state of "oneness" experientially, and the sequence of quantum jumps defined by the duration of the bound state behaves effectively as a single quantum jump. Macrotemporal quantum coherence making possible supercomputer like activities becomes possible.

   The hierarchy of Planck constants emerging from the non-determinism of Kähler action implying also spin glass degeneracy provides a more precise view about the emergence of quantum coherence. Also a connection with quantum criticality and hierarchy of breakings of conformal invariance emerges.

   The spin glass degeneracy associated with the join along boundaries bonds (the original space-time correlates for the bound state formation replaced later by magnetic flux tubes) lengthens the lifetimes of the bound states dramatically and solves thus the basic objections against quantum consciousness. The spin glass degeneracy is broken only by classical gravitational energy

of the system. The quantum jumps between different classical gravitational configurations involve the emission of gravitational (equivalently Z^0) MEs and the intention to remember is realized as a transformation of p-adic ME to negative energy gravitational ME. The fact that classical gravitational fields couple to classical gauge fields with a coupling which is about 10^8 stronger than the ordinary gravitational coupling, could play an important role too. Water clusters and macro-molecules with sizes in the range of cell membrane thickness and cell size are good candidates for generating gravitonic MEs responsible for all geometric memories. Also classical Z^0 interaction might be involved since gravitonic MEs can be regarded also as Z^0 MEs.

A neuro level model of long term memory is discussed. The model conforms with the basic facts known about the relationship of hippocampus and long term memory.

1.6.3 PART III: INTELLIGENCE, INFORMATION, AND COGNITION

Conscious Information and Intelligence

The notions of information and intelligence are discussed in TGD framework. Possible definitions for the information measures of the configuration space spinor field and information gain of conscious experience as well as the information theoretic interpretation of Kähler action are discussed in detail the first sections of the chapter.

1. The key element of the approach is the number theoretic generalization of entanglement entropy. Quantum entanglement between real and p-adic degrees of freedom makes sense if entanglement coefficients are rational or even algebraic numbers. In this case one can define entanglement entropy using the p-adic variant of the logarithm. p-Adic entropy can be also negative, and the states for which the entropy is negative are stable against self measurements (NMP) and define macrotemporally quantum coherent states. The number-theoretic entropy serves as an information measure for cognitive entanglement, and positive entanglement negentropy can be interpreted as a correlate for the experience of understanding. Number theoretic entanglement measures are natural in what might be called the intersection of real and p-adic worlds (partonic 2-surfaces have mathematical representations making sense both p-adically and in real sense) and this leads to a vision about life as something residing in this intersection. The consistency with standard quantum measurement theory leads to the conclusion that negentropic entanglement must correspond to a density matrix proportional to unit matrix. Entanglement matrix proportional to a unitary matrix characterizing quantum computation gives therefore rise to negentropic entanglement.

2. Various measures for the information contents of consciousness are discussed.

    (a) The reduction of entanglement entropy defines a natural measure for conscious information gain in single step of the state of state function reduction process decomposing subsystem to a pair of un-entangled sub-systems. If entanglement is negentropic the entanglement negentropy either increases or the system is stable against state function reduction.

    (b) It seems natural to assume that the information measures are associated with the entire cascade and that they are additive in the sense that information gain is sum over the information gains of the steps of the cascade and that a given step contributes by the sum of the information gains associated with unentangled subsystems which are subject to self measurement in a given step of the cascade.

    (c) One can also assign information measures to the resulting indecomposable systems. For subsystem which is bound state in the normal sense and thus has entropic entanglement, one can consider all possible decomposition of the system to a sub-system and its complement and define the entanglement negentropy as the negative for the minimum value of entropy obtained in this manner. If the system is negentropically entangled one can define entanglement negentropy as the maximum of entanglement negentropy obtained in this manner. This means that one can assign to the final state of state

function reduction unique negentropy as the sum of the negative contributions associated with selves which are internally bound state entangled and positive contributions of negentropic selves.

(d) The information content of the conscious experience associated with self is more interesting practically. Since self defines a statistical ensemble, it is straightforward to define entropies associated with the increments of quantum numbers and zero modes defining non-geometric and geometric qualia. These entropies characterize the fuzziness of the quale and are "negative" information measures. One can also assign to non-decomposable subselves the information measures and they give either positive or negative contribution to the information content of self.

(e) In principle this allows to define also the net information gain of quantum jump as the difference of the total negentropies of the final and initial states of quantum jump identified as those produced by the state function reduction process. Initial and final state negentropies would characterize spinor fields of WCW ("world of classical worlds").

3. Information theoretic interpretation of the Kähler function is discussed in detail. Quantum classical correspondence suggests that the magnetic part of Kähler action would correspond to information content of negentropic entanglement and electric part to the negative information content of entropic bound state entanglement. Kähler function defined as the negative of the Kähler action can be interpreted as an entropy type measure for the information content of the space-time surface. Without quantum criticality entropic configurations carrying strong Kähler electric fields would be favored. The proposal is that the quantum criticality of Kähler action possible for the critical value of Kähler coupling strength makes possible large degeneracy of the negentropic extremals carrying large Kähler magnetic action and makes TGD universe maximally interesting and maximizes its intelligence so that even infinite negentropy is possible. Number theoretical criticality would relate to this criticality very closely. The proposal that living matter is near vacuum extremal so that the degeneracy of negentropic configurations is high is discussed.

4. The physical interpretation for the hierarchy of Planck constants would be in terms of a hierarchy of quantum criticalities concretizing the vision about quantum criticality of TGD Universe. TGD Universe would be like a hill at the top of a hill at .... The larger the Planck constant the larger the size scale of the hill. Criticality involves crucially the notion of conformal gauge symmetry. The conformal symmetries correspond to sub-algebra of the full algebra isomorphic to it acting as gauge symmetries and with conformal weights coming as n-multiples of those for the full symmetry algebra. $h_{eff} = n \times h$ would label the levels of the hierarchy. This hierarchy would correspond directly to the hierarchy of measurement resolutions and to hierarchy of hyperfinite factors of type II_1 (HFFs). Also now one obtains infinite hierarchies of symmetry breakings and the identification with the hierarchies of inclusions of HFFs is compelling. Hence various hierarchies reflect the same underlying phenomenon.

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

Concerning the modelling of conscious intelligence the following aspects are important.

1. Zero energy states -which replace the earlier notion of association sequence inspired by the failure of strict determinism for Kähler action in standard sense - can be seen as memes with M-matrices characterizing the time-like entanglement representing "laws of physics".

Negentropic time like entanglement makes possible for fully state function reduced states to represent rules as quantum superposition of state pairs representing instances a→b for a general rule A→B. Also space-like negentropic quantum entanglement is important piece of the story. For fermion Fock states this gives Boolean rules as a special case. Zero energy states represent geometric memories, simulations for time development whereas selves represent subjective memories and conscious experience involves always the comparison of geometric and subjective memories telling whether expectations were realized. Quantum theory of self-organization applies also to the evolution of consciousness understood as self-organization in the ensemble of association sequences/selves and implies Darwinian selection also at the level of selves and conscious experiences.

2. TGD Universe is quantum computer in a very general sense. Negentropic quantum entanglement stabilizes qubits but makes them fuzzy. This leads to a modification of the standard paradigm of quantum computation. Quantum computationalism is shown to reproduce the relevant aspects of computationalism and connectionism without reducing conscious brain to a deterministic machine. Holographic brain is also one of the dominating ideas of neuroscience. TGD based realization of memory allows to reduce hologram idea to its essentials: what matters is that piece of hologram is like a small window giving same information as larger window but in less accurate form. This inspires the concept of neuronal window: each neuron has small window to the perceptive landscape and is typically specialized to detect particular feature in the landscape. Coherent photons emitted by mindlike space-time sheets and propagating along axonal microtubules serving as wave guides, realize neuronal windows quantum physically. Massless extremals allow rather precise definition for the notion of quantum hologram.

A more refined formulation of these ideas is based on the notion of conscious hologram. Many-sheeted space-time is essentially a fractal Feynman diagram with lines thickneed to 4-surfaces. The lines are like wave guides carrying laser beams and vertices are like nodes where these laser beams interfere and generate the points of the hologram. The 3-dimensionality of the ordinary hologram generalizes to stereo consciousness resulting in the fusion of mental images associated with various nodes of the conscious hologram. An essential element is the possibility of negative energy space-time sheets analogous to the past directed lines of the Feynman diagram: negative energy MEs are the crucial element of sensory perception, motor action, and memory.

3. An important element is effective four-dimensionality of brain making possible to understand long term memories, planning and motor activities in a completely new manner. Further important ideas are music metaphor already described and the vision about brain as an associative net. ZEO and the notion of CD (causal diamond) provides justification for the memetic code and relates it to fundamental elementary particles time scales. The codewords of the memetic code consist of sequences of 126 bits and are represented in terms of nerve pulse sequences or membrane oscillations and time varying quark magnetization, is the key essential element of brain as cognitive system. Codewords can be interpreted either as elements of a Boolean algebra or as bits in the binary expansion of an integer in the range $(0, 2^{126})$ so that memetic code makes brain able to assign numbers with qualia. An attractive and testable identification for the memetic codewords is as phonemes of language.

p-Adic Physics as Physics of Cognition and Imagination

TGD as a generalized number theory vision supports the interpretation of the p-adic physics in terms of physical correlates of cognition and intentionality so that matter-mind dichotomy would correspond to real–p-adic dichotomy at the level of the geometric correlates of mind. This interpretation has far reaching implications for both TGD inspired theory of consciousness and for the general world view provided by TGD. Cognition is predicted to be present in all length scales and the success of the p-adic physics in elementary particle length scales forces to conclude that cognition and intention are present even at this level.

The vision about life and conscious information and intelligence as something in the intersection of real and p-adic worlds is the key guiding principle also in TGD inspired quantum biology.

The very fact that the notion of conscious information makes sense only in this intersection supports the proposed interpretation of p-adic physics. Zero energy ontology (ZEO) and the notion of causal diamond (CD) with zero energy states having interpretation as memes in very general sense is also of central importance, and allows a quantitative formulation reducing the fundamental bio-rhythms to fundamental elementary particle time scales. The hierarchy of Planck constants as an explanation of dark matter and energy as macroscopic quantum phases even in astrophysical scales and implying that dark matter is a key actor in the drama of life is the third key element.

In this chapter the implications of this vision are studied from the point of view of cognitive consciousness. The basic ideas behind the proposed vision about intentionality and cognition are following.

1. p-Adic space-time sheets are identified as the correlates of cognition and intention. The possibility to identify the inherent non-determinism of the p-adic field equations as the non-determinism of imagination makes this identification attractive. Only the p-adic space-time sheets in the intersection of real and p-adic worlds allow the transformation of intentions to actions and sensory input to cognitions. Cognitions and intentions are related by time reversal in zero energy ontology. The common algebraic points of real and p-adic partonic 2-surfaces in the algebraic extension or rationals guaranteing that the representation of 2-surface makes sense both in real and p-adic senses define fundamental cognitive representations as finite point sets.

2. The "phase transition" of a p-adic space-time sheet to a real space-time sheet taking place in quantum jump between quantum histories corresponds to the transformation of a thought into action or sensory experience (during dreams and hallucinations) whereas the reverse transformation corresponds to the transformation of the sensory input into cognition. This transition can be thought to occur in the intersection of real and p-adic worlds where the mathematical representations of partonic 2-surface make sense both in real and p-adic sense. Motor action would correspond to the transformation of p-adic space-time sheets to their real counterparts and during sensory experience the reversal of this transformation would take place. In zero energy ontology these transformations could reduce to quark and lepton level as is suggested by the fact that the time scales assignable to quarks and leptons correspond to 1 ms and .1 s defining fundamental time scales of nerve pulse activity and EEG.

3. The obvious question is how to test p-adic physics empirically. First of all, thinking could be interpreted as p-adic sensory experiencing. Hence the reduction of theories–experimental science dichotomy to p-adic–real dichotomy seems natural: just like experimental science is an extension of everyday real sensory experience, theories represent an extension of everyday p-adic sensory experience (common sense thinking). Thus the basic test is how well p-adic physics based theories describe cognition. Secondly, the p-adic models for physical systems are strictly speaking models for cognitive models for real physics. The successes of these highly predictive models (consider only p-adic elementary particle mass calculations involving only very few integer valued parameters) supports the vision about p-adic physics as physics of cognition. p-Adic–real phase transitions as models for how thought is transformed to action and sensory input to thought provide a further testing ground for the new paradigm.

The following topics are discussed in the chapter.

1. The relationship between p-adic physics, intentionality, and cognition are discussed on general level. Basic cognitive functions such as imagination, hallucinations, formation of cognitive representations, Boolean mind, and learning are discussed in this conceptual framework.

2. Possible - necessarily indirect - evidence for p-adic cognition is considered.

3. In the mathematical sections the relationship between intentionality, cognition and number theory is discussed. Also the relation between p-adic and real physics is discussed at general level with basic vision being that the intersection of real and p-adic space-time sheets in the intersection of real and p-adic worlds consists of points belonging to the algebraic extension of rational needed to guarantee that the mathematical representation of the partonic 2-surface makes sense both in real and p-adic sense.

4. Frontal lobes are known to be the seat of the higher level intentional action and are discussed from p-adic point of view.

5. A generalization of the memetic code to cognitive codes is discussed and some proposals about codes are made. This generalization is based on p-adic length scale hypothesis. If the time scales involved correspond to time scales assignable to the CDs of the known elementary particles, the generalization is not favored. On the other hand, dark matter sector could allow entire fractal hierarchy of elementary particle physics whose existence is reflected as fundamental bio-rhytms and cognitive codes.

6. The intersection of real and p-adic partonic 2-surfaces defining space-like cognitive representations consist of algebraic points. The hypothesis that these intersections obey various kind of symmetries identifiable as molecular symmetries is discussed.

1.6.4   PART IV: PARANORMAL PHENOMENA

Quantum Model of Paranormal Phenomena

The general quantum model for bio-systems leads to a model for bio-control which applies to a very wide variety of hard-to-understand bio-chemical phenomena such as molecular recognition mechanisms, water memory, and homeopathy and leads to a generalization of genetic code explaining the mystery of introns. The same model generalizes to a model of paranormal phenomena such as psychokinesis, remote sensing, remote healing, telepathy, communications with deceased, and instrumental transcommunications. The basic difference is that magnetic body receives information and controls "foreign" biological (or even magnetic) body or "dead" matter system.

The basic notions of the 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.

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. The hierarchy of values of Planck constant would make possible this process in long time and length scales.

1. Magnetic mirrors (ME-magnetic flux tube pairs) 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 magnetic body and active strand receiving control commands leading to various forms of gene expresion. MEs are ideal for the transfer of both classical information and momentum.

2. p-Adic MEs represent the transfer of a mere intent and real MEs represent a transfer of action. p-Adic ME can be transformed to real ME either by receiver or some higher level magnetic self. This makes sense only in the intersection of real and p-adic worlds.

3. The transfer of intent gives rise to mechanism of remote interaction which can act both endo- and exogenously. Magnetic mirrors 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!).

4. The ME-magnetic flux tube pair 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 "dead" 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 magnetic body and the receival of sensory input from biological body by magnetic body. Hypnosis would be one example of this kind of interaction.

2. Remote mental interactions in the case "dead" 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. Negentropic entanglement 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 "dead". 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 multibrained and -bodied higher level colletive 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 lelel 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 multibrained 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.

TGD Based Model for OBEs

Out-of-body experiences (OBEs) are often understood as experience of seeing oneself from a position outside of the body. OBEs are poorly understood in the framework of neuro science and pose a challenge for the reductionistic world view.

In TGD framework the notion of magnetic body provides an attractive starting point in attempts to understand what OBEs and related experiences are. The basic idea is that magnetic

body serves effectively as a mirror defining a third person view as a cognitive representation also in ordinary wake-up state and that during OBEs this representation becomes sensory representation. Magnetic body need not always be a personal magnetic body but could correspond to a magnetic body receiving information from several brains (collective consciousness), magnetic body of another person, or be even associated with "dead" matter.

The progress in identifying dark matter as a phase of matter with large value of Planck constant making possible macroscopic quantum coherence has led to the vision about dark matter at magnetic flux quanta as quantum controller of ordinary matter in living systems. The Bose-Einstein condensates of dark photons decaying via decoherence to ordinary photons mediate interactions between ordinary and dark matter and the hypothesis is that dark photon "laser" beams from body and brain reflected at magnetic flux quanta give rise to third person aspect of consciousness which in OBEs and related experiences are realized as sensory representations. The identification of bio-photons as end products of the de-coherence of dark photon beams is natural.

Zero energy ontology and the notion of causal diamond (or CD defined roughly as the intersection of future and past directed light-cones) brings additional quantitative ingredients to the model. Sub-CDs define embedding space ($M^4 \times CP_2$) correlates for selves and by holography the 2-D partonic 2-surfaces at the light-like future and past boundaries of CDs are the ultimate space-time correlates for mental images. The moduli space for CDs makes possible a more detailed view about sensory representations.

A further new element is the vision about life as something in the intersection of real and p-adic worlds. The most important outcome is that the notion of number theoretic entanglement negentropy making sense in this situation is positive so that entanglement carries conscious information. The fusion of selves (in particular mental image) by negentropic entanglement is experienced as expansion of consciousness. It is negentropic entanglement between parts of biological body and corresponding parts of the magnetic body and biological body which makes living system living. This negentropic entanglement between magnetic body and biological body is important also for OBEs.

The model leads also to a model for dreams, hallucinations, sensory feedback from brain to sensory organs, and directed attention. Concrete models for how dark photons can give rise to experiences in various sensory modalities such as vision, hearing, olfaction, and tactile senses, are proposed.

Part I

BASIC IDEAS OF TGD INSPIRED THEORY OF CONSCIOUSNESS

Chapter 2

Matter, Mind, Quantum

2.1 Introduction

Topological Geometro-Dynamics (TGD) is a unified theory of fundamental interactions. TGD involves a quite far-reaching generalization of the space-time concept and, apart from the notion of quantum jump, reduces quantum theory to infinite-dimensional geometry. Quantum TGD requires the introduction of several new mathematical tools and concepts, in particular p-adic numbers.

TGD based theory of consciousness has developed gradually during the last fifteen years side by side with TGD based quantum measurement theory. For a summary of TGD and p-adic aspects of TGD see [K117, K62].

The emergence of the notions of zero energy ontology (ZEO) and hierarchy of Planck constants together with the increased understanding of the special features of number theoretical universality have led to a considerable deepening of the understanding during last half decade. The basic concepts and ideas of TGD based theory of consciousness as I would have formulated them around 2005 are introduced first. After that the ideas that have appeared during the period 2005-2014 are briefly summarized.

2.1.1 Basic Ideas Of TGD Inspired Theory Of Consciousness

In the following basic ideas of TGD inspired theory of consciousness as they were formulate for about half decade ago are summarized.

Identification of quantum states as quantum histories and the notion of quantum jump

General coordinate invariance (GCI) forces the identification of the quantum states as quantum histories rather than time=constant snapshots of single quantum history. Quantum history can be regarded as a classical spinor field in the world of all classical worlds (WCW) so that rather abstract concept is in question. This identification has several important consequences.

1. The possibility to regard unitary process followed by state function collapse as a quantum jump between quantum histories solves the basic paradox posed by the determinism of the Schrödinger equation contra non-determinism of the state function collapse.

2. A radical reconsideration of the concepts of psychological time and observer becomes necessary and forces a profound generalization of the standard views about time.

If quantum jump occurs between two different time evolutions of Schrödinger equation (understood here in very metaphoral sense) rather than interfering with single deterministic Schrödinger evolution, the basic problem of quantum measurement theory finds a resolution. The interpretation of quantum jump as a moment of consciousness means that volition and conscious experience are outside space-time and state space and that quantum states and space-time surfaces are "zombies". Quantum jump would have actually a complex anatomy corresponding to unitary process U, state function reduction and state preparation at least.

Negentropy Maximization Principle (NMP) codes for the dynamics of standard state function reduction and states that the state function reduction process following U-process gives rise to maximal reduction of entanglement entropy at each step. In the generic case this implies decomposition of the system to unique unentangled systems and the process repeats itself for these systems. The process stops when the resulting subsystem cannot be decomposed to a pair of free systems since energy conservation makes the reduction of entanglement kinematically impossible in the case of bound states.

The notion of self

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

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

There exists an infinite hierarchy of number theoretical entropies making sense for rational or even algebraic entanglement probabilities. In this case the entanglement negentropy can be negative so that negentropy maximization principle (NMP) favors generation of negentropic entanglement, which need not be bound state entanglement in standard sense. This leads to the vision that negentropic entanglement defines kind of Akashic records, kind of library storing potentially conscious information becoming conscious in interaction free measurement. Akashic records could define self model as opposed to self. Consistency with standard quantum measurement theory requires that density matrix for negentropic entanglement is projector and thus equal to a unit matrix associated to a unitary entanglement matrix characterizing quantum computation.

Self is assumed to experience sub-selves as mental images identifiable as "averages" of their mental images. This implies the notion of ageing of mental images as being due to the growth of ensemble entropy as the ensemble consisting of quantum jumps (sub-sub-subselves) increases.

The sub-selves of two unentangled selves can entangle although selves remain unentangled. This is possible by the modification of the subsystem concept forced by the p-adic length scale cutoff. The entanglement of sub-selves means fusion and sharing of mental images providing a universal telepathy like quantum communication mechanism and presumably making possible both molecular, cellular, and human societies.

Generalization of quantum measurement theory to a theory of consciousness

One must reformulate quantum measurement theory. The hypothesis that each quantum jump involves localization in the so called zero modes having interpretation as classical variables characterizing the observable geometric properties of the space-time surface, and thus of external macroscopic observer, together with an additional condition guaranteeing that the density matrix characterizing the entanglement between quantum fluctuating degrees of freedom and zero modes is diagonal, implies standard quantum measurement theory. Needless to emphasize, the reduction of the standard quantum measurement theory to fundamental quantum physics is a triumph of TGD approach.

This is however not the whole story. The standard quantum measurement is followed by a cascade self measurements inside self, which reduces entanglement between some subsystem and its complement in quantum fluctuating degrees of freedom: again a measurement of the density matrix is in question. This cascade is equivalent with the process of state preparation which is

a phenomenological notion in the standard quantum measurement theory. The dynamics of self measurement is governed by Negentropy Maximization Principle (NMP), which specifies which subsystems are subject to quantum measurement in a given quantum jump. NMP can be regarded as a basic law for the dynamics of quantum jumps and states that the information content of the conscious experience is maximized. In p-adic context NMP dictates the dynamics of cognition.

Zero energy ontology changes considerably the interpretation of the unitary process and state function reduction. In zero energy ontology quantum states are replaced with zero energy states defined as superpositions of pairs of positive and negative energy states identified as counterparts of initial and final states of a physical event such as particle scattering. Zero energy ontology is ideal from the point of view of consciousness and intentionality. Everything can be in principle be created from vacuum so that several frustrating paradoxes plaguing positive energy ontology disappear. Also the quantum jumps between p-adic and real quantum states suggested to correspond to intentional action are mathematically sensible in zero energy ontology.

The matrix defining entanglement between positive and negative - christened as M-matrix- is the counterpart of the ordinary S-matrix but need not be unitary. It can be identified as a "complex square root" of density matrix expressible as a product of positive square root of diagonal density matrix and unitary S-matrix. Quantum TGD can be seen as defining a "square root" of thermodynamics, which thus becomes an essential part of quantum theory.

U-matrix is defined between zero energy states and cannnot therefore be equated with the S-matrix used to describe particle scattering events. Unitary conditions however imply that U-matrix can be seen as a collection of M-matrices labelled by zero energy states so that the knowledge of U-matrix implies the knowledge of M-matrices. A natural guess is that U is directly related to consciousness and the description of intentional actions. For positive energy ontology state function reduction would serve as a state preparation for the next quantum jump. In zero energy ontology state function preparation and reduction can be assigned to the positive and negative energy states defining the initial and final states of the physical event. The reduction of the time-like entanglement during the state function reduction process corresponds to the measurement of the scattering matrix. In the case of negentropic time-like entanglement the reduction process is not random anymore and the resulting dynamics is analogous to that of cellular automata providing a natural description of the dynamics of self-organization in living matter.

Zero energy ontology leads to a precise identification of the subsystem at space-time level. General coordinate invariance in 4-D sense means that 3-surfaces related by 4-D diffeomorphisms are physically equivalent. It is conventient to perform a gauge fixing by a introducing a natural choice for the representatives of the equivalence classes formed by diffeo-related 3-surfaces.

1. Light-like 3-surfaces identified as surfaces at which the Minkowskian signature of the induced space-time metric changes to Euclidian one - wormhole contacts- are excellent candidates in this respect. The intersections of these surfaces with the light-like boundaries of CD defined 2-D partonic surfaces. Also the 3-D space-like ends of space-time sheets at the light-like boundaries of CDs are very natural candidates for preferred 3-surfaces.

2. The condition that the choices are mutually consistent implies effective 2-dimensionality. The intersections of these surfaces defining partonic 2-surface plus the distribution of 4-D tangent spaces at its points define the basic dynamical objects with 4-D general coordinate invariance reduced to 2-dimensional one. This effective 2-dimensionality was clear from the very beginning but is only apparent since also the data about 4-D tangent space distribution is necessary to characterize the geometry of WCW and quantum states. The descriptions in terms of 3-D light-like or space-like surfaces and even in terms of 4-D surfaces are equivalent but redundant descriptions. This has far reaching implications for the concrete mathematical realization of number theoretic universality [K56].

As far as consciousness is considered effective 2-dimensionality means holography and could relate to the fact that at least our visual experience is at least effectively 2-dimensional.

2.1.2   P-Adic Numbers And Consciousness

p-Adic number fields R_p (one number field for each prime $p = 2, 3, 5, ...$) are analogous to real numbers but differ from them in that p-adic numbers are not well-ordered. p-Adic numbers play

an absolutely essential role in the formulation of quantum TGD and of TGD inspired theory of consciousness. The inherent non-determinism of p-adic differential equations motivates the identification of the p-adic space-time sheets as cognitive representations of ordinary matter with p-adic non-determinism identified as non-determinism of imagination. Mind-matter duality is realized at the level of space-time geometry and mind stuff corresponds to p-adic regions of space-time. TGD Universe performs self mimicry in all length scales. Besides p-adic nondeterminism there is nondeterminism of Kähler action: these two nondeterminisms allow to represent some aspects of quantum jump sequences, that is contents of consciousness of selves, at space-time level cognitively and symbolically (language). This in turn makes possible self referentiality of consciousness: it is possible to become conscious about being conscious about...

Negentropy Maximization Principle and the notion of self

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

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

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

p-Adic physics as correlate for cognition leads to the notion of negentropic entanglement possible in the intersection of real and p-adic worlds involves experience about expansion of consciousness. Consistency with standard quantum measurement theory forces negentropic entanglement to correspond to density matrix proportional to unit matrix. Unitary entanglement typical for quantum computing systems gives rise to unitary entanglement.

The first state function reduction - wake-up of self- at given boundary of CD is a hierarchical cascade proceeding from long to short scales. The reduction process can stop also if the self in question allows only decompositions to pairs systems with negentropic entanglement. This does not require that that the system forms a bound state for any pair of subsystems so that the systems decomposing it can be free (no binding energy). This defines a new kind of bound state not describable as a jail defined by the bottom of a potential well. Subsystems are free but remain correlated by negentropic entanglement.

The ordinary state function reductions imply dissipation crucial for self organization and quantum jump could be regarded as the basic step of an iteration like process leading to the asympotic self-organization patterns. One could regard dissipation as a Darwinian selector as in standard theories of self-organization. NMP thus predicts that self organization and hence presumably also fractalization can occur inside selves. NMP would favor the generation of negentropic entanglement. This notion is highly attractive since it could allow to understand how quantum self.organization generates larger coherent structures. Note that state function reduction for ne-

gentropic entanglement is highly deterministic since the number of degenerate states with same negative entanglement entropy is expected to be small. This could allow to understand how living matter is able to develop almost deterministic cellular automaton like behaviors. In ZEO this self-organization is for 4-D spatio-temporal patterns since 3-surfaces are pairs of space-like surfaces at the boundaries of CD and maxima of Kähler function are selected in the process. These temporal patterns correspond to behaviors and functions in living matter.

Positive entanglement negentropy is possible in the intersection of real and p-adic worls

Positive entanglement negentropy is possible in the intersection of real and p-adic worlds and is stable against NMP. Giving up the original ad hoc interpretation as a counterpart for bound state entanglement leads to a beautiful vision about the role of negentropic entanglement in cognition and functioning of living matter.

1. The first form of NMP was rather naive. There was no idea about the anatomy of quantum jump and NMP only stated that the allowed quantum jumps are such that the information gain of conscious experience measured by the reduction of entanglement entropy resulting in the reduction of entanglement between the subsystem of system and its complement is maximal. Later it became clear that quantum jump has a complex anatomy consisting of unitary process U followed by the TGD counterpart of state function reduction serving as a state preparation for the next quantum jump.

2. The attempts to formulate NMP in p-adic physics led to the realization that one can distinguish between three kinds of information measures.

    (a) In real physics the negative of the entanglement entropy defined by the standard Shannon formula defines a natural information measure, which is always non-positive.

    (b) In p-adic physics one can generalize this information measure to p-adic valued information measure by replacing the logarithms of p-adic valued probabilities with the p-based logarithms $log_p(|P|_p)$ which are integer valued and can be interpreted as p-adic numbers. This p-adic valued entanglement entropy can be mapped to a non-negative real number by the so called canonical identification $x = \sum_n x_n p^n \to \sum_n x_n p^{-n}$. In both cases a non-positive information measure results.

    (c) When the entanglement probabilities are rational numbers or at most finitely algebraically extended rational numbers one can still define logarithms of probabilities as p-based logarithms $log_p(|P|_p)$ and interpret the entropy as a rational or algebraic number. In this case the entropy can be however negative and positive definite information measure is possible. Irrespective of number field one can in this case define entanglement entropy as a maximum of number theoretic entropies S_p over the set of primes. The first proposal was that the algebraic entanglement corresponds to bound state entanglement turned out to be wrong.

3. At some stage the importance of the almost trivial fact that bound state entanglement must be kinematically stable against NMP became obvious. One can imagine that the state function reduction proceeds step by step by reducing the state to two parts in such a way that the reduction of entanglement entropy is maximal.

    (a) If a resulting subsystem corresponds to a bound state having no decomposition to free subsystems the process stops for this subsystem. The natural assumption is that subsystems lose their consciousness when U process leads to bound state entanglement whereas bound state itself can be conscious.

    (b) If the entanglement is negentropic (and thus rational or algebraic) a more natural interpretation consistent with the teaching of spiritual practices is that subsystems experience a fusion to a larger conscious entity. The negentropic entanglement between free states is stabilized by NMP and negentropically entangled states need not reside at the bottom of potential well forbidding the reduction of entanglement. This makes possible

new kinds of correlated states for which binding energy can be negative. Bound state entanglement would be like the jail of organized marriage and negentropic entanglement like a love marriage in which companions are free to leave but do not what it. The existence of this kind of negentropic entanglement is especially interesting in living matter, where metabolism (high energy phosphate bond in particular) and the stability of DNA and other highly charged polymers is poorly understood physically: negentropic entanglement could be responsible for stabilization making possible the transfer of metabolic energy [**?**].

4. For the negentropic entanglement the outcome of the state function reduction ceases to be random as it is for the standard definition of entanglement entropy. Note however that U process as a creative act yielding superposition of possibilities from which state function reduction selects leaves means non-determinism. This has far reaching consequences. Ordinary state function reductions for an ensemble of systems lead to a generation of thermodynamical entropy and this explains the second law of thermodynamics. In the case of negentropic entanglement situation changes and the predicted breaking of second law of thermodynamics provides a new view to understand self-organization [K87]. and living matter could be identified as something residing in the intersection of real and p-adic worlds where p-adic intentions can be transformed to real actions.

5. One particular choice involved with state function reduction process could be the choice between generic entanglement and number theoretic entanglement possible only in the intersection of p-adic and real WCWs. If the choice is the generic entanglement, system ends up either to an unentangled state with maximal conscious freedom or to a bound state with a loss of consciousness. If the choice is algebraic entanglement, system ends up to negentropic entanglement and correlations with external world and experiences an expansion of consciousness. Maybe ethical choices are basically choices between these two options. Also positive emotions like love and experience of understanding could directly relate to various aspects of the negentropic entanglement.

2.1.3   TGD Inspired New Physics And Consciousness

ZEO, number theoretical universality, and hierarchy of Planck constants represent ideas, which have developed strongly during last half decade and have led to a considerable refinement of the overall view about consciousness and inspired also a vision about life as something residing in the intersection of real and p-adic worlds [K56].

TGD based space-time concept and the existence of macroscopic quantum phases

TGD implies a radical generalization of the space-time concept in all length and time scales. The concept of many-sheeted space-time leads to fresh proposals for how biosystems manage to be macroscopic quantum systems. Examples of these mechanisms are so called wormhole superconductivity, electronic high T_c super-conductivity, neutrino super-conductivity, ionic and a mechanism for generating coherent light and gravitons [K17, K18, K18, K68]. The notion of many-sheeted ionic equilibrium summarizes the basic vision about quantum control and coordination according to which the space-time sheets associated with the superconducting magnetic flux tube structures control ordinary biomatter at the atomic space-time sheets.

The so called massless exremals (MEs), which can be regarded as "topological light rays", are carriers of especially important exmple of macroscopic quantum states. The lightlike boundaries of MEs act as quantum holograms and carry representations of the superconformal and super-symplectic algebras. These states have gigantic almost-degeneracies, and are genuine quantum gravitational states (state functionals in the configuration space of 3-surfaces, "the world of classical worlds") and thus correspond to higher abstraction level than ordinary quantum states. MEs can control the supercurrents at superconducting magnetic flux tube structures by magnetic interactions, act as Josephson junctions, and induce magnetic quantum phase transitions. Therefore the quantum holograms associated with MEs are excellent candidates for quantum correlates of higher level consciousness.

Quantum criticality

The systems possessing self correspond to macroscopic quantum phases. In standard physics context the existence of the required macroscopic quantum phases is not at all obvious whereas the new physics implied by TGD predicts their existence. The point is that the Universe according to TGD is a quantum critical system. Quantum criticality is mathematically very similar to thermodynamical criticality and implies long range quantum correlations in all length scales. This in turn implies the existence of macroscopic quantum phases with large value of effective Planck constant and able to have negentropic entanglement - say entanglement characterized by a unitary matrix. TGD Universe is also quantum spin glass with state degeneracy broken only by the classical gravitational energy of the space-time sheets having same induced Kähler field.

This degeneracy basically makes it possible to have quantum coherence over time periods longer than CP_2 time of order 10^{-39} seconds characterizing the duration of single quantum jump so that biosystems can act as quantum computers in macroscopic time scales.

The understanding of quantum criticality has developed dramatically after writing the above lines.

1. The physical interpretation for the hierarchy of Planck constants would be in terms of a hierarchy of quantum criticalities concretizing the vision about quantum criticality of TGD Universe. TGD Universe would be like a hill at the top of a hill at .... The larger the Planck constant the larger the size scale of the hill. Criticality involves crucially the notion of conformal gauge symmetry. The conformal symmetries correspond to sub-algebra of the full algebra isomorphic to it acting as gauge symmetries and with conformal weights coming as n-multiples of those for the full symmetry algebra. $h_{eff} = n \times h$ would label the levels of the hierarchy. This hierarchy would correspond directly to the hierarchy of measurement resolutions and to hierarchy of hyperfinite factors of type II_1 (HFFs). Also now one obtains infinite hierarchies of symmetry breakings and the identification with the hierarchies of inclusions of HFFs is compelling. Hence various hierarchies reflect the same underlying phenomenon.

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

Dark matter hierarchy

Basic objection against quantum theories of consciousness and biology relate to the smallness of Planck constant making difficult to imagine macroscopic quantum coherence in the scales of living matter. Zero energy ontology partially resolves the problem by assigning to elementary particles macroscopic length and time scales. For instance, the time scale assignable to the CD of electron is.1 seconds defining the fundamental bio-rhythm.

The anomalies related to the interaction of ELF em fields on living matter and Nottale's observation that planetary orbits correspond approximately to Bohr orbits with a gigantic value of Planck constant led to the hypothesis that Planck constant has a discrete spectrum and can have arbitrarily large values [K97, K33]. The identification of dark matter as phases having large value of Planck constant [K97, K36, K32] led to a vigorous evolution of ideas. Entire dark matter hierarchy with levels labelled by increasing values of Planck constant is predicted, and in principle TGD predicts the values of Planck constant if physics as a generalized number theory vision is accepted [K36].

The hierarchy of Planck constants is realized in terms of a generalization of the causal diamond $CD \times CP_2$, where CD is defined as an intersection of the future and past directed light-

cones of 4-D Minkowski space M^4. $CD \times CP_2$ is generalized by gluing singular coverings and factor spaces of both CD and CP_2 together like pages of book along common back, which is 2-D sub-manifold which is M^2 for CD and homologically trivial geodesic sphere S^2 for CP_2 [K36]. The value of the Planck constant characterizes partially the given page and arbitrary large values of $\hbar$ are predicted so that macroscopic quantum phases are possible since the fundamental quantum scales scale like $\hbar$. The most general spectrum comes in rational multiples of standard value of Planck constant which corresponds to the unit of rationals. For CDs the scaling of Planck constants means scaling of the size of CD. This could explain why the rational multiples of the fundamental frequency are so special for music experience.

All particles in the vertices of Feynman diagrams have the same value of Planck constant so that particles at different pages cannot have local interactions. Thus one can speak about relative darkness in the sense that only the interactions mediated by the exchange of particles and by classical fields are possible between different pages. Dark matter in this sense can be observed, say through the classical gravitational and electromagnetic interactions. It is in principle possible to photograph dark matter by the exchange of photons which leak to another page of book, reflect, and leak back. This leakage corresponds to $\hbar$ changing phase transition occurring at quantum criticality and living matter is expected carry out these phase transitions routinely in bio-control. This picture leads to no obvious contradictions with what is really known about dark matter and to my opinion the basic difficulty in understanding of dark matter (and living matter) is the blind belief in standard quantum theory. These observations motivate the tentative identification of the macroscopic quantum phases in terms of dark matter and also of dark energy with gigantic "gravitational" Planck constant.

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by the 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.

At least dark matter could be a key player in quantum biology.

1. Dark matter hierarchy and p-adic length scale hierarchy would provide a quantitative formulation for the self hierarchy. To a given p-adic length scale one can assign a secondary p-adic time scale as the temporal distance between the tips of the CD. For electron this time scale is .1 second, the fundamental bio-rhythm. For a given p-adic length scale dark matter hierarchy gives rise to additional time scales coming as $\hbar/\hbar_0$ multiples of this time scale.

2. The predicted breaking of second law of thermodynamics chacterizing living matter - if identified as something in the intersection of real and p-adic words - would be always below the time scale of CD considered but would take place in arbitrary long time scales at appropriate levels of the hierarchy. The scaling up of $\hbar$ also scales up the time scale for the breaking of the second law.

3. The hypothesis that magnetic body is the carrier of dark matter in large $\hbar$ phase has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of [J60] [K33]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K51, 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].

If one accepts the hierarchy of Planck constants [K36]. it might be un-necessary to distinguish between self and quantum jump. The hierarchy of Planck constants interpreted in terms of dark matter hierarchy predicts a hierarchy of quantum jumps such that the size of space-time region contributing to the contents of conscious experience scales like $\hbar$. Also the hierarchy of space-time sheets labeled by p-adic primes suggests the same. That sequence of sub-selves/sub-quantum jumps

are experienced as separate mental images explains why we can distinguish between digits of phone number. The irreducible component of self (pure awareness) would correspond to the highest level in the "personal" hierarchy of quantum jumps and the sequence of lower level quantum jumps would be responsible for the experience of time flow. Entire life cycle could correspond to single quantum jump at the highest(?) level of the personal self hierarchy and pure awareness would prevail during sleep: this would make it possible to experience directly that I existed yesterday.

There are thus two definitions of self. The first definition introduces self as a notion separate from quantum jump. Second definition reduces the notion of self to a fractal hierarchy of quantum jumps. The equivalence between two definitions of the notion of self will be proposed.

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` [L17].

2.2 What Are The Problems Of Quantum Mind Theories?

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

2.2.1 Some Philosophical Problems Of Quantum Physics

"Monism, dualism, or something else?" is the first basic question. Monism appears as two variants which are mirror images. Materialism has the problem that consciousness becomes something totally reducible to the state of material system so that free will must be an illusion if one believes in the deterministic laws of physics. This is in a sharp contrast to what we directly experience. In the idealistic framework one loses completely physics. The difficulty of dualism- pointed out very clearly by Chalmers [J48] - is that it is very difficult to achieve consistency with the basic laws of physics which do not allow free will. It seems that one must have something new allowing to achieve consistency of the determinism of field equations with (partially) free will.

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

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

- The notion of time is highly problematic.

  - The relationship between experienced time and the geometric time of physicist is poorly understood. Subjective time is irreversible and has only recent moment and past, geometric time is reversible and spans entire eternity. The assignment of experienced time

with a 3-D wave front shifting in the direction of geometric time direction is in conflict with Lorentz symmetry and general coordinate invariance, which do not allow to identify a unique time coordinate as the subjective time. The natural basic object in general relativity is 4-dimensional space-time region, not time=constant snapshot.

– In physics conceptual difficulties are encountered already in the phenomenological description of dissipation by adding to the reversible field equations phenomenological dissipation terms. Rather remarkably, the quantum mechanical formulas for the reaction rates in terms used to calculated dissipation coefficients involve integral over entire space-time so that quantum events have at least formally an infinite duration. Finite duration is certainly necessary by Uncertainty Principle. Somehow quantum jump seems to involve entire geometric eternity: as if it would take place between two geometric eternities.

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

2.2.2   Basic Philosophical Problems Of Quantum Mind Theories

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

- What are the quantum correlates for consciousness? Entanglement has been proposed as a correlate of consciousness. For instance, in the orchestrated reduction approach of Hameroff and Penrose the period of consciousness ends with a state function reduction and quantum gravitation is believed to play a fundamental role in the understanding of consciousness. The believer in free will could see state function reduction or its generalization as as a natural quantum correlate for a moment of consciousness. The basic objection is that the randomness of state function reduction does not allow genuine goal directed free will. One could also argue that state function reduction generates entropy at least at the level of ensemble whereas intentional action should do just the opposite. Here one must however remember that entropy generation at the level of aspect need not mean entropy generation at the level of the member of ensemble.

- How the determinism of field equations and Schrödinger equation can be consistent with the non-determinism of the state function reduction? This question must be answered unless one is ready to give up the notion of objective reality completely or to believe in multiverse interpretation. These ways to circumvent the basic problem do not however leave much room for quantum consciousness theorizing. The closely related question about the relationship between experienced time and time of physicist has been already mentioned.

- What is the quantum correlate for the notion of self? The quantum notion of self should be a generalization of the notion of observer which in quantum measurement theory still remains a structureless outsider.

- What conscious information is? Can one give it a mathematical measure? Can one measure physically the amount of conscious information? Unfortunately the recent day physics can only provide measure for dis-information as Shannon entropy and the best that subsystem can achieve is no information at all if this picture is accepted.

- There is a bundle of questions about the quantum correlates of various aspects of conscious experience. For instance, what is the quantum correlate of mental image, and what are the quantum correlates of cognition, Boolean mind, sensory qualia, memory, and of emotions?

- An especially challenging question relates to the quantum correlate for the self referentiality of consciousness making possible reflective levels of consciousness. What it means physically to be conscious about what one is (or perhaps only "was") conscious? Jack Sarfatti was well aware about this problem and in his dualistic approach talked about feedback loop but still used a trick in which one divides various fields to matter-like and mind-like.

2.2.3   Basic Problems Of Quantum Biology And Quantum Neuroscience

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

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

- What distinguishes between living and dead matter is certainly the fundamental question. In standard biology based on materialistic philosophy one tries to reduce the distinction to a list of properties which as such can be possessed by inanimate matter. Ability to replicate, to process information, to communicate, to form representations about the external world, the ability to self-organize to increasingly complex configurations, intentional behavior, ability to co-operate, ... could be properties of this kind. Up to self-organization the reduction seems plausible. It is easy to model self-organization (by say cell automatons) but it this dynamics is like the dynamics of traffic rules and neither classical nor quantum dynamics resembles it. Intentional behavior is impossible to understand in classical physics unless one claims that it is a mere illusion. This is the case also in quantum physics as we understand it since the randomness of the outcome of state function reduction seems to be in conflict with intentional behavior. Here one must however keep in mind that the individual subsystem performing a state function reduction could quite well experience it as an intentional action. In any case, standard view about state function reduction makes it difficult to co-operative behavior.

- What distinguishes between biochemistry and organic chemistry? For instance, how biomolecules can find themselves in the dense soup of biomolecules and how can one understand the effectiveness of bio-catalysts? One might think that these problems are well-understood since we have learned what happens in DNA replication, transcription, and translation and we know the complex reaction pathways. The dynamics involved is very much like the symbolic dynamics of society (one can predict the day of practicizing professional from knowing his profession but not from the knowledge of initial data of every possible elementary particle in his body). But what makes the soup of biomolecules a molecular society obeying a dynamics based on symbols? The description of biochemistry in terms of kinematics allows to construct complex reaction pathways based on the idea that each step of the reaction pathway requires a key which fits to a lock of a room containing a key to the lock to the next room [I44] but can one really deduce this kind of kinematics from standard quantum theory?

- Both biology and neuroscience characterizes subsystems of biological systems and brain in terms of functions they possess and one should also understand whether and how the quantum counterparts of functions emerge. The identification of various functions as time evolution of standard self-organization patterns is certainly a part of the answer. But what self-organization means? Conscious information is certainly the key notion but is the existing quantum theory able to characterize it?

- At the level of brain one of the key questions concerns EEG. Since EEG correlates strongly with the contents of consciousness it is difficult to believe that it is random side product of neural activity. What is then the real role of neuronal activity and EEG and its variants? Why EEG is needed? Signalling related to communication and control is what comes first in

mind. But why this kind of signalling would be needed. Brain sends (receives) information but who receives (sends) it?

- How macroscopic quantum coherence is achieved allowing quantum super-positions in long time scales? How stable quantum entanglement is achieved? These are difficult problems if one wants to understand quantum mind without generalizing quantum theory itself. Planck constant is simply too small so that dissipation rates are too high and coherence times and lengths are too short. Should physicists adopt a humbler attitude and consider seriously the possibility that the existing physics is not enough and try to learn from biology instead of saying that living systems are just complex?

2.2.4   Could Anomalies Help?

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

- In quantum mind approach EEG should be a quantal phenomenon since it correlates with consciousness. From the basic formula $E = hf$ of quantum mechanics the energies of EEG photons are however ridiculously small as compared to the thermal energy at physiological temperatures. The strange quantal looking effects of ELF photons on vertebrate (why just vertebrate?!) brain at frequencies which correspond to cyclotron frequencies of biologically important ions such as Ca^{++} are however an experimental fact (see for instance [J44]). The effects of magnetic field patterns on brain studied by Persinger and collaborators represent also an example of this kind of strange effects [J108]. The strange findings about the behavior of cell membrane [I40] suggest that ionic currents do not dissipate much. The recently discovered burning of water when irradiated by radio wave photons [D11, D2] suggests that energetically these photons behave like photons of visible light. The recent findings about photosynthesis [I17] suggest quantum coherence in cellular length scale.

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

- Also bio-photons [I37] correlate with the state of living system but are poorly understood in the existing theoretical framework.

- Libet's findings about strange time delays associated with the passive aspects of consciousness serve also as a hint. Our sensory data has age which is a fraction of second and corresponds to a photon wavelength $\lambda = cT$ to a length scale, which is of order of Earth size. As if sensory data would be communicated somewhere. Where?

- Cyclotron frequencies of biologically important ions in a magnetic field.2 Gauss (smaller than the nominal value of.5 Gauss of the Earth's magnetic field) are involved with the effects of ELF radiation on vertebrate brain. Also Schumann resonances are reported to have effects on brain. Are some kind of magnetic field structures involved? Earth's magnetic field and perhaps also the magnetic field patterns associated with biological system itself with $B = 2B_E/5$ for one important level in the hierarchy? As noticed in [J122], the cyclotron energy scale of electron in pT range is in EEG range and pT range indeed characterizes the magnetic field associated with brain activity. Do also these magnetic structures carry Cooper pairs of electrons?

- ADP-ATP machinery is the core of energy metabolism and its description involves the problematic notion of high energy phosphate bond [I10]. Does this notion really reduce to standard quantum theory?

- The chiral selection of biomolecules in living matter [I4, I72] means a large parity breaking. This is a complete mystery in standard model which predicts extremely small parity breaking effects. Therefore chiral selection is extremely valuable anomaly helping to guess what kind of new physics might be involved with living matter. Somehow it seems that the parity breaking effects which are large in electro-weak scale appear in immensely zoomed up scales (scaling factors of order 10^{10} would be involved)

2.3   Some Aspects Of Quantum TGD

In the following I summarize very briefly those basic notions of TGD which are especially relevant for TGD inspired consciousness theory and quantum biology. The representation will be practically formula free. The article series published in Prespace-time Journal [L10, L11, L14, L15, L12, L9, L13, L16] describes the mathematical theory behind TGD. The seven books about TGD [K117, K111, K21, K62, K66, K86, K100] provide a detailed summary about the recent state of TGD.

2.3.1   New Space-Time Concept

The physical motivation for TGD was what I have christened the energy problem of General Relativity. The notion of energy is ill-defined because the basic symmetries of empty space-time are lost in the presence of gravity. The way out is based on assumption that space-times are imbeddable as 4-surfaces to certain 8-dimensional space by replacing the points of 4-D empty Minkowski space with 4-D very small internal space. This space -call it S- is unique from the requirement that the theory has the symmetries of standard model: $S = CP_2$, where CP_2 is complex projective space with 4 real dimensions [L16], is the unique choice.

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

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

1. Space-time decomposes into space-time sheets with finite size: this lead to the identification of physical objects that we perceive around us as space-time sheets. For instance, the outer boundary of the table is where that particular space-time sheet ends. Besides sheets also string like objects and elementary particle like objects appear so that TGD can be regarded also as a generalization of string models obtained by replacing strings with 3-D surfaces.

2. Elementary particles are identified as topological inhomogenuities glued to these space-time sheets. In this conceptual framework material structures and shapes are not due to some mysterious substance in slightly curved space-time but reduce to space-time topology just as energy- momentum currents reduce to space-time curvature in general relativity.

3. Also the view about classical fields changes. One can assign to each material system a field identity since electromagnetic and other fields decompose to topological field quanta. Examples are magnetic and electric flux tubes and flux sheets and topological light rays representing light propagating along tube like structure without dispersion and dissipation making em ideal tool for communications [K68]. One can speak about field body or magnetic body of the system.

Field body indeed becomes the key notion distinguishing TGD inspired model of quantum biology from competitors. The magnetic body inherits from the biological body an onion-like fractal structure. Each part of the magnetic body can be seen as an intentional agent using the corresponding part of the biological body as a motor instrument and sensory receptor. The size scale of the magnetic body is in general much larger than that of biological body. Cyclotron frequency identified as frequency of photons able to exist as oscillations at magnetic body gives an

estimate for the size of the magnetic body corresponding to a particular magnetic field strength. For 10 Hz frequency the size scale is of order Earth size. In this framework a fractal generalization of EEG and its variants provides a communication and control tool for magnetic body. The findings of Libet about time delays associated with the passive aspects and meaning that sensory data is a fraction of second old [J70] could be understood as delays due to the finite velocity of light: it takes finite time for the signal to propagate from biological body to the magnetic body.

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

2.3.2   Zero Energy Ontology

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

1. Positive and negative energy parts reside at future and past light-like boundaries of causal diamond (CD) defined as intersection of future and past directed light-cones and visualizable as double cone. The analog of CD in cosmology is big bang followed by big crunch. CDs for a fractal hierarchy containing CDs within CDs. Disjoint CDs are possible and CDs can also intersect.

2. p-Adic length scale hypothesis [?]otivates the hypothesis that the temporal distances between the tips of the intersecting light-cones come as octaves $T = 2^n T_0$ of a fundamental time scale T_0 defined by CP_2 size R as $T_0 = R/c$. One prediction is that in the case of electron this time scale is.1 seconds defining the fundamental biorhythm. Also in the case u and d quarks the time scales correspond to biologically important time scales given by 10 ms for u quark and by and 2.5 ms for d quark [K9]. This means a direct coupling between microscopic and macroscopic scales.

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

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

For thermodynamical states this is indeed the case and this leads to the idea that quantum theory in ZEO can be regarded as a "complex square root" of thermodynamics obtained as a product of positive diagonal square root of density matrix and unitary S-matrix. M-matrix defines time-like entanglement coefficients between positive and negative energy parts of the zero energy state and replaces S-matrix as the fundamental observable. In standard quantum measurement theory this time-like entanglement would be reduced in quantum measurement and regenerated in the next quantum jump if one accepts Negentropy Maximization Principle (NMP) [K56] as the fundamental variational principle. Various M-matrices define the rows of the unitary U matrix characterizing the unitary process part of quantum jump. From the point of view of consciousness

theory the importance of ZEO is that conservation laws in principle pose no restrictions for the new realities created in quantum jumps: free will is maximal.

2.3.3 The Hierarchy Of Planck Constants

The motivations for the hierarchy of Planck constants come from both astrophysics and biology. The biological motivations have been already discussed. In astrophysics the observation of Nottale [E1] that planetary orbits in solar system seem to correspond to Bohr orbits with a gigantic gravitational Planck constant motivated the proposal that Planck constant might not be constant after all [K97, K70].

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

A convenient technical manner to treat the situation is to replace embedding space with its n-fold singular covering. Canonical momentum densities to which conserved quantities are proportional would be same at the sheets corresponding to different values of the time derivatives. At each sheet of the covering Planck constant is effectively $\hbar = n\hbar_0$. This splitting to multi-sheeted structure can be seen as a phase transition reducing the densities of various charges by factor $1/n$ and making it possible to have perturbative phase at each sheet (gauge coupling strengths are proportional to $1/\hbar$ and scaled down by $1/n$). The connection with fractional quantum Hall effect [D3] is almost obvious. At the more detailed level one finds that the spectrum of Planck constants would be given by $\hbar = n_a n_b \hbar_0$.

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

1. Quantum coherence and quantum superposition become possible in arbitrary long length scales. One can speak about zoomed up variants of elementary particles and zoomed up sizes make it possible to satisfy the overlap condition for quantum length parameters used as a criterion for the presence of macroscopic quantum phases. In the case of quantum gravitation the length scale involved are astrophysical. This would conform with Penrose's intuition that quantum gravity is fundamental for the understanding of consciousness and also with the idea that consciousness cannot be localized to brain.

2. Photons with given frequency can in principle have arbitrarily high energies by $E = hf$ formula, and this would explain the strange anomalies associated with the interaction of ELF em fields with living matter [J44]. Quite generally the cyclotron frequencies which correspond to energies much below the thermal energy for ordinary value of Planck constant could correspond to energies above thermal threshold.

3. The value of Planck constant is a natural characterizer of the evolutionary level and biological evolution would mean a gradual increase of the largest Planck constant in the hierarchy characterizing given quantum system. Evolutionary leaps would have interpretation as phase transitions increasing the maximal value of Planck constant for evolving species. The space-time correlate would be the increase of both the number and the size of the sheets of the covering associated with the system so that its complexity would increase.

4. The phase transitions changing Planck constant change also the length of the magnetic flux tubes. The natural conjecture is that biomolecules form a kind of Indra's net connected by the flux tubes and $\hbar$ changing phase transitions are at the core of the quantum bio-dynamics. The contraction of the magnetic flux tube connecting distant biomolecules would force them near to each other making possible for the bio-catalysis to proceed. This mechanism could be central for DNA replication and other basic biological processes. Magnetic Indra's net could be also responsible for the coherence of gel phase and the phase transitions affecting flux tube lengths could induce the contractions and expansions of the intracellular gel phase. The reconnection of flux tubes would allow the restructuring of the

signal pathways between biomolecules and other subsystems and would be also involved with ADP-ATP transformation inducing a transfer of negentropic entanglement [**?**] (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book). The braiding of the magnetic flux tubes could make possible topological quantum computation like processes and analog of computer memory realized in terms of braiding patterns [K2].

5. p-Adic length scale hypothesis and hierarchy of Planck constants suggest entire hierarchy of zoomed up copies of standard model physics with range of weak interactions and color forces scaling like $\hbar$. This is not conflict with the known physics for the simple reason that we know very little about dark matter (partly because we might be making misleading assumptions about its nature).

   Dark matter would make possible the large parity breaking effects manifested as chiral selection of bio-molecules [I4]. What is required is that classical Z^0 and W fields responsible for parity breaking effects are present in cellular length scale. If the value of Planck constant is so large that weak scale is some biological length scale, weak fields are effectively massless below this scale and large parity breaking effects become possible.

   For the solutions of field equations which are almost vacuum extremals Z^0 field is non-vanishing and proportional to electromagnetic field. The hypothesis that cell membrane corresponds to a space-time sheet near a vacuum extremal (this corresponds to criticality very natural if the cell membrane is to serve as an ideal sensory receptor) leads to a rather successful model for cell membrane as sensory receptor with lipids representing the pixels of sensory qualia chart. The surprising prediction is that bio-photons [I37] and bundles of EEG photons can be identified as different decay products of dark photons with energies of visible photons. Also the peak frequencies of sensitivity for photoreceptors are predicted correctly [K81].

2.3.4   P-Adic Physics And Number Theoretic Universality

p-Adic physics [K104, K62] has become gradually a key piece of TGD inspired biophysics. Basic quantitative predictions relate to p-adic length scale hypothesis and to the notion of number theoretic entropy. Basic ontological ideas are that life resides in the intersection of real and p-adic worlds and that p-adic space-time sheets serve as correlates for cognition.

p-Adic number fields

p-Adic number fields Q_p [A16] -one for each prime p- are analogous to reals in the sense that one can speak about p-adic continuum and that also p-adic numbers are obtained as completions of the field of rational numbers. One can say that rational numbers belong to the intersection of real and p-adic numbers. p-Adic number field Q_p allows also an infinite number of its algebraic extensions. Also transcendental extensions are possible. For reals the only extension is complex numbers.

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

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

Physical and biological motivations for p-adic number fields

The physical motivations for p-adic physics came from the observation that p-adic thermodynamics -not for energy but infinitesimal scaling generator of so called super-conformal algebra [A5] acting as symmetries of quantum TGD [K111] - predicts elementary particle mass scales and also masses correctly under very general assumptions [K62]. In particular, the ratio of proton mass to Planck mass, the basic mystery number of physics, is predicted correctly. The basic assumption is that the preferred primes characterizing the p-adic number fields involved are near powers of two: $p \simeq 2^k$, k positive integer. Those nearest to power of two correspond to Mersenne primes $M_n = 2^n - 1$. One can also consider complex primes known as Gaussian primes, in particular Gaussian Mersennes $M_{G,n} = (1 + i)^n - 1$.

It turns out that Mersennes and Gaussian Mersennes are in a preferred position physically in TGD based world order. What is especially interesting is that the p-adic length scale range 10 nm-5 μm contains as many as four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ assignable to Gaussian Mersennes $M_k = (1 + i)^k - 1$, $k = 151, 157, 163, 167$ [K81]. This number theoretical miracle supports the view that p-adic physics is especially important for the understanding of living matter.

p-Adic length scale hypothesis suggests the identification of metabolic energy currencies as energy quanta liberated as particle drops from space-time sheet to a larger one. These energy quanta correspond to increments of zero point kinetic energy. Metabolic energy currencies would be completely universal and exist already during the prebiotic era so that metabolic machinery would build up around this pre-existing structure. A simple (and also rough) model based on p-adic length scale hypothesis allows to estimate the increments of zero point kinetic energy. The quantum corresponding to about.5 eV has place in this hierarchy for which basic energies (those for which larger space-time sheet is very large) come as octaves of basic energy quantum [K9, K46]. These energy quanta do not have interpretation in terms of molecular transitions and there exist anomalous lines of radiation from interstellar space both in IR, visible, and UV region [K9].

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

The philosophical for p-adic numbers fields come from the question about the possible physical correlates of cognition [K64]. Cognition forms representations of the external world which have finite cognitive resolution and the decomposition of the perceptive field to objects is an essential element of these representations. Therefore p-adic space-time sheets could be seen as candidates of thought bubbles, the mind stuff of Descartes.

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

1. The intersection could consist of the rational and possibly some algebraic points in the intersection of real and p-adic partonic 2-surfaces at the ends of CD. This set is in general discrete. The interpretation could be as discrete cognitive representations.

2. The intersection could also have a more abstract meaning. For instance, the surfaces defined by rational functions with rational coefficients have a well-defined meaning in both real and p-adic context and could be interpreted as belonging to this intersection. There is strong temptation to assume that intentions are transformed to actions only in this intersection. One could say that life resides in the intersection of real and p-adic worlds in this abstract sense.

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

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

Negentropy Maximization Principle [K56] coding the basic rules of quantum measurement theory implies that negentropic entanglement can be stable against the effects of quantum jumps unlike entropic entanglement. Therefore living matter could be distinguished from inanimate matter also by negentropic entanglement possible in the intersection of real and p-adic worlds. In consciousness theory negentropic entanglement could be seen as a correlate for the experience of understanding or any other positively colored experience, say love.

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

2.4   Consciousness Theory As Extension Of Quantum Measurement Theory

TGD inspired theory of consciousness [K54] could be seen as a generalization of quantum measurement theory. The notions of quantum jump and self self are the key notions. Negentropy Maximization Principle (NMP) [K56] is the basic dynamical principle. NMP is mirror image for the second law of thermodynamics and states that the amount of conscious information gain in quantum jump is maximal. NMP reproduces standard quantum measurement theory for entropic entanglement and is in this case consistent with the second law since the non-determinism of state function reductions implies the increase of ensemble entropy.

2.4.1   Quantum Jumps As Moment Of Consciousness

The starting point of TGD inspired theory of consciousness was the identification of quantum jump as a moment of consciousness [K54].

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

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

   For the ordinary definition of entanglement entropy the process would lead to a completely unentangled situation. If the number theoretic entanglement entropy making sense for ratio-

nal (and even algebraic) entanglement probabilities is allowed, the process stops unless the reduction of entanglement reduces the entanglement entropy. Therefore the number theoretic entanglement possible in the intersection of real and p-adic worlds can be stable and living systems are able to preserve their coherence.

2. Since the reduction cascade proceeds from top to bottom, one can speak about fractal formed by quantum jumps within quantum jumps. One cannot assign to the steps of this sequence any duration of geometric time. One can however associate to it an experienced duration and it is very tempting to assume that the experienced duration increases as one climbs up in the self hierarchy.

3. Quantum jump replaces the quantum superposition of classical histories (space-time surfaces, classical worlds) with a new one whereas ordinary state function reduction would do this for time=constant snapshot of Schrödinger evolution. Quantum jump does not spoil the determinism of classical dynamics or of Dirac equation since it occurs entirely outside space-time and Hilbert space. In quantum jump both the geometric future and past (defined only within measurement resolution) are replaced with new ones. The mysterious finding of Libet [J34] that intentional action is preceded by neural activity can be interpreted in this framework without giving up the notion of free will. This raises a fascinating question about time scales in which the geometric past can be affected in quantum jump. Also memories stored in the geometric past can be affected in quantum jumps and the fact that memories are highly unstable suggest that the time scale is measured in years.

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

2.4.2   The Notion Of Self

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

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

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

There exists an infinite hierarchy of number theoretical entropies [K56] making sense for rational or even algebraic entanglement probabilities. In this case the entanglement negentropy

can be negative so that Negentropy Maximization principle (NMP) favors generation of negentropic entanglement, which need not be bound state entanglement in standard sense.

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

This leads to the vision that negentropic entanglement defines kind of Akashic records, kind of library storing conscious or potentially conscious information. According to the recent view, Akashic records could define self as opposed to self model defined in terms of memory representations relying on bits. Consistency with standard quantum measurement theory [K56] requires that density matrix for negentropic entanglement is proportional to unit matrix associated to unitary entanglement matrix associated with quantum computation. "Akashic records" would define self and would be consciously experienced.

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

By quantum classical correspondence self has also space-time correlates. One can visualize sub-self as a space-time sheet "glued" by topological sum to the space-time sheet of self. Subsystem is not described as a tensor factor as in the standard description of subsystems. Also sub-selves of selves can entangle negentropically and this gives rise to a sharing of mental images about which stereo vision would be basic example. Quite generally, one could speak of stereo consciousness. Also the experiences of sensed presence [J122] could be understood as a sharing of mental images between brain hemispheres which are not themselves entangled. This is possible also between different brains. In the normal situation brain hemispheres are entangled.

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

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

The relationship between experienced time and time of physicist is one of the basic puzzles of modern physics. In the proposed framework they are certainly two different things and the challenge is to understand why the correlation between them is so strong that it has led to their identification. One can imagine several alternative views explaining this correlation [K116, ?, K7] and it is better to keep mind open.

Basic questions

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

1. Why the contents of conscious of self comes from a finite space-time region looks like an easy question. If the contents of consciousness for sub-selves representing mental images is localized to the sub-CDs with indeed have defined temporal position inside CD assigned with the self the contents of consciousness is indeed from a finite space-time volume. This implies a new view about memory. There is no need to store again and again memories to the "brain now" since the communications with the geometric past by negative energy signals and also

time-like negentropic quantum entanglement allow the sharing of the mental images of the geometric past.

2. There are also more difficult questions. Subjective time has arrow and has only the recent and possibly also past. The subjective past could in principle reduce to subjective now if conscious experience is about 4-D space-time region so that memories would be always geometric memories. How these properties of subjective time are transferred to apparent properties of geometric time? How the arrow of geometric time is induced? How it is possible that the locus for the contents of conscious experience shifts or at least seems to be shifted quantum jump by quantum jump to the direction of geometric future? Why the sensory mental images are located in a narrow time interval of about .1 seconds in the usual states of consciousness (not that sensory memories are possible: scent memories and phantom pain in leg could be seen as examples of vivid sensory memory)?

The recent view about arrow of time

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

1. What seems clear now is the decisive role of ZEO and hierarchy of CDs, and the fact that the quantum arrow of geometric time is coded into the structure of zero energy states to a high extent. The still questionable but attractively simple hypothesis is that U matrix two basis with opposite quantum arrows of geometric time: is this assumption really consistent with what we know about the arrow of time? If this is the case, the question is how the relatively well-defined quantum arrow of geometric time implies the experienced arrow of geometric time. Should one assume the arrow of geometric time separately as a basic property of the state function reduction cascade or more economically- does it follow from the arrow of time for zero energy states or only correlate with it?

2. The state function reductions can occur both boundaries of CD. If the reduction occurs at given boundary is immediately followed by a reduction at the opposite boundary, the arrow of time alternates: this does not conform with intuitive expectations: for instance, this would imply that there are two selves assignable to the opposite boundaries!

   Zero energy states are however de-localized in the moduli space CDs (size of CD plus discrete subgroup of Lorentz group defining boosts of CD leaving second tip invariant). One has quantum superposition of CDs with difference scales but with fixed upper or lower boundary belonging to the same light-cone boundary after state function reduction. In standard quantum measurement theory the repetition of state function reduction does not change the state but now it would give rise to the experienced flow of time. Zeno effect indeed requires that state function reductions can occur repeatedly at the same boundary. In these reductions the wave function in moduli degrees of freedom of CD changes. This implies "dispersion" in the moduli space of CDs experienced as flow of time with definite arrow. This view lead to a precise definition of self as sequence of quantum jumps to the reducing to the same boundary of CD.

3. This approach codes also the arrow of time at the space-time level: the average space-time sheet in quantum superposition increases in size as the average position of the "upper boundaries" of CDs drift towards future state function reduction by state function reduction.

4. In principle the arrow of time can temporarily change but it would seem that this can occur in very special circumstances and probably takes place in living matter routinely. Phase conjugate laser beam is a non-biological example about reversal of the arrow of time. The act of volition would correspond to the first state function reduction to the opposite boundary so that the reversal of time arrow at some level of the hierarchy of selves would take place in the act of volition.

2.4.4   Quantum Correlates For Various Aspects Of Conscious Experience

The identification of quantum correlates of cognition and intentionality, of sensory qualia, Boolean mind, and of emotions [K39] represents one challenge for Quantum Mind theories. As already explained, p-adic physics, the vision about life as something residing in the intersection of real and p-adic worlds, and the notion of number theoretic entropy provide a plausible starting point when one tries to say something about the geometric and quantum correlates of cognition and intentionality. Zero energy ontology makes possible the transitions transforming p-adic zero energy states to their real counterparts and having interpretation in terms of intentional action.

1. Quantum numbers characterize quantum states. Therefore the increments ΔQ of quantum numbers for a subsystem should characterize quantum jumps and it is attractive to assign classify fundamental qualia in terms of quantum number increments. "The increments of quantum numbers for a sub-system representing self" looks innocent but what it really means is surprisingly difficult to make precise. The following attempt relies on ZEO.

   (a) For the positive energy part of state located at "lower" boundary of CD self - subsystem S - and environment E are un-entangled. At the "upper" boundary there is entanglement between S and E, and it should be able to assign qualia as quantum number increments to this entanglement.

   (b) Consider increments of color quantum numbers identified in terms of visual colors as an example. In the positive energy state color quantum numbers for an unentangled subsystem S vanish by color confinement. In negative energy state they can be non-vanishing for S but vanish for $S \otimes E$. The experienced qualia for S are determined as quantum averages of color quantum numbers in the entangled state and expressible in terms of the sub-system density matrix. One can indeed assign to the zero energy state increments ΔQ_{ZEO} of color quantum numbers as difference of color quantum numbers for S at "upper" and "lower" boundaries of C. These increments characterize zero energy state rather than quantum jump.

   (c) In state function reduction the entanglement at upper boundary is reduced if the entanglement is entropic whereas negentropic entanglement can be stable. Quale is experienced sensorily as long as quantum jumps preserve negentropic entanglement. When entanglement is eventually reduced, the experience can be only a memory about the experienced quale. The increments ΔQ of color quantum numbers in quantum jump can be identified as $\Delta Q = \Delta Q_{ZEO}$. Hence this notion is indeed well-defined.

   (d) This interpretation allows to assign to the quantum jump also space-time evolution changing the quantum numbers in the same manner as they change in quantum jump. This is what quantum-classical correspondence indeed requires.

One application is the identification of basic colors in terms of color quantum number increments of quantum states [K39]. This identification makes sense if one accepts the fractal hierarchy of QCD like dynamics allowed by p-adic length scale hierarchy and by the hierarchy of Planck constants. The original concrete model was provided by the capacitor model of sensory qualia in which a large number of particles which same quantum numbers flows to a subsystem during quantum jump inducing the analog of di-electric breakdown (note the analogy with nerve pulse). Bose-Einstein condensation provides one possible realization. In this case one can say that the quantum numbers of the particle in question represent the basic quale which is amplified.

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

quale. This suggests a holographic memory in which quale eventually is represented in very small scale in terms of negentropic entanglement.

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

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

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

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

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

2. Very often emotions are characterized by good-bad/right-wrong dichotomy characterizable by single binary digit. Perhaps emotions provide a representation of a high level summary about large amounts information, a kind of Boolean function of very many qubits. The function of neural transmitters can be often interpreted in terms of reward or punishment. Information and emotions seem to be closely related: peptides are often regarded as both information molecules and molecules of emotion [J43]. This can be understood if the function of information molecule is to induce emotional response representing the information.

3. Comparison to a standard -be it moral rule, expected or desired behavior, or something else- is rather often an essential aspect of emotion. Comparison can in principle be represented as a quantal Boolean function involving the standard (say moral rule) represented in terms of negentropic entanglement. If the Boolean instance compared with the rule corresponds to an instance allowed by the rule, positive emotion results. Otherwise the emotion is negatively colored. One might also think that there is expectation for the result of comparison. If the outcome differs from expected- which corresponds to a flip of bit, positive or negative emotion results but could do so as a secondary representation. The above argument suggests that the outcome of comparison does not represent the emotion as such but there is a neural circuitry encoding the outcome to reward or punishment.

2.4.5   Self Referentiality Of Conscious Experience

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

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

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

Many-sheeted space-time and self-referentiality

The fractal hiearchy of magnetic flux tubes giving rise to braids, which in turn make possible topological quantum computation would be a rather realization of this representation, A possible concrete physical realization of self-referentiality is suggested by DNA as quantum computer model [K2]. One assumes that DNA nucleotides and lipids are connected by magnetic flux tubes. Since the lipid layer of the cell membrane is 2-dimensional liquid crystal, the lipids are in continual hydrodynamical motion and this means in time direction entanglement of the orbits. The events in nearby environment and also nerve pulses affect this flow. This braiding in time direction defines a topological quantum computation. This motion entangles also the flux tubes connecting the lipids to DNA nucleotides so that when the topological quantum computation halts it becomes stored into memory as space-like entanglement. In TGD framework also the time-like braiding provides a space-time representation of the quantum computation which also gives to a conscious experience at some level of the hierarchy.

Infinite primes and self-referentiality

The hierarchy of infinite primes (and of integers and rationals) [K102] was the first mathematical notion stimulated by TGD inspired theory of consciousness. The construction recipe is equivalent with a repeated second quantization of a super-symmetric arithmetic quantum field theory with bosons and fermions labeled by primes such that the many-particle states of previous level become the elementary particles of new level. At a given level there are free many particles states plus counterparts of many particle states. There is strong structural analogy with polynomial primes. For polynomials with rational coefficients free many-particle states would correspond to products of first order polynomials and bound states to irreducible polynomials with non-rational roots.

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

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

The correspondence between the quantum states defined by WCW spinor fields and wave functions in the infinite-dimensional discrete space of hyper-octonionic units can be made more concrete [K102]. These wave functions must transforming irreducibly under discrete subgroup SU(3) of octonion automorpisms transforming ordinary hyper-octonionic prime to a new hyper-octonionic prime. SU(3) has interpretation as color group. One can assign standard model quantum numbers to these wave functions and prime property in principle fixes the spectrum of possible quantum states- in particular the spectrum of masses. Therefore the extremely esoteric looking notion of infinite prime might turn out to be very practical calculational tool.

Quantum Mathematics and self referentiality of consciousness

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

1. This suggests a generalization of calculus for Hilbert spaces. Mathematical objects which are defined for numbers in various number fields become well defined when these numbers are replaced with Hilbert spaces. One can speak of the Hilbert space analogs of algebraic numbers, transcendentals, p-adic numbers and their extensions. Anything having as a building brick rationals, algebraic numbers, real or p-adic numbers or finite fields generalizes. Even the notions like matrix group, algebras, and ring generalize. Also the notion of manifold generalizes as well as the notion of calculus.

2. The Hilbert space in associated with the element of number field characterizes its number theoretic anatomy and therefore could be a correlate of cognition. The crucial step in the generalization of this process to the level of the Hibert space representing points. Points of Hilbert spaces can be replaced with Hilbert spaces and process can be repeated ad infinitum. This suggests that the self-referentiality at the deepest level corresponds to this fractal view about space-time based on assignment of quantum dynamics to numbers. Also a connection with the hierarchy of n: th order logics. A close relationship to infinite primes would not be surprising since in both cases one an infinite hierarchy of processes analogous to second quantization is involved. A natural question is whether many-sheeted space-time provides a dynamical representation in terms of space-time sheets for the number theoretic anatomy so that kind of Brahman=Atman identity or algebraic holography would hold true. This correspondence could be see as a cognitive representation of external world and one could also see the external world as symbolic representation of the world of cognition.

3. A connection with generalized Feynman diagrams and hierarchy of Planck constants is suggestive and the idea was originally inspired by the observation that the two vertices of generalized Feynman diagrams identifiable as generalizations of the basic stringy 3-vertex for closed strings and basic 3-vertex for Feynman diagrams correspond naturally to direct sum and tensor product in turn having natural correspondence with + and × of the usual arithmetics. This correspondence motivates the introduction of co-operations of direct sum and tensor product meaning that quantum dynamics is brought into the game through these vertices. This suggests that Quantum Mathematics is actually Quantum dynamics in which generalized Feynman diagrams define sequences of arithmetic or even more general algebraic operations.

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

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

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

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

2. Could topological condensation be the counterpart of this process in many-sheeted space-time of TGD? The states of previous level would be assigned to the space-time sheets topologically condensed to a larger space-time sheet representing the new level and the many-particle states of previous level would be the elementary particles of the new level.

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

2.5 Various Types Of Conscious Experiences

In the following the general structure and classication of conscious experiences is discussed. Most predictions are brain independent. Assuming that zero modes of the configuration space, characterizing the geometry of macroscopic classical space-time, determine the geometric information contents of conscious experience and identifying macroscopic quantum phases as quantum correlates of various sensory modalities, one can make rather far reaching predictions about basic aspects of, say, sensory experience of any experiencer, be it human brain or some strange life form in distant galaxy.

2.5.1 Basic Structure Of Conscious Experience

Before continuing, it is perhaps useful to recall the basic anatomy of the quantum jump: $\Psi_i \to U\Psi_i \to \Psi_{f_0} \to \ldots.\Psi_f$, where the final quantum history Ψ_f is a superposition of space-time surfaces, which are macroscopically equivalent and only bound state entanglement is present. Every space-time surface of the superposition consists of parallel space-time sheets (connected by wormhole contacts). Some of these space-time sheets have infinite time extension and some have not. The latter ones are "mindlike space-time sheets". One must make a clear distinction between the quantum superposition of the space-time surfaces and the decomposition of the space-time surface to space-time sheets.

Real and imagined experiences

The assumption that p-adic physics is physics of imagination means division of qualia to real qualia and imagined qualia. There are good arguments based on mathematical consistency that in p-adic WCW degrees of freedom complete localization occurs in each quantum jump (see Appendix). This means that there are no quantum fluctuations in p-adic degrees of freedom and since non-geometric sensory qualia like color correspond to quantum number increments in quantum fluctuating degrees of freedom, there are no p-adic non-geometric qualia. This however leaves p-adic geometric qualia determined by the increments of p-adic WCW coordinates. This view is certainly consistent with intuitive notion that cognitive qualia are only about the geometric aspects, like shape and size, of the objects of the external world.

One could debate about whether cognition can be identified as imagination but this is the working hypothesis made. The tranformations of thoughts into actions or sensory experiences and of sensory inputs into thoughts correspond to p-adic–real phase transitions for mindlike space-time sheets so that one can speak about matter-mind interaction in a well-defined sense. Cognition is predicted to be present already at elementary particle length scales and this assumption is crucial for understanding the success of the p-adic length scale hypothesis works and p-adic mass calculations.

One can identify p-adic space-time sheets as correlates of memes [J137] and relate them to the morphic fields of Sheldrake. The p-adic vision about cognition is discussed in [K64].

Whole-body consciousness and ordinary consciousness

TGD predicts two basic modes of consciousness.

1. Reducible self is the state in which sub-selves are "falling asleep" and "waking up" all the time, corresponds naturally to the ordinary state of consciousness. Sub-selves represent mental images which pop out and dissappear all the time.

2. In case of irreducible self quantum jumps do not lead to a generation of sub-selves. Thus the sub-systems of irreducible self have only bound state entanglement and self measurement cascade stops at irreducible self. This state is presumably accompanied by the experience of "oneness" and could therefore be called a state of "whole-body consciousness". The absence of the sub-selves means the absence of mental images so that the identification as a state of pure self awareness without any contents is natural. Less ideal situation is that sub-selves are generated but are very short lived and represent short flashes against background awareness. "Whole-body-consciousness" presumably means abnormally low metabolism since dissipation inside sub-selves is not present.

Active and passive aspects of conscious experience

Conscious experience involves two fundamental contributions.

1. The "non-classical" contribution from the quantum measurement reducing quantum entanglement associated with the fermionic degrees of freedom and with the quantum fluctuating configuration space degrees of freedom (as opposed to zero modes).

2. The "classical" contribution determined by the localization in zero modes and by the selection between different degenerate preferred extremals.

The natural guess is that the experienced free will corresponds to the non-determinism of the quantum jump somehow. The standard objection is that the non-determinism of the quantum measurement gives rise to randomness rather than volition. Quantum numbers relate to microscopic aspects of the quantum jump and the average quantum numbers measured in quantum jumps probably sum up to zero in the presence of energy feed and external perturbations. Indeed, if temporal binding for the experiences of self involves averaging, this component of experience need not give rise to an experience of volition since it is expected to average out for large number of quantum jumps (10^{38} per second by the argument for the arrow of psychological time). Therefore the time averaging involved with the temporal binding smooths out this non-determinism.

Here the special features of TGD however come in rescue.

1. The first candidate for the quantum correlate of volition is the localization in zero modes. This localization corresponds to the spontaneous symmetry breaking of quantum field theories which selects one classical configuration among many degenerate ones. Spontaneous symmetry breaking has been suggested to be a basic aspect of the quantum jump also by Joel Henkel [J84]. Asymptotic localization in zero modes seems to be however determined statistically by the self-organization process taking the system to the bottom of some valley of the spin glass energy landscape. Hence volition need not be in question.

2. The second candidate for volition is classical non-determinism of Kähler action (which gives rise to the geometric model of thought as "association sequence"). The selection between the different degenerate alternative classical time evolutions, that is different degenerate absolute minima $X^4(Y^3)$ going through a given 3-surface Y^3, is an excellent candidate for the volitional act. The reason is that absolute minima differ macroscopically so that the choice between degenerate minima dramatically affects the entire geometric future. Note also that the selection between branches of a multifurcation of macroscopic space-time is in question, the choice can be done only when mindlike space-time sheet is located in a narrow time interval around multifurcation and is hence irreversible.

   The identification of the classical non-determinism as a geometric correlate of the volitional non-determinism is in nice accordance with the "ontogeny recapitulates phylogeny" principle stating that the geometric time evolution at the level of the space-time surface reflects the time evolution by quantum jumps at the level of the configuration space. One can however argue that this kind of volition is still passive in that it is only a selection between given alternatives rather than a transformation of an intention to action. The second objection is that there are actually infinite number of options between which to select in the state function reduction: why do we not experience these alternatives consciously?

3. The third candidate for volition is a quantum jump in which p-adic-to-real transformation for a p-adic space-time sheet representing cognitively intention occurs so that it becomes an action. For long time I believed that this identification of the volitional act is the most realistic one. It does not however explain why intention develops as a plan and will to do something and leads to horrible mathematical challenges which might be impossible to meet.

4. The recent view is implied by zero energy ontology (ZEO). In ZEO self corresponds to a sequence of state function reductions at fixed boundary of causal diamond (CD) changing only the situation at the opposite boundary (in standard quantum measurement theory nothing would happen to the state). This sequence can also give also rise to the development of intention. The volitional action begins with the first state function reduction to the opposite boundary of CD and means that the sub-self (mental image, we are also mental images) dies and reincarnates at the opposite boundary of CD. This picture leads to a simple answer to the basic questions and is certainly the most feasible one found hitherto. The strong prediction is that the arrow of time is not fixed and the behavior of living systems can be interpreted by accepting that the arrow of time can change.

   An interesting possibility is that the zero modes characterizing the macroscopic features of the macroscopically equivalent space-time surfaces present in the *final* quantum state of quantum jump determine the contents of at least sensory experiences. This would be in accord with the idea that pure sensory experiences represent quantities which indeed "are in the world", the world being identified as the macroscopic space-time associated with the final quantum history of the quantum jump. One could however argue that it is only *the increments of zero modes* in quantum jump, which are perceived directly consciously: this claim is consistent with the fact that insects are able to see only the motion and that also human visual consciousness is crucially dependent on saccadic motion. Localization in the zero modes involves the fixing of the parameters characterizing the shape and size of the 3-surface X^3 as well as the Kähler field of $X^4(X^3)$. Kähler field can reduce to a purely electromagnetic or Z^0 type classical gauge field and is in general also accompanied by a classical color field. The spatio-temporal patterns of the induced Kähler field should correlate strongly with the contents of the conscious experience.

2.5.2 Cognition And P-Adic Physics

p-Adic non-determinism follows from the fact that functions with vanishing derivatives are piecewise constant functions in the p-adic context. More precisely, p-adic pseudo constants depend on the pinary cutoff of their arguments and replace integration constants in p-adic differential equations. In case of field equations this means roughly that the initial data are replaced with initial data given for a discrete set of time values chosen in such a way that a unique solution of field equations results. Solution can be fixed also in a discrete subset of rational points of the embedding space. Presumably the uniqueness requirement implies some unique pinary cutoff.

Thus the space-time surfaces representing solutions of p-adic field equations are analogous to space-time surfaces consisting of pieces of solutions of the real field equations. Thus p-adic reality is much like the dream reality consisting of rational fragments glued together in illogical manner or pieces of child's drawing of body containing body parts in more or less chaotic order.

The obvious interpretation for the solutions of the p-adic field equations is as a geometric correlate of imagination. Plans, intentions, expectations, dreams, and cognition in general are expected to have p-adic cognitive space-time sheets as their geometric correlates. A deep principle seems to be involved: incompleteness is characteristic feature of p-adic physics but the flexibility made possible by this incompleteness is absolutely essential for imagination and cognitive consciousness in general.

2.5.3 Reflective- And Proto-Levels Of Consciousness

The decomposition into proto consciousness and reflective consciousness (consciousness about being conscious) is one of the fundamental features of conscious experience. Logical thinking is also a fundamental component of conscious mind and probably also the mind unconscious-to-us, in fact so fundamental one that is has inspired the computationalistic approach to consciousness. One can consider two alternative identifications for the reflective level of consciousness.

Boolean mind as reflective mind?

The state basis of the Fock space generated by N fermionic creation operators is isomorphic with the Boolean algebra consisting of 2^N possible statements about N basic statements. This follows from the simple observation that by Pauli exclusion principle the fermion number associated with a given fermion state can have only two values: 0 (false) or 1 (true). This observation leads to the idea that many fermion states give representation for what might be called reflective consciousness in the sense that the information contents for experiences about conscious experiences could correspond to the quantum jumps in the fermionic sector.

A more convincing interpretation is that Boolean mind is onlh a special case of reflective mind. In p-adic case only quaternion conformal degrees of freedom are possible for WCW spinors (see appendix) and since pure cognition involves no emotions and no values it must correspond to logic (true/false). In real case the spin associated with the WCW metric correlates with the sensory experience and naturally corresponds to the logic of aesthetics (beautiful/ugly) whereas real quaternion conformal degrees of freedom having no correlation with the sensory experience correspond naturally to the logic of ethics (right/wrong), or more generally the true/false logic of belief system having strong right/wrong emotional coloring. Thus the Goodness-Truth-Beauty trinity would thus have a reduction to the Boolean algebra defined by the Fock basis for the WCW spinor s.

TGD based model of abstraction process involves a hierarchy of statements about statements about.... starting from 2 basic statements such that the statement represented by empty set in the set theoretic realization of Boolean algebra is thrown away at each step. The model predict besides the genetic code also a memetic code consisting of 127-bit code words such that 126-bit statements form a maximal number of mutually consistent statements. In case of genetic code 7-bit code words represent all possible statements and 64-bit codewords represent statements consistent with a fixed atomic statement (single bit fixed).

In real context, 6-bit code words for the genetic code and 126 bit code words for the memetic code code form a maximal number of mutually consistent "this is right thing to do" beliefs. 7-bit resp. 127-bit code words can be interpreted as coding these statements and their negations: all bits must be realized in p-adic case since formal logic requires also the negations of the basic statements. Lying is a cognitive skill. Genetic code would represent in case of the molecular society the moral and social rules whereas memetic code would represent these rules in case of the ordinary society. DNA would provide a symbolic representation for the 64 fundamental truths, kind of a legal code.

Symbolic and cognitive representations as means of becoming conscious about being conscious about?

An alternative identification of the reflective mind is in terms of language and cognitive representations made possible by the nondeterminism of Kähler action and inherent nondeterminism

of p-adic differential equations. These nondeterminisms allow to represent contents of consciousness of self (quantum jump sequence) cognitively and symbolically and to become conscious these representations: this is nothing but becoming conscious about being conscious about...

The (inconvincing) Boolean identification of reflective mind predicts a single directly experienced reflective level. In the second case given quantum jump allows the emergence of only single new reflective level. Indeed, it is easy to become conscious about seeing red but one cannot have direct experience of being conscious about being conscious about seeing red. It is also easy to build theorems about theorems (or imagine what happens under given circumstances) but deriving theorems about theorems about theorems looks impossible without paper and pencil.

Zero energy ontology allows to realize the vision about the reflective hierarchy of consciousness in a concrete manner. The basic building blocks would be negentropically entangled systems representing rules with state pairs defining the entangled state interpreted as instances of the rule. One can construct rules about rules as states formed from this kind of states. The many-sheeted space-time would provide geometric correlates for these rules about rules. The hierarchy of infinite primes would also relate to this abstraction hierarchy.

2.5.4   General model for sensory experiences

The concept of self provides considerable insight to the model of sensory experiencing.

1. If temporal binding involves averaging over the experiences occurred after the wake-up, experiences are reliable.

2. Also the averaging over the experiences of separate sensory subsub-selves implied by the summation hypothesis could be involved.

3. Sensory experiences can involve more than the direct experiencing: also a comparison with the earlier sensory data could quite well be involved and is made possible by subjective and geometric memories. Sensory experiences certainly involve computational aspects.

In the following the general model of sensory experiencing is discussed only briefly [K89].

Macroscopic quantum phases are needed

Self must be able to remain unentangled in subsequent quantum jumps. The presence of the macroscopic quantum condensate means usually energy gap between ground state and excited states. This can make the generation of real entanglement very slow process and self can exist.

The fact that macroscopic quantum phases have coupling to the classical gauge fields, suggests that the order parameters of the macroscopic quantum phases are compeletely determined by the localization in the zero modes. Thus the contents of the sensory experience should correlate with these order parameters. This motivated the original attempt to identify macroscopic quantum phases as quantum correlates of the sensory qualia. A more refined approach identifies quantum phase transitions of the macroscopic quantum phases as correlates of sensory qualia so that the increments of quantum numbers in the phase transition label various qualia. This identification is completely general and almost brain independent (cell length scale turns however be crucially important p-adic length scale).

Many-sheeted space-time concept makes possible large number of macroscopic quantum phases not possible in standard physics context. In particular, the so called massless extremals (MEs) representing "topological light rays" provide a model for how linear structures such as DNA and microtubules could act as quantum antennae emitting and absorbing coherent photon distribution fixed completely by localization in zero modes. Coherent photons could realize the concept of global workspace [J38] and could make possible "mass media" at neural level. Also the concept of "neural window" abstracting the notion of hologramic brain suggests itself [K22, K39]. MEs form a fractal hierarchy and are carriers of super-symplectic representations for which states are genuine functionals in the space of 3-surfaces ("world of worlds") and thus correspond to higher abstraction level than ordinary quantum states. Super-symplectic states have also gigantic almost degenaries. MEs act also as quantum holograms.

For these reasons MEs are ideal candidates for a hierarchy of life forms [K39]. In particular, the assignment of *"our"* sensory qualia with super-symplectic quantum transitions looks reasonable

whereas magnetic quantum phase transitions might well correspond to more primitive chemical qualia not directly conscious to us.

The functions of nerve pulses

The identification of the sensory qualia in terms of the quantum phase transitions associated with macroscopic quantum phases is in conflict with the general belief that neuronal activity determines completely the contents of the sensory experiences. In TGD framework one can understand the role of the nerve pulse activity differently. Brain is quantum spin glass and the evolution of sub-selves/mental images is a dissipative self-organization process leading to some asymptotic self-organization patterns which correspond to the valleys of the spin glass energy landscape. The contents of the sensory experiences are determined by the zero modes which in turn determine the ground state patterns of the order parameters of various macroscopic quantum phases.

The crucial element of the self-organization is external energy feed making possible interesting self-organization patterns. One role of the nerve pulses is to provide this metabolic energy feed. This suggests that the axons are seats of the self-organization patterns coding at least part of the neuronal experience. Brain seems to systematically maximize the length of the axons feeding sensory data (for instance, right ear feed its sensory input to the left hemisphere). Brain anatomy seems also to favour long pyramidal axons. This phenomenon, which seems to be in conflict with the principles of good metabolic economy, is consistent with the maximization of the expressive power of the sensory pathways. Microtubule conformations are excellent candidates for realizers of declarative memory and this would also explain why the lengths of sensory axons tend to be maximized. Myelin sheets guarantee that external perturbations do not affect the self-organization patterns. It is also possible that myelin sheets form together with the axon Josephson junctions for various super conductors predicted by TGD and are thus essential for the generation of neuronal sensory experiences.

Nerve pulses affect also the postsynaptic cell: typically excitation or inhibition is in question. The interpretation is that the incoming nerve pulses push and pull the postsynaptic cell in different directions and in this manner cause frustrations typical for spin glass like systems. The assumption that neural transmitters give rise to some kind of chemical senses at neuronal level as well as neuronal emotions is in accordance with this. Also frequency coding is consistent with the identification of the nerve pulse activity as a control function.

Of course, spatio-temporal patterns of nerve pulses might also code information about sensory experience. There is indeed evidence that various odours are coded into spatio-temporal nerve pulse patterns [J90]. For instance, for the neurons of the associative regions of cortex receiving inputs from several sensory modalities this kind of discrimination is obviously highly desirable. One can even consider the possibility that nerve pulse patterns, in some parts of brain at least (in output axons of association regions), provide a precise naming for axonal experiences.

The model for sensory qualia and sensory representations [K39, K48] assumes that nerve pulse patterns generate EEG MEs (massless extremals) entangling brain with the sensory magnetic canvas. The question where the mental images responsible for the sensory qualia are located, still lacks a convincing answer. Primary qualia could even correspond to mental images associated with the sensory receptors and sensory pathways could serve as cortex-receptor entanglers. Brain would give names for sensory inputs and percepts rather than creating the primary qualia. This would require feedback from brain to the sensory organs.

Frequency coding is not the only manner to code information to nerve pulse patterns and delicate temporal coding mechanisms exist. For instance, frequencies can be coded to peaks of the spike interval distribution by stochastic resonance [D8]. Also the coding of spike interval distribution to EEG frequencies is possible (a kick to a harmonic oscillator at the correct half period leads to a resonant amplification [K84]).

How qualia are associated with neural pathways?

Since TGD predicts entire hierarchy of selves, it is important to specify whose sensory experience one is talking about. In TGD framework nerve pulse patterns as such need not give rise to our sensory exerience and it is quite possible that also primary sensory organs have sensory experiences.

Frustratinly, the question about the seat of quale mental images remains unanswered.

1. The assumption that primary qualia are somehow associated with or determined by the sensory receptors would resolve a difficult question about how sensory pathways, which do not seem to have any obvious differences at the level of brain, give rise to qualia. The entanglement of the sensory receptors with brain in turn entangled with the magnetic body would give rise to the sensory representations. Our sensory experience would not be localizable to what happens in the brain region: indeed, MEs in EEG frequency region have size of order Earth size.

   Various objections (hallucinations, experiences generated by the stimulation of the sensory pathways, phantom leg phenomenon, dreams) against this view can be circumvented if there is a feedback between brain and sensory organs (as there indeed is), and if sensory experiences can also correspond to geometric memories (say in the case of phantom leg experience).

   For instance, pain in phantom leg would be sensory memory of pain in the leg, which still existed. The memory feats of idiot savants and people with left brain damage would be most naturally also due to sensory (visual or auditory) memories. Also ordinary people can have sensory memories when neurons in temporal lobes are stimulated electrically.

   If sensory receptors are the experiencers of the primary sensory qualia, then conscious experience can precede the neural activity in the cortex, as observed by Libet in his classical experiements concerning the timing of the sensory experiencing [J70].

2. A more general view is that the neuronal receptors (also "field receptors" responsible for neuronal vision and hearing can be present) along the sensory pathway are specialized to experience only special sensory qualia characterizing the sensory pathway.

How the primary and possible also secondary sensory receptors or sensory pathways could then give rise to particular qualia? Quite generally qualia correspond to average increments of quantum numbers for the quantum jump sequence defining sub-self. In the case of color qualia one has a partial answer. For MEs super-symplectic quantum transitions are characterized by WCW Hamiltonians carrying spin and color ($SU(3)$) quantum numbers. For WCW photons state functional in WCW degrees of freedom is nontrivial and characterized by WCW Hamiltonian with quantum numbers characterizing a particular quale. This suggests that somehow neural pathway or sensory receptor should be able to generate " WCW photons" (MEs) BE condensing on larger MEs and inducing visual color qualia at least. This would mean that WCW photons would in a well-defined sense carry qualia: the photons generated by sensory receptors and brain could be colored after all!

The educated guess is that the EEG transition frequencies coded the spike interval distributions associated with the sensory pathway characterize the sensory pathway partially. EEG frequencies in turn determine partially the quantum phase transitions which can be stimulated by that particular sensory pathway. The miminal option is that these transitions relate only with what parts of magnetic body the sensory pathway is entangled with. This would make possible very high functional flexibility in accordance with the observed plasticity of brain.

Only changes are perceived

One of the basic laws about sensory experiencing is that only changes and novelties are perceived. For instance, totally monochromatic illumination is experienced as darkness. The zero modes characterizing the macroscopic space-time associated with the final quantum history of the quantum jump should determine the contents of the sensory experience. Part of the zero modes corresponds to the induced Kähler of CP_2 which is nonlinear Maxwell field closely related to the classical electromagnetic and Z^0 fields. There are also zero modes representing the size and shape of 3-surface: these might be related to the discriminative sense of touch. A possible generalization of the law is that sensory stimulus generates Kähler electric field proportional to the gradient of the stimulus. This creates however a problem. Kähler electric flux must be conserved in the approximation that vacuum Maxwell's equations are satisfied (they are not exactly satisfied since vacuum can carry currents of Kähler charge). Suppose that stimulus has a strong gradient: where does the Kähler electric flux go in this kind of situation?

The solution of the problem might be very simple: mindlike space-time sheet is generated and the flux goes to the mindlike space-time sheet through wormhole contacts. Since sensory

stimulus varies rapidly at the boundaries of the objects of the external world, this means that the objects of the perceptive field are automatically represented by mindlike space-time sheets and give rise to selves, mental images already at the level of the sensory organ or the sensory pathway leading to thalamus.

The extreme generality of the mechanism suggests that it could be at work also at the level of brain. Understanding of the computational aspects of sensory experience (say stereovision) is not possible unless one assumes that mindlike space-time sheets in sensory pathway combine with the primary sensory organs to form coherent quantum systems. "Ontogeny recapitulates phylogeny" principle requires that these space-time sheets are connected by flux tubes most naturally associated with axons leading from sensory organ to brain.

Are the ultimate sensory representations realized outside brain?

One of the dramatic almost predictions of TGD inspired theory of consciousness is that our physical body is accompanied by a hierarchy of field bodies, in particular magnetic body. A given field body provides abstract representations about quantum aspects of the physical body, kind of a manual. This prediction plus some general arguments lead to the view that sensory representations are most naturally realized outside the physical body at the personal magnetic body (first person aspect of consciousness) and at the magnetic body of Earth (third person aspect of consciousness).

This vision leads to the interpretation of EEG as being involved with MEs projecting sensory data to the magnetic body. EEG ME would generate quantum entanglement between two mental images: a feature inside brain and a "simple feeling of existence" mental image at the magnetic body and representing a point of the external world. Thus the main function of brain would be the construction of features and sensory representations would be completely separated from their construction. Note that also in the case of computers the representation of the data is separated from the generation of the data.

2.5.5 Emotions

TGD suggests several visions about emotions and it is not yet completely clear whether these views are really mutually consistent.

Emotions and comparisons

The basic element of mentality is the comparison between the expectations of future and what actually occurred. In TGD framework this tension between potential and actual can be understood. Subjective and geometric memories make it possible to compare the expectations with what really occurred during the time interval since subjective memory is kind of heap of predictions of future arranged with respect to the value of the psychological time. Many higher emotions such as sorrow, depression, frustration, desire, happiness, feeling of relief, pain, fear, anger, envy, hatred, etc... clearly involve comparison of expectations and reality. This could perhaps mean that these emotions are created by the comparison of the predicted or desired geometric time history and subjective time history (what really happened). This would mean that at least higher emotions differ from the sensory qualia, which seem to be determined solely by the localization into zero modes representing the non-quantum fluctuating aspects of space-time geometry.

One might however argue that very primitive emotions such as rage without any object and involving only the activity of the limbic brain could be quale like and that hormones are the quantum correlates of these emotions. These emotions involve however a change of behaviour (e-motion!) so that one could argue that also now there is a simple comparison involved. Perhaps changes in the hormone concentrations could be regarded as consequences of the change of the emotional state. Or vice versa, if hormones are messangers telling to very simple selves of limbic brain whether the real course of events was the desired one or not, then hormones indeed effectively control the emotional state and can be regarded as quantum correlates of emotions.

It is difficult to assign any comparison to an emotion like deep love since it involves a complete acceptance of the object of love and is free of desires. Perhaps the claim of mystics that deep experience of love means that subject and object of love cease to exist as separate objects, makes sense. Lovers quantum entangle and die as separate selves (for some fraction of time only,

of course!) and the higher self consisting of lovers experiences whole-body consciousness. Perhaps more mundane love means that my sub-selves representing me and the loved one entangle to form a sub-self experiencing whole-body consciousness. Perhaps also feelings like empathy belong to this class of emotions.

Emotions and entropy

The concrete model of qualia to be developed in [K39] provides an alternative general vision about emotions which allows to understand the difference between comparison type emotions and other emotions as well as the role of emotions in control.

1. The statistical physics approach to qualia leads to the hypothesis that emotions correspond to rates for the generation of various type of entropies for the sub-selves of self. The sign of the rate tells whether emotion is positive or negative. Negative emotions would thus be conscious control variables warning self when some sub-system is generating entropy. The holistic nature of the emotions can be understood easily in this picture and also the fact that they are not directly related to sensory input. One could perhaps also understand higher level emotions like sorrow as reflecting the growing disorder of the virtual world of brain resulting from the primary cause of sorrow.

2. It is known that peptides correlate strongly with emotions and moods [J43] and they are even called molecules of emotions. Peptides are also regarded as information molecules. This connection between information and emotions fits nicely with the fact that peptides and other important biomolecules certainly induce strong entropy gradients with respect to subjective time.

3. Sensory qualia can be divided to geometric and non-geometric ones. One can classify also emotions in this manner. Emotions corresponding to the localization in zero modes would perhaps correspond to "higher level emotions" about external world (say, aesthetic qualia) whereas the non-geometric emotions associated with the state preparation would correspond to "self-centered" emotions about the state of body (pain, physical pleasure, ...).

4. Also pure emotions which seem to involve no obvious comparison (love, joy, excitement, ..) are possible. For instance, the emotions produced by music might represent this kind of emotions. The view about emotions as entropy gradients allows to understand also emotions of this kind. In state of deep love, self enters into very low-entropy state and mental images (not necessarily even present in "enlightened states") become very pure.

5. An interesting question is whether the entropy growth of our sensory sub-selves is only sensory representation for the entropy growth occurring at the level of atomic space-time sheets or corresponds directly to it. The enormous difference of the temperatures associated with the atomic space-time sheets (ordinary matter) and superconducting magnetic flux tube structures would suggest that the growth rates for these entropies are of totally different order of magnitude and our emotions serve have the role of conscious control variables telling whether things are going well at the atomic space-time sheets.

Consider now the comparison type emotions and the relation of emotions to control in more detail.

1. Many emotions are comparison type emotions. These emotions tend to be negative (say envy). The first option is that comparison type emotions result from the comparison of geometric and subjective memories occurring automatically in any quantum jump and thus to some degree with any quale. Unfortunately, it is very difficult to imagine how to concretely test this kind of hypothesis and it is also difficult to see how the connection with entropy gradient could emerge.

2. One must also seriously consider the possibility that emotions result from the comparison of remembered/anticipated experience and real experience rather than the fundamental comparison involved with anticipation and memory: kind of quasi-computerized version of geometric memory would be in question. The result of comparison would be coded to the sign

of the growth rate of some entropy variable. The comparison could perhaps be realized in such a way that subsequent quantum jumps for comparing sub-system could represent either the anticipated or real quale. If this were the case, the difference between anticipated and real would automatically induce growth of entropy and negative emotion would result. This would be the basic mechanism of dissappointment. In this picture comparison type emotions could be seen as a system of rewards and punishments used to control the self (the controller could be higher level self (conscience) or higher levels selves which also want to survive (the emotions generated by hunger, first, and physical pain). Punish/reward mechanisms could basically involve negentropy/entropy feed to some sub-self.

3. One could also regard emotion as induced by generalized sensory qualia giving information about CNS itself rather than external world or the boundary between external world and body. The regulation involved with the homeostasis involves comparison in an essential manner so that one could perhaps regard emotions as analogous to control variables representing consciously the result of comparison of expected and desired forcing the organism to behave in a way to reduce this difference and end up to a rest and digest state. This aspect is consistent with the statistical interpretation since the entropy gradients associated with the organism are stronger than those associated with the surrounding world. Also amplification mechanisms exaggerating the entropy gradients might have developed. For instance, our reactions to some odours or tastes could involve this kind of amplification.

4. A hypothesis consistent with these views is that emotional component is involved with all sensory experiences and that we are used to call generalized sensory experiences emotions when they are about body. The emotionality of qualia indeed increases in the sequence of perceptive fields external world – CNS-world boundary – body. The degree of emotionality of experience should be characterized by the deviation of real from expected or desired and this suggests that the emotional component is much stronger for sensory experiences about CNS itself, since the system in question is much less predictable than the external world consisting of dead objects. Interpretation of emotion as measure for entropy gradient explains also this hierarchy.

5. Depression could be seen as a lost ability to experience emotions, be they positive or negative. Depression indeed involves emotional flatness. This state results when mental images become maximally entropic (emotional counterpart of heat death). That depression can follow deep sorrow is natural since negative emotions tend to increase the entropy of the mental images. It is known that depression involves over-activity of the amygdala and under-activity of some forebrain regions and an abnormally small population of glial cells known to be closely involved with metabolism and "cleansing activities" at brain level. This supports the view that glial cells might be warriors in the war against second law at the level of atomic space-time sheets and the loss of this war is sensorily mapped to the level of mental images and leads to depression. One function of serotonin, dopamin and various other neuropharmaca tending to produce pleasant experiences could be a reduction of entropy either at atomic space-time sheets or, less probably, directly at the level of our sensory sub-selves.

2.5.6 Directed Attention

The possibility to interpret self as a statistical ensemble suggests that the entropy of the mental image measures its fuzziness. Thus both attentiveness, alertness and level of arousal should relate very closely to the entropy of the mental images. Attention to a mental image could mean fight against second law to keep the mental image in a low entropy state and this requires metabolism (the icons on the computer screen provide a good example of this). Also alertness means mental images with low entropy content. 7 ± 2 rule of cognitive science suggests that the maximum number of our cognitive sub-selves which can be awake simultaneously, is rather limited. The rule might be based on the metabolic limitations: sub-selves can have low entropy content only in the presence of an external negentropy feed and metabolism must provide the needed negentropy feed. Note however that the needed metabolic energy might be extremely low.

Directed attention is one of the basic processes of consciousness occurring continually. Directed attention seems to involve free choice but focusing of attention could also occur sponta-

neously. One can imagine several models for the focusing of attention.

1. One possibility is that subsub-self inside sub-self representing mental image (say "monitor screen" as average over subsub-selves representing the visual objects) somehow pops up one level higher in the self hierarchy so that it becomes mental image. Geometrically this could correspond to the re-gluing of the corresponding space-time sheet to the space-time sheet of self instead of that of sub-self. In this case attended object would not pre-exist.

2. A further aspect of the focused of attention is as a wake-up of sub-self and keeping it in wake-up state and hence in short term memory. This could occur at the expense of the other sub-selves, which would be in wake-up state for only short times. A possible mechanism of selection is a phase transition changing the topology of chosen region (say from p-adic to real or from p_1-adic to p_2-adic) so that a new sub-self pops up from the background.

3. Self directs automatically its attention only to sub-systems immediately below it in the hierarchy. It seems however possible to direct attention to lower levels of the self hierarchy. For instance, I can direct my attention to the entire sentence, which I am writing here or to some word of this sentence or to individual letters of this word. The phenomenon of bio-feedback demonstrates that it is possible to learn to direct the attention to even single neuron. This suggests that selves are able to modify the hierarchy of selves by raising some sub...sub-self to the role of sub-self temporarily and thus experience the former sub...sub-self as a direct mental image. Formation of the flux tubes between mindlike space-time sheets at various levels of the self hierarchy provides a general geometric mechanism making possible temporary changes of the structure of the self hierarchy. Also the learning taking place during sleep [J77] migh involve interaction between different levels of the self-hierarchy.

Anyone can do a simple but thought provoking experiment suggesting the presence of the macroscopic quantum entanglement at the level of brain and a change of the level of sub-self in the self hierarchy. Look at a mirror, direct your attention at your left eye, and redirect the gaze to the right eye. What you find that it is impossible to perceive the change in the direction of the eye gaze.

1. Consider first what probably happens when we perceive a moving object. A negentropic binding of the mental images of the visual field to single mental image implies that both the parts and the whole can be experienced so that the motion is perceived. If the direction of the gaze is stationary, the object moves relative to the background, and if the direction of the gaze follows the object the background moves with respect to the direction of gaze. In both cases the motion can be perceived.

2. If the eye follows its own rotating mirror image, neither of these options is realized if the environment to which the attention is directed is restricted to be the eye itself. The direction of the gaze should remain the same in order to perceive the change of the direction of the gaze but this is impossible.

3. The perceptive field however contains also other objects and one could argue that if the attention is directed also to these simultanenously, it should be possible to perceive the changing direction of gaze as they move relative to the changing direction of gaze. Does the very act of directing attention to the mirror image of eye separate it from the negentropic entanglement with the other mental images so that the conscious comparison with them is not possible anymore? Or is the visual mental image representing eye at a different level of hierarchy as mental images from the very beginning and cannot negentropically entangle with the other visual mental images? Eye cannot perceive itself! Not even in mirror.

One should also understand what it means to direct the attention to an object of perceptive field. Certainly this process is directed and selective. Could the direction of attention to an object of perceptive field separate the corresponding mental image from the negentropic fusion of mental images as a separate mental image? Could it be that the motion of object can be perceived only if the attention is fixed only temporarily to the object? There are almost incredible sounding experiments demonstrating that the attention directed intensely to a fixed object makes it impossible to perceive what happens in environment.

2.5.7 Altered States Of Consciousness

The proposed concept of self provides allows rather rich a palette of altered states of consciousness and one cannot avoid the temptation to a concrete modelling of various altered states of consciousness. It seems that negentropic entanglement provides a general explanation for the reported characteristic of these experiences.

Whole-body consciousness and ordinary consciousness

Krishnamurti has described in his books states of consciousness having natural identification as states of "whole-body consciousness". For instance, according to Krishamurti, one can achieve this state only if one is able to stop thinking entirely. If thoughts correspond to cascades of selves decomposing into sub-selves during state function reduction proess, then this is just what is required. The characteristic of this state of consciousness as reported by meditators are the experience of one-ness and the absence of all separations. The absence of separation would conform with negentropic entanglement. One-oneness could correspond to irreducible selfness without subselves or to the negentropic fusion of mental images to single mental image. Also "timelessness" characterizes these experiences: the explanation is that internal clock is provided by some sub-self waking up periodically and since there are no sub-selves there can be no time. Note also that negentropic time like entanglement fuses the subselves assignable to the future and past boundaries of CD to single self.

I have personally experienced states of whole-body consciousness and also states in which whole-body consciousness is limited to some part of body. These states begin with a sudden fall of silence: all the usual "noise" from the body disappears suddenly although ordinary physical sounds are still heard. This could be interpreted as disappearance of sub-selves from body or as generation of negentropic entanglement stable under quantum jumps. There is experience like thrill in spine going through the entire body. Interesting experience of this kind occurred when my cat was sleeping over my breast: I woke up and realized that my breast was in the state of whole-body consciousness. Could this mean that sleeping cat was also in this state and that my breast had entangled with the quantum state of cat? Could this in turn mean that during sleep we indeed are in a state of whole-body consciousness or even that our entire body is entangled with some large self? Could the absence of neuronal quantum jumps explain why we do not remember anything about these states? Are remembered states of whole-body-consciousness always such that at least some part of brain is awake?

Possession of ego defined as a collection subselves, which repeatedly unentangle themselves from the external world means dissipation, aging and eventual physical death (note however that self lives as a conscious memory realized as a sub-self of higher level self providing kind of summary about the lifetime of self). There would be two ways to getting rid of ego. Get rid of subselves or try to achieve a state in which they negentropically entangle to single mental image.

The absence of neuronal and cell level dissipation during states of whole-body consciousness provides a possible test for the phenomenonon. Test persons could be trained meditators and test should involve the measurement of neural or cellular dissipation occurred during the state of whole-body consciousness. Reduced rate of metabolism could be a measurable signature of whole-body consciousness. Dissipation should be absent or should be very small during this state at least if it is present for sufficiently large fraction of time. The absence of dissipation means that all changes suffered by the cells during whole-body consciousness are reversible and curable. This could explain various miraculous healings. Whole-body consciousness, if possible to arrange artificially, could provide medical means of saving the lifes of victims of accidents (say of victim of heart attack or bleed in brain).

Negentropic entanglement allows the component systems to be free in the sense that there is no binding energy. Even more, negentropic systems could carry metabolic energy but would not liberate it or liberate it in much longer time scale than usually (also large $\hbar$ could be involved). As a matter fact, the high energy phosphate bond assumed in the model of metabolism could correspond to negentropic entanglement carrying metabolic energy [**?**].

Synchronous neural firing is a possible candidate for whole-body consciousness at the level of brain.

1. The anomalously low value of neuronal oxidative metabolism during synchronous neuronal

firing in cortex could be interpreted in terms of negentropic inter-neuronal entanglement during which ATP-ADP Karma's cycle is absent and dissipation is reduced.

2. One could of course argue that metabolic energy is liberated but from other source than ATP. For instance, the formation of bound state entanglement between the group of firing neurons could liberate the binding energy as metabolic energy. The formation of hydrogen bonds could be the counterpart for the process at molecular level. This mechanism would however imply dissipation and there is no strong reason to assign whole-body consciousness to this kind of state (of course, synchoronous neural firing need not corre.

Whole-body consciousness could explain some spectacular phenomena (not of course taken seriously by skeptics).

1. The claimed ability of yogis to survive for months without eating anything and even without oxygen could have explanation in terms of whole-body consciousness. Oxygen consumption compensates the loss of chemical energy caused by the quantum jumps in biochemical length scales. These quantum jumps occur only if neuronal and lower level chemical selves exist. Under usual circumstances the continuous supply of oxygen makes the ageing of cells slow and the lack of oxygen leads to rapid dissipation and neuronal death. The situation is analogous to Benard flow: if heat feed is stopped, the beautiful flow pattern rapidly dissipates away. If all cells are entangled during whole-body consciousness, no dissipation occurs and the lack of the oxygen supply does not have any irreversible effects and possible effects might be cured automatically. An alternative explanation for the mystery of yogis who need not eat is that the generation of bound state entanglement involves the liberation of the binding energy as a usable energy possibly compensating for the ordinary metabolic energy.

2. In certain cultures people in trance are able to dance with their bare feet on burning charcoals without any disastrous effects. The disastrous effects of the interaction of heat from burning charcoals with cells in soles of foot must be irreversible changes. If these persons are in a state of whole-body consciousness, then the changes of the invididual cells would reversible.

That-which-is experiences

Irreducible self does not possess any sub-selves. The absence of sub-selves in turn means the absence of mental images. This kind of situation could correspond to that-which-is experience. The reports of Buddhist meditators about pure awareness with discrete twinkles of consciousness identifiable as short-lived sub-selves are in accord with this view.

In principle meditation could make possible to silence the hierarchy sub-selves and make it possible to directly experience quantum jumps occurring at elementary particle level! In zero energy ontology the temporal size scales assignable to elementary particles are time scales of human consciousness (electron corresponds to.1 second time scale and u and d quarks to millisecond time scale) plus the hierarchy of Planck constants as a realization of dark matter hierarchy crucial for living matter and predicting scaled up variants of these time scales, this idea need not be so crazy at it looks at first sight. In this speculative spirit one could even consider the possibility that the abstract theories of elementary particle physics result basically as a summation of the experiences of matter-mind sub-systems entangled with elementary particles! One can even consider the possibility that genetic code is realized in terms of the sub-CDs assignable to the electronic CDs and could form first level realization of the phonemes of language.

One can also considera weaker notion of one-ness in which self has only single mental image. In this case sub-selves would fuse to single subself either by bound state entanglement or negentropic entanglement. The formation of these states is accompanied by the formation of flux tubes -say magnetic flux tubes- between space-time sheets representing binding sub-systems. State function reduction does not occur in these degrees of freedom anymore, macroscopic quantum coherence is preserved from quantum jump to quantum jump, and the system behaves as macroscopic multiverse with new macroscopic degrees of freedom making possible macroscopic quantum computation. This might be the mechanism for how water, DNA, protein, tubulin, ... molecules and even neurons bind to quantum computing macroscopic multiverses [K2].

Zen type experiences and negentropic entanglement

Negentropic entanglement is possible in the intersection of real and p-adic worlds. Negentropic states are not eigenstates of measured observables giving information about the quantum numbers of the system or its complement but about the entire system. Conscious experience is an abstraction about the correlation between states of entangled systems- a rule with instances of the rule being represented as state pairs. Negentropic entanglement can be also time-like and between systems corresponding to space-time sheets in different number fields in the intersection of real and p-adic worlds. The simplest example about negentropic entanglement are fuzzy qubits. Zero energy ontology allows to imagine entire hierarchies of negentropic entanglements between negentropic states and an attractive interpretation is in terms of a reflective hierarchy producing statements about statements.

The reported experience about disappearence of illusions would conform with the interpretation about experience of understanding assignable to the state. The disappearence of the decomposition to observer and observed would correspond to the experience of oneness. Zen Buddhists experiences are often characterized as states of consciousness in which no selection is made between mutually exclusive alternatives. Hofstadter has described this aspect of Zen in hilarious manner in his book "Gödel, Escher, Bach". Also this aspect conforms with the basic properties of negentropic entanglement.

The absence of external-world-me separation and absence of desires is also reported to be a characteristic feature of that-which-is and Zen type experiences. Ego separates itself from external world in quantum jump by state function reduction leading to an uncorrelate product state. Ego disappers when the self fuses with external world negentropically. Perhaps also desires could be equated with the tendency to preserve ego.

Extended states of consciousness

Extended states of consciousness seem to be the exact opposite of that-which-experiences. Psi experiments concern subtle connections between subjects removed in space, and occasionally also in time. These experiments are reviewed in [J61] and the following representation follows this review closely. The pioneering work related with card and dice-guessing was done by J. B. Rhine in 1930s.

The formation of negentropic entangelement gives a natural general explanation of these experiences. Negentropic sharing and fusion of mental images would be part of the mechanism for extended states of consciousness.

The notions of geometric memory and electromagnetic self allow also to understand basic features of these experiences. For instance, the notion of geometric memory allows to understand memories about previous lives and prenatal experiences in which the the contents of consciousness is time shifted. The model for sensory representations leads to the conclusion that the topological field quanta of ELF fields, having frequencies in EEG range and by Uncertainty Principle having size of Earth, are crucial element of our sensory experience. The formation of flux tubes between topological field quanta associated with different selves could explain a large variety of paranormal experiences.

1. The experiments of Russel Targ and Harold Puthoff

The experiments of Russel Targ and Harold Puthoff [J142] were carried in the 1970's some of the best known experiments on subtle connections among distant subjects in regard to the transference of thoughts and images. Both sender and receiver were closed in a sealed, opaque, electrically shielded chamber so that no sensory communication was possible. Sender was subjected to light flashes at regular intervals. This caused a characteristic pattern in the EEG of the sender. In some cases also the receiver exhibited these rhytms.

In remote vision experiments sender served as a beacon. Receiver tried to describe verbally or by scetches what the beacon saw. Independent judges matched on the average 66 per cent of time with what was actually seen by the beacon. There are also remote viewing experiments from other laboratories. The distances between sender and receiver vary from miles to thousands of miles and it seems that distance does not matter.

Distance independence supports the interpretation of both experiments in terms of fusion and sharing of mental images.

2. The experiments of Stanley Krippner

In the experiments of Stanley Krippner [J148] image transmission was studied while receiver was asleep. Experimenter, sender and volunteer met each other in the beginning of the experiment. Sender spent the night concentrating on an art print, which he/she had received in the beginning of the experiment in a closed envelope. The brain waves and eye movements of the volunteer were recorded. The experimenter woke the volunteer at the end of the REM period by intercom and the volunteer described the dream.

A correlation between the contents of the dream and of the art print was observed. The score was higher on nights, when there were few or no electric storms in the area and sunspot activity was lowest.

The simplest interpretation is again in terms of fusion of mental images of the subject persons. These mental images are perhaps represented at the personal magnetic sensory canvas. Electric storms and sunspot activity affect directly Earth's magnetic field and should affect the communication mechanism since the experiments of Blackman and other suggest that em selves could correspond to magnetic transition frequencies associated with magnetic field of.2 Gauss which is near to the nominal value .5 Gauss of the Earth's magnetic field. In fact, there exists independent evidence for a general correlation of geomagnetic activity with psi experiences [J109].

3. The experiments of J. Grinberg-Zylverbaum

In the experiments of J. Grinberg-Zylverbaum [J68] the transfer of EEG potentials was studied. Two subject persons were involved. They were closed in Faraday cages. The sender was meditating. Another subject person was subject to a stimulus in random intervals; not even the experimenter knew, when they were applied. Non-stimulated subject person was in a relaxed state. Stimulus was sudden, short light or sound or short electric shock to index and ring fingers of the right hand causing a characteristic pattern in the EEG of the stimulated person.

The EEG's of the subject persons were synchroninized. The possible presence of transferred potentials in the EEG of nonstimulated subject was studied. Transferred potentials were detected in 25 percent of all cases *provided* persons had met before the experiment. A dramatic example was young couple, deeply in love, whose EEGs remained synchronized throughout the experiment.

The fusion of ELF selves means synchronization of ELF em fields and since ELF selves correspond directly to EEG frequencies, synchronization of EEGs is an immediate consequence and can transfer the synchronous firing in brain circuit of the sender to corresponding brain circuit of the receiver. The personal contact before the experiment certainly enchanges the probablity for the fusion of ELF selves. Also quantum entanglement between sub-selves of subject persons might be involved.

It is known that the EEGs of right and left brain are synchronized in deep meditation. There are also experiments of synchronization of EEGs for different subjects in group meditation [J116]. The explanation is same as in above case. Also quantum entanglement might be involved. For instance, quantum entanglement is crucial for the fusion of left and right perceptive fields to single perceptive field.

4. Telesomatic effects

Also the tansfer of actual bodily effects from subject person to another has been studied: references to these experiments can be found in [J61]. Physiological changes are found to be triggered in the targeted person by the mental process of another. Distance makes little of no difference. Thus the interpretation in terms of quantum entanglement suggests itself.

There are also reports of the transference of pain between persons having very close mutual relationship. Identical twins, mothers and their sons or daughers, couples in love, etc, . Also the relationship between psychiatrist and patient provides example of this kind and is known as projective identification. The general rule seems to the that the relationship between inviduals is always involved with psi effects. This is in accordance with the hypothesis about sharing of mental images having ELF em fields and field bodies as physical correlates. For instance, the field bodies of persons in an intimate relationhip might develop gradually direct contacts (say magnetic flux tubes connecting physical bodies).

5. Grof's experience with altered states of consciousness

Findings of modern psychotherapists, especially the work of Stanislav Grof [J61, J138] suggest that besides the ordinary "biographic-recollective" domain of psyche also perinatal and transpersonal domains of psyche exist. Transpersonal domain can mediate connection between our mind and practically any part or aspect of the phenomenal world. Grof studied for several decades altered states of consciousness induced by psychedelic drugs or holotropic breathing.

In the experience of *"dual unity"*, loosening and melting of the boundaries of the body ego happens but in the merging with another person, own identity is not lost. In the *identification* with another person loss of own identity occurs. Body image, physical sensations, emotional reactions and attitudes, thought processes, memories, facial expressions, typical gestures and mannerisms, postures, movement and even the inflection of the voice become those of the second person. The other can be someone in the presence or absent. Identification involving time shift is also possible. Part of an experience can come from subject's childhood, his or her ancestry or even of a previous lifetime.

Also group identification and group consciousness is possible. Person can identify with an entire group of people having some racial, cultural, national, ideolological, religional, political or professional characteristics. People may experience the totality of suffering of all the soldiers or tenderness of all lovers and dedication of all mothers in regard to their babies.

Identification with animals is possible. This involves body image, specific physiological sensations, instinctual drives, unique perceptions of the environment, emotional reactions, etc.. Person can identify with plants and botanical processes. Also identification with inorganic world can occur. People can identify with rivers, storms, tornadoes, mountains, ... Or stones, quartz crystals, minerals.... Even the identification with structures of atomic and sub-atomic world is claimed to be possible. At the second end of spectrum are racial and collective experiences and identification with entire human species and the experiences in which one identifies with the whole Earth or even entire cosmos. Also out of body experiences, clairvoyance, clairaudience and telepathy are common. Displacement in time is possible. Patient can have embryonical and fetal experiences and even ancestral experiences as well as past incarnation experiences.

Identification experiences can be generally understood as sharing and fusion of mental images. The fusion of mental images can occur between very many inviduals, say members of a species and would give rise to kind of stereo consciousness analogous to the stereo vision resulting in the fusion of left and right visual fields. We could also share this stereo consciousness: for instance, shamanist could share the mental images of animal species.

Perinatal experiences and memories extending beyond the lifetime of individual could be explained in terms of geometric memory and the notion of 4-dimensional body: actually these experiences do not in any significant manner differ from ordinary memories. The content of the conscious experience is multilocal both in subjective and geometric time in the sense that the experience contains contributions from several moments of geometric time simultaneously.

Our personal self hierarchy could actually contain higher levels than the levels represented by ELF emf fields associated with EEG. This hypothesis makes sense if the contribution of the higher levels of our self hierarchy to our conscious experience under normal circumstances is only some kind of general awareness ("silent observer"). These higher levels could actually explain the experienced continuity of self. For instance, during sleep there there would be some kind of basic awareness present: the lack of memories about sleep state would lead to, in this framework, erraneous conclusion that sleep state is unconscious.

2.6   Boolean Mind And Cognition

2.6.1   Fermions And Boolean Cognition

Fermionic Fock state basis defines naturally a quantum version of Boolean algebra. In zero energy ontology predicting that physical states have vanishing net quantum numbers, positive and negative energy components of zero energy states with opposite fermion numbers define realizations of Boolean functions via time-like quantum entanglement. One can also consider an interpretation of zero energy states in terms of rules of form $A \to B$ with the instances of A and B represented as elements Fock state basis fixed by the diagonalization of the density matrix defined by $M-$-matrix.

Hence Boolean consciousness would be basic aspect of zero energy states. Physical states would be more like memes than matter. Note also that the fundamental super-symmetric duality between bosonic degrees of freedom (size and shape of the 3-surface) and fermionic degrees of freedom would correspond to the sensory-cognitive duality.

This would explain why Boolean and temporal causalities are so closely related. Note that zero energy ontology is certainly consistent with the usual positive energy ontology if unitary process U associated with the quantum jump is more or less trivial in the degrees of freedom usually assigned with the material world. There are arguments suggesting that U is tensor product of of factoring S-matrices associated with 2-D integrable QFT theories [K24]: these are indeed almost trivial in momentum degrees of freedom. This would also imply that our geometric past is rather stable so that quantum jump of geometric past does not suddenly change your profession from that of musician to that of physicist.

2.6.2   Fuzzy Logic, Quantum Groups, And Jones Inclusions

Matrix logic [A9] emerges naturally when one calculates expectation values of logical functions defined by the zero energy states with positive energy fermionic Fock states interpreted as inputs and corresponding negative energy states interpreted as outputs. Also the non-commutative version of the quantum logic, with spinor components representing amplitudes for truth values replaced with non-commutative operators, emerges naturally. The finite resolution of quantum measurement generalizes to a finite resolution of Boolean cognition and allows description in terms of Jones inclusions $\mathcal{N} \subset \mathcal{M}$ of infinite-dimensional Clifford algebras of the world of classical worlds (WCW) identifiable in terms of fermionic oscillator algebras. $\mathcal{N}$ defines the resolution in the sense that quantum measurement and conscious experience does not distinguish between states differing from each other by the action of $\mathcal{N}$.

The finite-dimensional quantum Clifford algebra $\mathcal{M}/\mathcal{N}$ creates the physical states modulo the resolution. This algebra is non-commutative which means that corresponding quantum spinors have non-commutative components. The non-commutativity codes for the that the spinor components are correlated: the quantized fractal dimension for quantum counterparts of 2-spinors satisfying $d = 2cos(\pi/n) \leq 2$ expresses this correlation as a reduction of effective dimension.

The moduli of spinor components however commute and have interpretation as eigenvalues of truth and false operators or probabilities that the statement is true/false. They have quantized spectrum having also interpretation as probabilities for truth values and this spectrum differs from the spectrum $\{1, 0\}$ for the ordinary logic so that fuzzy logic results from the finite resolution of Boolean cognition [K120].

2.6.3   P-Adic Physics As Physics Of Cognition

p-Adic physics as physics of cognition and intentionality provides a further element of TGD inspired theory of consciousness. At the fundamental level light-like 3-surfaces are basic dynamical objects in TGD Universe and have interpretation as orbits of partonic 2-surfaces. The generalization of the notion of number concept by fusing real numbers and various p-adic numbers to a more general structure makes possible to assign to real parton a p-adic prime p and corresponding p-adic partonic 3-surface obeying same algebraic equations. The almost topological QFT property of quantum TGD is an essential prerequisite for this. The intersection of real and p-adic 3-surfaces would consists of a discrete set of points with coordinates which are algebraic numbers. p-Adic partons would relate to both intentionality and cognition.

Real fermion and its p-adic counterpart forming a pair would represent matter and its cognitive representation being analogous to a fermion-hole pair resulting when fermion is kicked out from Dirac sea. The larger the number of points in the intersection of real and p-adic surfaces, the better the resolution of the cognitive representation would be. This would explain why cognitive representations in the real world are always discrete (discreteness of numerical calculations represent the basic example about this fundamental limitation).

All transcendental p-adic integers are infinite as real numbers and one can say that most points of p-adic space-time sheets are at spatial and temporal infinity in the real sense so that intentionality and cognition would be literally cosmic phenomena. If the intersection of real and p-adic space-time sheet contains large number of points, the continuity and smoothness of p-adic

physics should directly reflect itself as long range correlations of real physics realized as p-adic fractality. It would be possible to measure the correlates of cognition and intention and in the framework of zero energy ontology [K24] the success of p-adic mass calculations can be seen as a direct evidence for the role of intentionality and cognition even at elementary particle level: all matter would be basically created by intentional action as zero energy states.

2.6.4 Infinite Primes And Cognition

Somehow it is obvious that infinite primes must have some very deep role to play in quantum TGD and TGD inspired theory of consciousness. What this role precisely is has remained an enigma although I have considered several detailed interpretations, one of them above.

In the following an interpretation allowing to unify the views about fermionic Fock states as a representation of Boolean cognition and p-adic space-time sheets as correlates of cognition is discussed. Very briefly, real and p-adic partonic 3-surfaces serve as space-time correlates for the bosonic super algebra generators, and pairs of real partonic 3-surfaces and their algebraically continued p-adic variants as space-time correlates for the fermionic super generators. Intentions/actions are represented by p-adic/real bosonic partons and cognitions by pairs of real partons and their p-adic variants and the geometric form of Fermi statistics guarantees the stability of cognitions against intentional action. It must be emphasized that this interpretation is not identical with the one discussed above since it introduces different identification of the space-time correlates of infinite primes.

Infinite primes very briefly

Infinite primes have a decomposition to infinite and finite parts allowing an interpretation as a many-particle state of a super-symmetric arithmetic quantum field theory for which fermions and bosons are labelled by primes. There is actually an infinite hierarchy for which infinite primes of a given level define the building blocks of the infinite primes of the next level. One can map infinite primes to polynomials and these polynomials in turn could define space-time surfaces or at least light-like partonic 3-surfaces appearing as solutions of Chern-Simons action so that the classical dynamics would not pose too strong constraints.

The simplest infinite primes at the lowest level are of form $m_B X/s_F + n_B s_F$, $X = \prod_i p_i$ (product of all finite primes). The simplest interpretation is that X represents Dirac sea with all states filled and $X/s_F + s_F$ represents a state obtained by creating holes in the Dirac sea. m_B, n_B, and s_F are defined as $m_B = \prod_i p_i^{m_i}$, $n_B = \prod_i q_i^{n_i}$, and $s_F = \prod_i q_i$, m_B and n_B have no common prime factors. The integers m_B and n_B characterize the occupation numbers of bosons in modes labelled by p_i and q_i and $s_F = \prod_i q_i$ characterizes the non-vanishing occupation numbers of fermions.

The simplest infinite primes at all levels of the hierarchy have this form. The notion of infinite prime generalizes to hyper-quaternionic and even hyper-octonionic context and one can consider the possibility that the quaternionic components represent some quantum numbers at least in the sense that one can map these quantum numbers to the quaternionic primes.

The obvious question is whether WCW degrees of freedom and WCW spinor (Fock state) of the quantum state could somehow correspond to the bosonic and fermionic parts of the hyper-quaternionic generalization of the infinite prime. That hyper-quaternionic (or possibly hyper-octonionic primes would define as such the quantum numbers of fermionic super generators does not make sense. It is however possible to have a map from the quantum numbers labelling super-generators to the finite primes. One must also remember that the infinite primes considered are only the simplest ones at the given level of the hierarchy and that the number of levels is infinite.

Algebraic Brahman=Atman identity

The proposed view about cognition emerges from the notion of infinite primes [K102], which was actually the first genuinely new mathematical idea inspired by TGD inspired consciousness theorizing. Infinite primes, integers, and rationals have a precise number theoretic anatomy. For instance, the simplest infinite primes correspond to the numbers $P_\pm = X \pm 1$, where $X = \prod_k p_k$

is the product of all finite primes. Indeed, $P_{\pm}\ mod\ p = 1$ holds true for all finite primes. The construction of infinite primes at the first level of the hierarchy is structurally analogous to the quantization of super-symmetric arithmetic quantum field theory with finite primes playing the role of momenta associated with fermions and bosons. Also the counterparts of bound states emerge. This process can be iterated: at the second level the product of infinite primes constructed at the first level replaces X and so on.

The structural similarity with repeatedly second quantized quantum field theory strongly suggests that physics might in some sense reduce to a number theory for infinite rationals M/N and that second quantization could be followed by further quantizations. As a matter fact, the hierarchy of space-time sheets could realize this endless second quantization geometrically and have also a direct connection with the hierarchy of logics labeled by their order. This could have rather breathtaking implications.

1. One is forced to ask whether this hierarchy corresponds to a hierarchy of realities for which level below corresponds in a literal sense infinitesimals and the level next above to infinity.

2. Second implication is that there is an infinite number of infinite rationals behaving like real units ($M/N \equiv 1$ in real sense) so that space-time points could have infinitely rich number theoretical anatomy not detectable at the level of real physics. Infinite integers would correspond to positive energy many particle states and their inverses (infinitesimals with number theoretic structure) to negative energy many particle states and $M/N \equiv 1$ would be a counterpart for zero energy ontology to which oneness and emptiness are assigned in mysticism.

3. Single space-time point, which is usually regarded as the most primitive and completely irreducible structure of mathematics, would take the role of Platonia of mathematical ideas being able to represent in its number theoretical structure even the quantum state of entire Universe. Algebraic Brahman=Atman identity and algebraic holography would be realized in a rather literal sense.

This number theoretical anatomy should relate to mathematical consciousness in some manner. For instance, one can ask whether it makes sense to speak about quantum jumps changing the number theoretical anatomy of space-time points and whether these quantum jumps give rise to mathematical ideas. In fact, the identifications of Platonia as spinor fields in WCW on one hand and as the set number theoretical anatomies of point of embedding space force the conclusion that WCW spinor fields (recall also the identification as correlates for logical mind) can be realized in terms of the space for number theoretic anatomies of embedding space points. Therefore quantum jumps would be correspond to changes in anatomy of the space-time points. Embedding space would be experiencing genuine number theoretical evolution. The whole physics would reduce to the anatomy of numbers. All mathematical notions which are more than mere human inventions would be imbeddable to the Platonia realized as the number theoretical anatomies of single embedding space point.

In [K25, K102] a concrete realization of this vision is discussed by assuming hyper-octonionic infinite primes as a starting point. The simplest realization of infinite octonionic/quaternionic primes as products of infinite primes and octonions avoids the problems related to non-associativity and commutativity. Quantum states are required to be associative in the sense that they correspond to quantum super-positions of all possible associations for the products of finite primes (say $|A(BC)\rangle + |(AB)C\rangle$). The ground states of super conformal representations would correspond to infinite primes mappable to space-time surfaces (quantum classical correspondence). The excited states of super-conformal representations would be represented as quantum entangled states in the tensor product of state spaces $\mathcal{H}_{h_k}$ formed from Schrödinger amplitudes in discrete subsets of the space of 8 real units associated with embedding space 8 coordinates at point h_k: the interpretation is in terms of a 8-fold tensor power of basic super-conformal representation. Although the representations are not completely local at the level of embedding space, they involve only a discrete set of points identifiable as arguments of n-point function. The basic symmetries of the standard model reduce to number theory if hyper-octonionic infinite rationals are allowed. Color confinement reduces to rationality of infinite integers representing many particle states.

2.7   Quantum Correlates Of Qualia

The basic theoretical ingredients described above lead to the following general vision about qualia described in detail in [K39]. In the following the latest view about theory is summarized. The notion of quale is understood in an extremely general sense: "primary attribute of conscious experience" might serve as a synonym for "quale" in the sense as it is used in the following.

2.7.1   Development Of Ideas

To achieve something which would deserve to be called a general theory of qualia required almost a decade. During the first years, and in lack of any general theory of qualia, I could only make educated guesses, which were doomed to be wrong.

1. A connection between qualia and EEG MEs emerged, when I learned about the effects of classical electromagnetic fields on brain at frequencies which are cyclotron frequencies or amplitude modulated by cyclotron frequencies [J53].

2. The discovery that p-adic physics is physics of cognition (or at least imagination, one should be very cautious in order to avoid over generalizations!) clarified the views about the relationship between cognition and sensory experience [K64].

3. The notion of the many-sheeted ionic flow equilibrium was a further important breakthrough [K17, K18]. It allowed to realize that MEs, superconducting magnetic flux tubes, and ordinary biomatter at atomic space-time sheets form a three-levelled master-slave hierarchy.

4. The realization that MEs carrying super-symplectic representations at their light-like boundaries are excellent candidates for the carriers of at least some of our qualia, gave a totally new perspective to the problem of qualia [K68]. It seems however that MEs are not all that is needed: our qualia involve both super-symplectic and magnetic quantum phase transitions.

5. The work with the problems related to the precise formulation of Negentropy Maximization Principle led to the realization that each quantum jump defines a quantum measurement followed by a state preparation leading to an unentangled product state. This means the reduction of the quantum measurement theory to basic quantum TGD. The next realization was that the quantum jump sequence defining self defines a statistical ensemble of prepared states. One can identify the fundamental statistical ensembles of statistical physics as selves and implied a deep and precise connection between thermodynamics and the theory of qualia allowing a general classification of qualia and an identification of their thermodynamical correlates.

6. The last breakthrough in development, which is still continuing, was the realization that very general arguments lead to the view that ultimate (conscious-to-us) sensory representations are realized outside the body on the magnetic canvas provided by the magnetic flux tube structures associated with brain and having most plausibly size for which Earth size as a natural unit. One can see cortex as a collection of standard features some of which are associated to the objects of the perceptive field represented as magnetic sub-selves. Frequency place coding (MEs generate magnetic quantum phase transitions) plays a key role in this association.

Music metaphor at axonal level

Music metaphor has been one philosophical quide line behind the identification of the quantum correlates of the sensory qualia.

1. Axons are like strings of a music instrument. What this metaphor means is however not obvious. Frequency coding relates only the intensity of the sensory quale. Nerve pulses induce dropping of various ions to magnetic flux tubes and this generates EEG MEs at EEG frequencies serving as entanglers to the sensory magnetic canvas and the variation of these frequencies could code for the distance to the object of the perceptive field.

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

A stronger interpretation of the metaphor is that sensory pathways are like strings of a musical instrument such that the sound produced by the string corresponds to a sensory modality associated with the sensory pathway. Nerve pulse patterns determine the experience as chords from from the notes of various instruments in the same sense as the musician produces the music. This leads to a generalization of the idea about brain as an associative net.

More concretely, postsynaptic receptors act as neuronal sensory receptors and transmitters emitted and MEs generated by the presynaptic neuron induce neuronal sensory experiences in the postsynaptic neuron. The specialization of the neuronal receptors would be same for the entire sensory pathway and determine the qualia associated with it.

2. Resonance is an essential aspect of music instrument as is resonant frequency modulation which can involve several levels. The frequencies characterizing the hierarchical modulation provides a partial characterization of the sensory representations. Quantum mechanically resonance corresponds to a harmonic perturbation with frequency which is difference of energies for the states of some sub-system. In this kind of situation quantum jumps can be amplified to quantum phase transitions and sub-self representing mental image wakes up.

Unfortunately, music metaphor is only a metaphor and has led to a plethora of various models for qualia.

ME's and qualia

The identification of MEs as building blocks of sensory and cognitive structures leads to a rather concrete model for long term memory and forces the hypothesis that MEs define an infinite hierarchy of electromagnetic life forms living in symbiosis with each other, magnetic flux tube structures, and the matter at atomic space-time sheets. The realization that MEs serve as quantum holograms and the properties of the super-symplectic stats gave the final justification for this identification. The model allows to understand EEG as a direct physical correlate of mind-like space-times sheets (MEs) associated with ELF selves and provides a general vision about the electromagnetic organization of brain as sensory and motor organ of higher level self. Also what might be called RF (radio frequency) and MW (microwave) MEs representing our mental images are crucial for the model.

The model of qualia leads to rather detailed view about the sizes of the hierarchy of various MEs defining what might be called our radiation body. Also the notion of magnetic body is needed. It took a long time to answer the question whether we should identify ourselves with the self associated with brain; with the entire body; with ELF ME having size at least of order Earth circumference; or with self having literally infinite size. The last two options seems to be more plausible than the first two: the illusion that we are nothing but our physical bodies is created by the fact that during wake-up state sensory input is about the region surrounding our body. The simplest option is that the relevant magnetic flux tube structures have same sizes as ELF MEs. During sleep our attention might be directed to transpersonal levels of consciousness.

MEs, magnetic superconductors, and many-sheeted ionic flow equilibrium

The lack of clearcut empirical evidence for the predicted supra phases has been a stumbling block for the quantitative development of the theory for a long time. The situation changed dramatically when I learned about the effects of ELF em fields on living matter[1]. This article provided the ingredients making possible a general quantitative model of quantum control and coordination in which self hierarchy has as its dynamical correlate hierarchy of weakly coupled super conductors

---

[1] I am grateful for Gene Johnson for sending me the popular article of Yarrow [J53] about bio-electromagnetism.

and massless extremals (MEs) interacting with the ordinary matter at atomic space-time sheets. MEs indeed provide a model of Josephson junction and an explanation for the amplitude windows observed in the experiments of Blackman and others [J115].

Later the experimental findings challenging the notions of ionic channels and pumps [I40] led to the identification of homeostasis as many-sheeted ionic flow equilibrium in which the ionic concentrations at atomic space-time sheets are controlled by much smaller ionic concentrations at superconducting magnetic flux tubes. MEs control superconducting magnetic flux tubes via magnetic induction, by inducing magnetic phase transitions and by acting as Josephson junctions between magnetic flux tubes.

Magnetic transitions at superconducting magnetic flux tubes serve as seeds for phase transitions in quantum critical quantum spin glass type phase of macroscopic super conductor leading to generation of a region of new kind of phase whose quantum numbers differ from old one by the quantum numbers associated with magnetic transition frequency. Thus quantum transitions are amplified to macroscopic quantum transitions and Bose-Einstein condensation (analogous to induced emission) is the basic mechanism behind the process.

The first natural guess was that magnetic quantum phase transitions correspond to our qualia. That transition frequencies are involved is indeed in nice accordance with quantum jumps between histories as moment of consciousness identification. However, the fact that magnetic states correspond to a lower level of abstraction than super-symplectic states associated with MEs, suggests that magnetic qualia do not correspond to our qualia directly. Rather primitive chemical qualia experienced by cell level selves might be in question.

The role of super-symplectic algebra

An important step in the development of the theory of qualia was the realization of the importance of super-symplectic symmetries. The answer to this question might have been guessed by taking quantum measurement theory as a starting point.

1. Basic geometric objects is the configuration space of all possible 3-surfaces in $M_+^4 \times CP_2$. In absence of non-determinism of Kähler action everything would reduce to the boundary of the future light-cone ($\delta M_+^4 \times CP_2$) carrying representations of super-symplectic and super-conformal algebra localized with respect to the light-like radial coordinate of the light-cone boundary. These symmetries are obviously cosmological. Also quaternion conformal symmetries are possible and these can be identified as the TGD counterparts of string model conformal symmetries responsible for elementary particle quantum numbers.

2. The non-determinism of Kähler action forces to introduce super-symplectic representations at the light-like boundaries X^3 of MEs acting as quantum holograms. Thus superconformal and super-symplectic symmetries become macroscopic symmetries and must be crucial for consciousness.

3. There are two kinds of WCW degrees of freedom: quantum fluctuating non-zero modes and zero modes which can be regarded as classical, non-quantum fluctuating degrees of freedom in complete consistency with the reduction of standard quantum measurement theory to the localization in zero modes occurring in each quantum jump. Zero mode algebra contains the generators of super-symplectic algebra with even conformal weight. In particular, zero modes contain the points of an infinite-dimensional flag-manifold extended to contain the radial Virasoro algebra of the light-like boundary of ME localized with respect to CP_2. Radial coordinate corresponds to the light-like coordinate of the light-like boundary of ME. This flag-manifold parametrizes all possible choices of the quantization axes for the canonical Lie-algebra.

2.7.2 Qualia And Thermodynamics

The connection between thermodynamics and qualia was the real breakthrough in the development of ideas. In some sense this finding is not a news: the close connection between pressure sense and temperature sense and thermodynamics is basic facts of psychophysics. In TGD framework the contents of consciousness is determined as some kind of average over the sequence of very large

number of quantum jump and this suggests strongly that non-geometric qualia allow statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps after the last "wake-up" of self. This picture allows to see the ageing of self with respect to subjective time as an approach to thermal equilibrium.

1. There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about zero modes or about increments of zero modes in quantum jump.

2. The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM...$ generalizes to TGD context: note however that in case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light-cone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is gradient (flow) of the extensive variable in the direction of the subjective time. Super-symplectic thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

3. Since subjective experience corresponds to quantum jumps, it is natural to assume that only the increments of zero modes and quantum numbers are experienced consciously. Statistical interpretation also suggests that an averaging over increments occurs. The possibility of sub-selves makes possible to have mental images of finite time duration and this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of phone number). A further working hypothesis is universality: qualia associated with quantum phase transitions depend only on the quantum number increments. In particular, the increments of Poincare and color and electroweak quantum numbers define what might be called universal kinesthetic qualia.

The thermodynanical expression for dE suggests a general classification of qualia consistent with the "holy trinity" of existences implied by TGD.

1. Emotions as order-disorder qualia

$T - S$ pair correspond subjective existence and generalizes to disorder-order type, information theoretic qualia qualia about the state of self: hot-cold and pain-pleasure type sensations and also more abstract experiences associated with various sub-selves of self. These qualia are strongly emotional single-pixel holistic qualia measuring whether some kind of an entropy variable is increasing or decreasing. The total entropy for the statistical ensemble defined by self determines how sharp the mental image is. Low entropy content means alertness and attentiveness. High entropy content means fuzzy mental image. Getting tired means inability to keep mental images in low entropy state.

2. Kinestetic qualia defined by generalized forces

p-V pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. The increments of maximum number of mutually commuting Poincare, color and electroweak quantum numbers define this kind of qualia. The increments of four-momentum code for the sensation of force whereas the increments of orbital angular momentum code for the sensation of torque. Spin flip could code for something else. Tactile senses such as pressure sense and their generalizations involve kinesthetic qualia. The increment of energy or equivalently, increment of frequency, can be identified as correlate for hearing in generalized sense responsible for the dynamical nature of auditory experience (hearing is time-like version of force sense). It is not clear whether spin flip has interpretation as torque or possibly as figure background separation. In TGD based model of auditory experience hearing relates to Z^0 magnetic spin flip phase transitions for cognitive neutrino pairs.

The rate for the increase of the two diagonal color quantum numbers should code intensity type variables associated with color sensation. The rate for the increase of electric charge of sub-self should code for electric sense possessed by, say, fishes. Also $B - M$, $\phi\rho$ and $E - P$ pairs

correspond to generalized forces since electromagnetic fields are reduced to space-time geometry in TGD framework.

3. Generalized chemical qualia vm

$\mu - N$ pair corresponds to "objective existence" defined by quantum histories and N is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. Quite generally, super-symplectic and quaternion conformal super algebras should define these qualia and the number of these qualia is very large.

i) One can assign particle numbers to phases with various magnetic quantum numbers and these could define generalized chemical qualia which could perhaps be regarded as qualia and subqualia of chemical qualia defined by a particular ion and chemical qualia could actually reduce to magnetic qualia. Since the changes of magnetic field induce these quantum phase transition, it would seem that magnetic and Z^0 magnetic quantum phase transitions at superconducting magnetic flux tubes could correspond to this kind of qualia. In principle, endogenous NMR and its generalizations induced by the interaction of magnetic and Z^0 magnetic fields of MEs with magnetic and Z^0 magnetic flux tube structures are possible. Chemical qualia would very naturally correspond to the Bose-Einstein condensation of ions to the superconducting magnetic flux tubes: these ions could be even the ions of tastant or odorant. Also secondary representations at the level of cortex in terms of superconducting light ions are possible and would give rise to classification of tastes and odours. Magnetic qualia are characterized by definite transition frequencies and this makes possible place-/time coding by magnetic transition frequencies if magnetic or Z^0 magnetic field varies along magnetic flux tube/is a function of time. The activation of a point of living map would generate some quale at that point.

ii) For super-symplectic qualia the number of Bose-Einstein condensed " WCW photons" having nontrivial dependence on WCW degrees of freedom replaces number of molecules. The condensation rates for the numbers of the WCW photons with non-vanishing color quantum numbers could be interpreted as correlates of color qualia whereas the condensation rates for color singlet WCW photons could relate to the intensity of color sensation. If the rates for the transfer of color quantum numbers define intensity type variables associated with color experience then BE condensation to color singlet states does not give rise to experienced quale so that only non-diagonal color generators correspond to visual colors. Also the BE condensation of the ordinary coherent light should give rise to some kind of quale: perhaps vibratory sense which can be developed to effective vision, could correspond to non-colored vision. WCW Hamiltonians are also labelled by 2-dimensional orbital spin quantum number and longitudinal momentum. Polarization sense and sensation about motion of the object of visual field would naturally relate to spin and longitudinal momentum.

iii) Tactile senses involve topological phase transitions involving the creation of flux tubes between object and skin whose number would thus be the relevant variable. The purely sensory aspect of physical pain could correspond to a topological phase transition involving the splitting of join-along boundaries bonds between space-time sheets (MEs could even define these bonds) so that N would be now the number of flux tubes. The simplest picture requires that the MEs associated with sensory organs are connected to the MEs responsible for our experience. Of course, splitting and generation of flux tubes could occur also at the level of sensory representations.

4. Boolean qualia

Boolean qualia

Boolean qualia would be naturally associated with fermion number or fermionic spin degrees of freedom. There are super-symplectic and super-Kac Moody type Boolean qualia. The spin flipping transitions associated with the fermionic generators of super-symplectic algebra might give rise to Boolean consciousness with intrinsic meaning ("This is true") but there are many other possibilities.

A general model for abstraction process based on the Combinatorial Hierarchy [K41] not only explains the basic numbers of the genetic code but also suggests an entire hierarchy of codes in accordance with fractality of TGD Universe.

The next code after genetic code in the hierarchy of codes defined by Combinatorial Hierarchy is very attractive candidate for a "memetic code". The hypothesis predicts correctly the .1 second time scale for the duration of "our" self (immediate short term memory, duration of psychological moment). Code-words correspond to the sequences of 126 bits with a duration of 1/1260 seconds: this is slightly below the time scale of nerve pulse so that membrane oscillations are perhaps a more natural realization for the code. The facts that the time scale of causal diamond CD associated with d quark corresponds to 1280 Hz frequency and the time scale of electron's CD corresponds to 10 Hz frequency suggest that quark pairs allow a realization of the memetic code with single quark sub-CD representing and electron CD the code word.

2.7.3 Geometric Qualia And Zero Modes

The zero modes of WCW are special in the sense that in each quantum jump localization occurs in this space. Zero modes characterize the size and shape of 3-surface and are excellent candidate to represent information about the state of organism (3-surface itself) geometrically. Zero modes can be parametrized as an infinite-dimensional flag-manifold associated with the algebra of the infinitesimal canonical transformations of $E^2 \times CP_2$, where S^2 is sphere at the light-cone boundary extended by Virasoro algebra acting in radial direction of light-cone boundary. Physically this space corresponds to all possible choices of the quantization axes for generators of super-symplectic Algebra and, in accordance with the basic assumptions of quantum measurement theory, each quantum jump involves this kind of choice. Infinite-dimensional flag manifold contains as sub-flag-manifold $S^2 \times F_3$ parameterizing choices of quantization axes of spin and color ($F_3 = SU(3)/U(1) \times U(1)$). Lorentz invariance suggests the extension of S^2 to 2+2 dimensional flag-manifold $F = SO(3,1)/SO(2) \times R$ parameterizing various choices of the quantization axes for Lorentz quantum numbers [K39].

There are continuous, geometric and kinestetic (both geometric in four-dimensional sense) qualia like position and velocity; orientation and angular velocity, and also geometric time and experienced rate of time flow. All these pairs correspond to mutually in-compatible observables quantum mechanically. The hypothesis motivated by the work of Barbara Shipman [Shipman_{1,2,3}] is that some coordinates of F_3 parametrize positions. The generalization of this hypothesis is that the infinite-dimensional flag-manifold associated with the zero mode part super-symplectic algebra somehow gives rise to a conscious representation of continuous, classical qualia basically assignable to the choise of quantization axes. The hypothesis indeed makes sense: the entire isometry group of WCW , in particular the sub-group defined by zero modes, leaves induced Kähler form invariant but affects magnetic and Z^0 magnetic fields and hence magnetic transition frequencies. Also color rotations act in F_3 nontrivially and, although they leave Kähler form invariant, they affect magnetic and Z^0 magnetic fields and thus the corresponding magnetic transition frequencies. This means that a curve of the infinite-dimensional flag-manifold can be mapped to a varying cyclotron frequency.

2.8 Solutions To Some Paradoxes

The TGD inspired theory of consciousness provides a solution to the many paradoxes related to the basic quantum physics and the philosophy of conscious mind. The solution of these paradoxes is basically due to the replacement of the dualistic and monistic world views by the tripartistic world view of TGD.

2.8.1 Paradoxes Related To Quantum Physics

The basic paradox is the conflict between the non-determinism of the state function reduction and the determinism of the Schrödinger equation. At a more general level this paradox is the conflict between the subjectively experienced actuality of the free will and the determinism of the objective world. The resolution of this paradox is simple in TGD context. One must give up the idea of single objective reality and replace it with a deterministic quantum history, which changes in each quantum jump, which is a genuine act of free will occurring outside the realm of the geometric space-time. Thus the objective reality, in the sense of a physical theory, is indeed deterministic,

apart from the non-determinism related to the special properties of the Kähler action. In fact, a determinism of the Kähler action is achieved by replacing the ordinary concept of the 3-space with the concept of an association sequence and this naturally leads to a model for thinking systems. Volition seems to correspond to the selection between various degenerate absolute minima of the Kähler action and has thus a direct classical counterpart.

In the context of the deterministic physics, theoretician encounters two rather unpleasant paradoxes. The determinism implies that the unique objective reality corresponds to a single solution of the field equations. The first question is "What determines the initial conditions, say at the moment of the big bang?" and the attempt to answer this question leads necessarily outside the physical theory: one possibility is to postulate anthrophic principle. In TGD objective reality changes at each quantum jump and the localization in zero modes and NMP imply a genuine evolution: therefore the recent objective reality is an outcome of conscious selections. The second problem encountered by a theoretician is that in principle it is not possible to test a deterministic theory since only single solution of the field equations is realized and a genuine testing would require the comparison of the time developments for various initial data. In practice this problem can be circumvented by assuming the existence of identical sub-systems having very weak interactions with the external world but in principle the problem remains unsolved.

The famous Einstein-Bohr debate was related with the question whether God plays dice or not. Amusingly, in TGD context both were correct in their own ways! Quantum histories are indeed deterministic but God can replace the old quantum history with a new one: perhaps one should not however call this act dice playing but simply an act of free will. Einstein was also an advocate of local realism: this led to Einstein-Podolski-Rosen paradox created by the possibility of quantum entanglement between distant system. In TGD framework local realism holds true at the level of the infinite-dimensional WCW but not at the level of space-time since point like particles are replaced with 3-surfaces.

The Schrödinger cat paradox has also an elegant solution in TGD context. The point is that conscious experience is associated with a quantum jump leading to a final state in which cat is either dead or alive. There is no conscious experience about the situation in which the cat is both dead and alive giving answer to the question "Dead or alive?". More generally, this feature of consciousness also could explain why the world of our conscious experience looks classical: it simply cannot look but classical since the very moment of consciousness makes it classical. In fact, the world *is* predicted to be genuinely classical to the extent that mutual quantum entanglement between different p-adic sub-Universes seems impossible for purely mathematical reasons. The localization into zero modes occurring in quantum jumps strengthens this conclusion considerably since it implies that the final states of quantum jumps are superpositions of macroscopically equivalent space-time surfaces: the world of conscious experience is genuinely classical.

The phenomenon of dissipation is paradoxal from the point of view of standard physics. It is generally accepted that the fundamental laws of classical physics are reversible whereas everyday reality is manifestly irreversible. Thus the situation is rather schizophrenic. Two worlds, the reversible and extremely beautiful world of the fundamental physics and the irreversible and mathematically rather ugly "real" world, seem to exist simultaneously. The quantum jumps between quantum histories concept solves the paradox and one can understand the dissipative world as an effective description forming an "almost" -envelope for the sequence of reversible worlds (time developments).

The standard physics is based on positive energy ontology and leads to the paradox caused by conservation laws. Quantum jumps preserve the values of conserved quantum numbers so that the question about initial values of the quantum numbers arises and leads to the necessity to postulate some meta level principle selecting the quantum states of entire universe having the preferred values of total quantum numbers. Of course, the problems are also caused by the fact that one must be able to compare the infinite values of total conserved quantum numbers- at least in the case of energy. Zero energy ontology provides an elegant solution of the problem and implies that any zero energy state is in principle creatable from vacuum.

2.8.2   Paradoxes Related To The Theories Of Consciousness

Chalmers describes in his book "Conscious Mind" [J48] several paradoxes related to the materialistic and dualistic theories of mind. A common denominator for these problems is the assumption

that consciousness is a property of a physical state: hence these paradoxes disappear in TGD context. These paradoxes are encountered also in the quantum theories of consciousness identifying consciousness as a property of a macroscopic quantum state, say Bose Einstein condensate.

In the materialistic theories of mind, postulating a unique objective reality, consciousness is an epiphenomenon and free will is necessarily a peculiar illusion and one can always ask why the consciousness is needed at all: nothing changes in the physical reality if consciousness is dropped away. It is also very difficult to understand how the contents of consciousness are determined by the state of the material world.

In the dualistic theories postulating a unique objective reality (say the theory of Chalmers [J48]), the problems are related to the coupling between matter and mind. The basic problem of the dualistic theories is what Chalmers calls hard problem: how the physical processes in the brain give rise to conscious experience? If the laws of the physics determine the behaviour of the system completely then one ends up immediately either with a complete separation of the mind and matter so that our conscious experience tells nothing about the material world or with materialism and epiphenomenalism. One can also consider a non-trivial coupling between matter and "mind like" fields but assuming a deterministic physics one ends up with a situation in in which the mind fields are effectively just additional physical fields and consciousness is again redundant.

An exotic example of this kind of a paradox is the following one described in [J48]. In the dualistic theories in which the physical laws determine the objective reality, all psychological (third person) aspects of the mind are in principle purely physical. The book written by Chalmers about consciousness is obviously an example of a completely physical phenomenon. Therefore the contents of the book need not have anything to do with Chalmers's ideas about consciousness! More generally, the reports about the states of consciousness need not have anything to do with the states of consciousness in the dualistic theories of this kind. The only manner to save the day (and the uniqueness of the objective reality) is to accept materialism and epiphenomenalism.

In TGD framework, which could be called tripartistic, hard problem and other problems of the dualistic theories disappear since there is no need to assign consciousness to quantum history. Moment of consciousness as quantum jump between quantum histories hypothesis allows even to define measures for the information contents of the conscious experience despite the fact that one cannot write explicit formulas for the contents of conscious experience.

2.8.3   Logical Paradoxes And Concept Of Time

Many logical paradoxes could be resolved if one assumes that there are two times: geometric and subjective and that the space-time surface providing linguistic representations changes quantum jump by quantum jump. In particular, during the conscious argument leading to the logical paradox!

The objections of Uri Fidelman [J147] against the Platonic vision about reality involve the paradoxes of the cyclic cosmology (one might think that Turing machine in cyclic cosmology might be able to "know" whether it has halted immediately after starting and thus be much more powerful than ordinary Turing machine). Basic paradox is that in cyclic cosmology allowing time travel one can imagine a son who murders his mother.

It is interesting to consider this paradox as resulting from identification of the identification of subjective time with geometric time, which I see only as an approximation. In TGD the counterpart of time travel would be sequence of quantum jumps changing the entire classical history quantum jump by quantum jump and inducing the shift of the space-time region, where the contents of consciousness of time traveller are concentrated, to the geometric past. No paradoxes result since space-time is not a fixed arena of dynamics but changes in each quantum jump.

As a second example one can take the second objection of Uri Fidelman [J147] against Penrose's program known as Berry's paradox. *Non-formalizable theory cannot provide a model of the physical world which includes the brain's cognitive function, since such a model must be lingual, written or spoken. However, such a model implies the following paradox of Berry: Let n be the smallest number which cannot be defined by an English sentence having less than, say, a hundred letters. This number exists, since the number of all possible combinations of a hundred letters is finite. Nevertheless, it has just now been defined by a sentence comprising less than a hundred letters.*

Berry's paradox could be understood when the piece of text is seen as inducing a sequence of quantum jumps in which the space-time region at which the argument is represented symbolically changes. For the initial space-time region representing my cognitive state there is indeed smallest number n which cannot be defined by using less than one hundred words (using the English in that space-time!). After reading the statement quantum history is replaced by a new, more complex one in which this this number can be defined by using less than one hundred words since a new reflective level of cognitive consciousness has emerged and is represented at space-time level.

This example encourages to think the possibility of replacing the idea of a fixed axiomatic system with a living and dynamically evolving system becoming conscious of new axioms from which new theorems can grow. Mathematician would not be anymore an outsider but and active participator affecting the mathematical system he is studying. For instance, when paradoxal statement represented symbolically becomes conscious in quantum jump sequence, also the context in which it was originally stated changes. This dynamical view about mathematical system could allow to solve antinomies.

Chapter 3

Negentropy Maximization Principle

3.1 Introduction

Quantum TGD involves "holy trinity" of time developments. There is the geometric time development dictated by the preferred extremal of Kähler action crucial for the realization of General Coordinate Invariance and analogous to Bohr orbit. There is what I originally called unitary "time development" U: $\Psi_i \to U\Psi_i \to \Psi_f$, associated with each quantum jump. This would be the counterpart of the Schrödinger time evolution $U(-t, t \to \infty)$. Quantum jump sequence itself defines what might be called subjective time development.

Concerning U, there is certainly no actual Schrödinger equation involved: situation is in practice same also in quantum field theories. It is now clear that in Zero Energy Ontology (ZEO) U can be actually identified as a sequence of basic steps such that single step involves a unitary evolution inducing delocalization in the moduli space of causal diamonds CDs) followed by a localization in this moduli space selecting from a superposition of CDs single CD. This sequence replaces a sequence of repeated state function reductions leaving state invariant in ordinary QM. Now it leaves in variant second boundary of CD (to be called passive boundary) and also the parts of zero energy states at this boundary. There is now a very attractive vision about the construction of transition amplitudes for a given CD [K110], and it remains to be see whether it allows an extension so that also transitions involving change of the CD moduli characterizing the non-fixed boundary of CD.

A dynamical principle governing subjective time evolution should exist and explain state function reduction with the characteristic one-one correlation between macroscopic measurement variables and quantum degrees of freedom and state preparation process. Negentropy Maximization Principle is the candidate for this principle. In its recent form it brings in only a single little but overall important modification: state function reductions occurs also now to an eigen-space of projector but the projector can now have dimension which is larger than one. Self has free will to choose beides the maximal possible dimension for this sub-space also lower dimension so that one can speak of weak form of NMP so that negentropy gain can be also below the maximal possible: we do not live in the best possible world. Second important ingredient is the notion of negentropic entanglement relying on p-adic norm.

The evolution of ideas related to NMP has been slow and tortuous process characterized by misinterpretations, over-generalizations, and unnecessarily strong assumptions, and has been basically evolution of ideas related to the anatomy of quantum jump and of quantum TGD itself.

Quantum measurement theory is generalized to theory of consciousness in TGD framework by replacing the notion of observer as outsider of the physical world with the notion of self. Hence it is not surprising that several new key notions are involved.

1. ZEO is in central role and brings in a completely new element: the arrow of time changes in the counterpart of standard quantum jump involving the change of the passive boundary of CD to active and vice versa. In living matter the changes of the of time are inn central role: for instance, motor action as volitional action involves it at some level of self hierarchy.

2. The fusion of real physics and various p-adic physics identified as physics of cognition to single adelic physics is second key element. The notion of intersection of real and p-adic worlds (intersection of sensory and cognitive worlds) is central and corresponds in recent view about TGD to string world sheets and partonic 2-surfaces whose parameters are in an algebraic extension of rationals. By strong form of of holography it is possible to continue the string world sheets and partonic 2-surfaces to various real and p-adic surfaces so that what can be said about quantum physics is coded by them. The physics in algebraic extension can be continued to real and various p-adic sectors by algebraic continuation meaning continuation of various parameters appearing in the amplitudes to reals and various p-adics.

   An entire hierarchy of physics labeled by the extensions of rationals inducing also those of p-adic numbers is predicted and evolution corresponds to the increase of the complexity of these extensions. Fermions defining correlates of Boolean cognition can be said so reside at these 2-dimensional surfaces emerging from strong form of holography implied by strong form of general coordinate invariance (GCI).

   An important outcome of adelic physics is the notion of number theoretic entanglement entropy: in the defining formula for Shannon entropy logarithm of probability is replaced with that of p-adic norm of probability and one assumes that the p-adic prime is that which produces minimum entropy. What is new that the minimum entropy is negative and one can speak of negentropic entanglement (NE). Consistency with standard measurement theory allows only NE for which density matrix is n-dimensional projector.

3. Strong form of NMP states that state function reduction corresponds to maximal negentropy gain. NE is stable under strong NMP and it even favors its generation. Strong form of NMP would mean that we live in the best possible world, which does not seem to be the case. The weak form of NMP allows self to choose whether it performs state function reduction yielding the maximum possible negentropy gain. If n-dimensional projector corresponds to the maximal negentropy gain, also reductions to sub-spaces with $n-k$-dimensional projectors down to 1-dimensional projector are possible. Weak form has powerful implications: for instance, one can understand how primes near powers of prime are selected in evolution identified at basic level as increase of the complexity of algebraic extension of rationals defining the intersection of realities and p-adicities.

4. NMP gives rise to evolution. NE defines information resources, which I have called Akashic records - kind of Universal library. The simplest possibility is that under the repeated sequence of state function reductions at fixed boundary of CD NE at that boundary becomes conscious and gives rise to experiences with positive emotional coloring: experience of love, compassion, understanding, etc... One cannot exclude the possibility that NE generates a conscious experience only via the analog of interaction free measurement but this option looks un-necessary in the recent formulation.

5. Dark matter hierarchy labelled by the values of Planck constant $h_{eff} = n \times h$ is also in central role and interpreted as a hierarchy of criticalities in which sub-algebra of super-symplectic algebra having structure of conformal algebra allows sub-algebra acting as gauge conformal algebra and having conformal weights coming as n-ples of those for the entire algebra. The phase transition increasing h_{eff} reduces criticality and takes place spontaneously. This implies a spontaneous generation of macroscopic quantum phases interpreted in terms of dark matter. The hierarchies of conformal symmetry breakings with $n(i)$ dividing $n(i+1)$ define sequences of inclusions of HFFs and the conformal sub-algebra acting as gauge algebra could be interpreted in terms of measurement resolution.

   n-dimensional NE is assigned with $h_{eff} = n \times h$ and is interpreted in terms of the n-fold degeneracy of the conformal gauge equivalence classes of space-time surfaces connecting two fixed 3-surfaces at the opposite boundaries of CD: this reflects the non-determinism accompanying quantum criticality. NE would be between two dark matter system with same h_{eff} and could be assigned to the pairs formed by the n sheets. This identification is important but not well enough understood yet. The assumption that p-adic primes p divide n gives deep connections between the notion of preferred p-adic prime, negentropic entanglement, hierarchy of Planck constants, and hyper-finite factors of type II_1.

6. Quantum classical correspondence (QCC) is an important constraint in ordinary measurement theory. In TGD QCC is coded by the strong form of holography assigning to the quantum states assigned to the string world sheets and partonic 2-surfaces represented in terms of super-symplectic Yangian algebra space-time surfaces as preferred extremals of Kähler action, which by quantum criticality have vanishing super-symplectic Noether charges in the sub-algebra characterized by integer n. Zero modes, which by definition do not contribute to the metric of "world of classical worlds" (WCW) code for non-fluctuacting classical degrees of freedom correlating with the quantal ones. One can speak about entanglement between quantum and classical degrees of freedom since the quantum numbers of fermions make themselves visible in the boundary conditions for string world sheets and their also in the structure of space-time surfaces.

NMP has wide range of important implications.

1. In particular, one must give up the standard view about second law and replace it with NMP taking into account the hierarchy of CDs assigned with ZEO and dark matter hierarchy labelled by the values of Planck constants, as well as the effects due to NE. The breaking of second law in standard sense is expected to take place and be crucial for the understanding of evolution.

2. Self hierarchy having the hierarchy of CDs as embedding space correlate leads naturally to a description of the contents of consciousness analogous to thermodynamics except that the entropy is replaced with negentropy.

3. In the case of living matter NMP allows to understand the origin of metabolism. NMP demands that self generates somehow negentropy: otherwise a state function reduction to the opposite boundary of CD takes place and means death and re-incarnation of self. Metabolism as gathering of nutrients, which by definition carry NE is the way to avoid this fate. This leads to a vision about the role of NE in the generation of sensory qualia and a connection with metabolism. Metabolites would carry NE and each metabolite would correspond to a particular qualia (not only energy but also other quantum numbers would correspond to metabolites). That primary qualia would be associated with nutrient flow is not actually surprising!

4. NE leads to a vision about cognition. Negentropically entangled state consisting of a superposition of pairs can be interpreted as a conscious abstraction or rule: negentropically entangled Schrödinger cat knows that it is better to keep the bottle closed.

5. NMP implies continual generation of NE. One might refer to this ever expanding universal library as "Akaschic records". NE could be experienced directly during the repeated state function reductions to the passive boundary of CD - that is during the life cycle of sub-self defining the mental image. Another, less feasible option is that interaction free measurement is required to assign to NE conscious experience. As mentioned, qualia characterizing the metabolite carrying the NE could characterize this conscious experience.

6. A connection with fuzzy qubits and quantum groups with NE is highly suggestive. The implications are highly non-trivial also for quantum computation allowed by weak form of NMP since NE is by definition stable and lasts the lifetime of self in question.

In the sequel the formulation of NMP and various ideas involved with NMP are discussed first. The formulation of NMP for hyper-finite factors is discussed in separate section. The last section considers some consequences of NMP discussed in more detail in various books.

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` [L17].

3.2   Basic Notions And Ideas Behind NMP

In the following the basic ideas and notions behind NMP as well as evolution of NMP are summarized. The first form of NMP was rather naïve. There was no idea about the anatomy of quantum

jump and NMP only stated that the allowed quantum jumps are such that the information gain of conscious experience measured by the reduction of entanglement entropy resulting in the reduction of entanglement between the subsystem of system and its complement is maximal. Later it became clear that quantum jump has a complex anatomy. The term quantum jump is still however used about the process in question.

3.2.1 Zero Energy Ontology

Zero energy ontology (ZEO) changes considerably the interpretation of the unitary process. In zero energy ontology (ZEO) quantum states are replaced with zero energy states defined as a superpositions of pairs of positive and negative energy states identified as counterparts of initial and final states of a physical event such as particle scattering. The matrix defining entanglement between positive and negative - christened as M-matrix - is the counterpart of the ordinary S-matrix but need not be unitary. It can be identified as a "complex square root" of density matrix expressible as a product of positive square root of diagonal density matrix and unitary S-matrix. Quantum TGD can be seen as defining a "square root" of thermodynamics, which thus becomes an essential part of quantum theory.

U-matrix is defined between zero energy states and cannot therefore be equated with the S-matrix used to describe particle scattering events. Unitary conditions however imply that U-matrix can be seen as a collection of M-matrices labelled by zero energy states so that the knowledge of U-matrix implies the knowledge of M-matrices. The unitarity conditions will be discussed later. A natural guess is that U is directly related to consciousness and the description of intentional actions. For positive energy ontology state function reduction to the opposite boundary of CD would serve as a state preparation for the next quantum jump: state preparation and reduction are therefore related by time reflection.

In ZEO state function preparation and reduction can be assigned to the positive and negative energy states defining the initial and final states of the physical event. The reduction of the time-like entanglement during the state function reduction process corresponds to the measurement of the scattering matrix. In the case of negentropic time-like entanglement the reduction process is not random anymore and the resulting dynamics is analogous to that of cellular automata providing a natural description of the dynamics of self-organization in living matter. This self-organization is also 4-dimensional in ZEO: this is of utmost importance in attempts to understand living matter.

According to standard quantum measurement theory state function reductions can take place repeatedly without any change in the state. In ZEO state function reduction to a given boundary of CD can occur repeatedly without changing the corresponding part of zero energy state but affecting the part at the opposite boundary. Superposition of CDs with different sizes is possible and one can assign to the second (active) boundary a wave function in the space of moduli, which include the proper time distance between the tips of CD and discrete boosts by a subgroup of Lorentz group leaving the tip of the fixed (passive) boundary invariant. This distance must increase in average sense and this gives rise to the arrow of experienced time. Self can be identified as a sequence of quantum jumps reducing to same boundary of CD.

The simplest assumption is that there are sequences of repeated state function reductions leaving everything at the passive boundary of CD invariant. In the moduli space for active boundary (parametwrized by Lorentz boost leaving passive boundary invariant and integer shift for the proper time distance between the tips of CD given repeated reduction, which consist of a unitary evolution in the moduli space of CDs inducing delocalization followed by localization to a fixed CD.

ZEO leads to a precise identification of the subsystem at space-time level. General coordinate invariance (GCI) in 4-D sense means that 3-surfaces related by 4-D diffeomorphisms are physically equivalent. It is convenient to perform a gauge fixing by a introducing a natural choice for the representatives of the equivalence classes formed by diffeo-related 3-surfaces.

1. Light-like 3-surfaces identified as surfaces at which the Minkowskian signature of the induced space-time metric changes to Euclidian one - wormhole contacts- are excellent candidates in this respect. The intersections of these surfaces with the light-like boundaries of CD define 2-D partonic surfaces. Also the 3-D space-like ends of space-time sheets at the light-like boundaries of CDs are very natural candidates for preferred 3-surfaces.

2. The condition that the choices are mutually consistent implies effective 2-dimensionality, whose original formulation was as follows. The intersections of these surfaces defining partonic 2-surface plus the distribution of 4-D tangent spaces at its points define the basic dynamical objects with 4-D general coordinate invariance reduced to 2-dimensional one. This effective 2-dimensionality was clear from the very beginning but is only apparent since also the data about 4-D tangent space distribution is necessary to characterize the geometry of WCW and quantum states. The quantum descriptions in terms of 3-D light-like or space-like surfaces and even in terms of 4-D surfaces are equivalent but redundant descriptions. 4-D space-time is necessary for classical part of description necessary in order to perform and interpret quantum measurements. Holography defines the correspondence between quantal (2-D surfaces) and 4-D classical degrees of freedom in space-time interior.

3. The recent formulation of effective 2-dimensionality is slightly different. Partonic 2-surfaces and string world sheets at which the modes of the induced spinor field are localized by well-definedness of em charge define the basic entities of strong form of holography [K121]. Space-time surfaces can be determined as preferred extremals from these data assuming quantum criticality meaning that clasical super-symplectic Noether charges associated with the sub-algebra of super-symplectic algebra with conformal weights coming as n-ples of those for the full algebra vanish for them.

As far as consciousness is considered effective 2-dimensionality means holography and could relate to the fact that at least our visual experience is at least effectively 2-dimensional.

3.2.2 Fusion Of Real And P-Adic Physics

The fusion of real and p-adic physics to a larger structure has been a long standing challenge for TGD. The motivations come both from elementary particle physics and TGD inspired theory of consciousness. The basic idea is that various number fields are fused to a larger structure by gluing them along rationals and common algebraic numbers. The challenge is to imagine what quantum jump and NMP could mean in this framework. The first question is how the unitary process acts.

1. U-process acts in spinorial degrees of freedom of WCW (fermionic Fock space for a given 3-surface) and in WCW degrees of freedom (the space of partonic 2-surfaces roughly).

2. WCW should decompose to sectors corresponding to space-time surfaces in variuos number fields. This suggests strongly an adelic view [K119] in which reals and various p-adic number fields form a structure analogous to a Cartesian product. These number fields froming adele (http://tinyurl.com/64pgerm) would have rationals in common. One can define adele also for any algebraic extension of rationals and now the algebraic extension is shared by the factors. This suggests that the various number fields are glued together like pages of a book along common back defined by the algebraic extension. Thus one has something which is not quite the Cartesian product. The implication would be a hierarchy of algebraic extensions forming an evolutionary hierarchy.

3. If one would have Cartesian proeuct, the tensor product for the fermionic Fock spaces for corresponding sub-WCWs would at the first look very natural but would lead to a situation in which each sector would contain fermionic states separately. This does not look natural. Rather, the real space-time sheets should correspond to a sensory representation of the quantum state and p-adic space-time sheets to cognitive representations of one and the same thing [K119]. Hence fermions must be localized at the back of the book.

   Fermions are indeed localized at string world sheets and partonic 2-surfaces already from the well-definedness of em charges and also the equivalence of octonionic spinor structure with the ordinary one necessary for twistorialization demands this. Also the strong form of holography is consistent with the vision that the quantum dynamics is coded by the data at these 2-D surfaces. Classical physics would be 4-D and necessary for the physical testing and interpretation of the theory. Fermions would correspond to Boolean cognition in intersection of realities and p-adicities and would be number theoretically universal as already their anti-commutation relations suggest: also the quantal version of the anti-commutation relations is number theoretically universal in the algebraic extension of rationals.

4. What can one say about the U-matrix and its satellites M and S [K61]? The earlier vision was that the transitions between different number fields are possible. The construction of transition amplitudes for them - interpreted as amplitudes for the realization of intention represented as p-adic space-time sheet as action predicted as real space-time sheet - would be possible in the intersection but their continuation to different number fields does not seem to make sense: one should always chose on number field.

   In the intersection everything is number theoretically universal. Hence the only reasonable conclusion is that these matrices exist separately in each sector and co-incide in the intersection: this is very powerful constraint and means reduction to algebraic geometry. They would give different representations of one and same thing. p-Adic mass calculations would serve as an excellent example about the usefulness of the cognitive representations - p-adic arithmetics is extremely simple as compared to the real one and the number theoretical existence fixes the physics to a high degree. This would give extremely powerful constraints also the real U-matrix.

3.2.3 Dark Matter Hierarchy

The identification of dark matter as phases having large value of Planck constant [K97, K36, K32] led to a vigorous evolution of ideas. Entire dark matter hierarchy with levels labelled by increasing values of Planck constant is predicted, and in principle TGD predicts the values of Planck constant if physics as a generalized number theory vision is accepted [K36].

The original vision was that the hierarchy of Planck constants demands a generalization of quantum TGD. This would have required a generalization of the causal diamond $CD \times CP_2$, where CD is defined as an intersection of the future and past directed light-cones of 4-D Minkowski space M^4. It however became clear that the hierarchy of Planck constants labels a hierarchy of quantum criticalities characterized by sub-algebras of super-symplectic algebras possessing a natural conformal structure. The sub-algebra for which the conformal weights come as n-ples of those for the entire algebra is isomorphic to the full algebra and acts as a conformal gauge algebra at given level of criticality.

In particular, the classical symplectic Noether charges for preferred extremals connecting 3-surfaces at the ends of CD vanish. and this defines preferred extremal property. There would be n conformal gauge equivalence classes of preferred extremals which would correspond to n sheets of a covering of the space-time surface serving as base space. There is very close similarity with the Riemann surfaces. Therefore coverings would be generated dynamically and there is no need for actual coverings of the embedding space.

The gauge degeneracy corresponds to the non-determinism associated with the criticality having interpretation in terms of non-determinism of Kähler action and with strong form of holography. The extremely strong super-symplectic gauge conditions would guarantee that the continuation of string world sheets and partonic 2-surface to preferred extremals is possible at least for some value of p-adic prime. A good guess is that this is the case for the so called ramified primes associated with the algebraic extension in question. These ramified primes would characterize physical system and the weak form of NMP would allow to understand how p-adic length scale hypothesis follows [K119].

p-Adic continuations identifiable as imaginations would be due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K64]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes.

A further strong prediction is that the phase transitions increasing h_{eff} and thus reducing criticality (TGD Universe is like hill at the top of the hill at....) occur spontaneously [?]. This conforms with NMP and suggests that evolution occurs spontaneously. The state function reduction increasing h_{eff} means however the death of a sub-self so that selves are fighting to stay at the criticality. The metabolic energy bringing inNE allows to satisfy the needs of NMP so that the system survives and provides a garden in which subselves can are born and die and gradually generate negentropic entanglement. Living systems are thus negentropy gatherers and each death and re-incarnation generates new negentropy.

All particles in the vertices of Feynman diagrams have the same value of Planck constant so that the particles at different pages cannot have local interactions. Thus one can speak about relative darkness in the sense that only the interactions mediated by the exchange of particles and by classical fields are possible between different pages. Dark matter in this sense can be observed, say through the classical gravitational and electromagnetic interactions. It is in principle possible to photograph dark matter by the exchange of photons which leak to another page of book, reflect, and leak back. This leakage corresponds to h_{eff} changing phase transition occurring at quantum criticality and living matter is expected carry out these phase transitions routinely in bio-control. This picture leads to no obvious contradictions with what is really known about dark matter and to my opinion the basic difficulty in understanding of dark matter (and living matter) is the blind belief in standard quantum theory. These observations motivate the tentative identification of the macroscopic quantum phases in terms of dark matter and also of dark energy with gigantic "gravitational" Planck constant.

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by the following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of h_{eff} 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.

Dark matter could be a key player in quantum biology.

1. Dark matter hierarchy and p-adic length scale hierarchy would provide a quantitative formulation for the self hierarchy. To a given p-adic length scale one can assign a secondary p-adic time scale as the temporal distance between the tips of the CD. For electron this time scale is.1 second, the fundamental bio-rhythm. For a given p-adic length scale dark matter hierarchy gives rise to additional time scales coming as $h_{eff}/h = n$-multiples of this time scale.

2. The predicted breaking of second law of thermodynamics chacterizing living matter - if identified as something in the intersection of real and p-adic words - would be always below the time scale of CD considered but would take place in arbitrary long time scales at appropriate levels of the hierarchy. The scaling up of h_{eff} also scales up the time scale for the breaking of the second law.

3. The hypothesis that magnetic body is the carrier of dark matter in large h_{eff} phase has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of [J60] [K33]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K51, 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].

3.2.4   Quantum Classical Correspondence

Quantum classical correspondence (QCI) has served as a guideline in the evolution of the ideas and the identification of the geometric correlates of various quantum notions at the level of embedding space and space-time surfaces has been an important driving force in the progress of ideas.

1. In ZEO causal diamonds (CDs) identified roughly as intersections of future and past directed light-cones are in key role. At embedding space level CD is a natural correlate for self and sub- CDs serve as correlates of sub-selves identified as mental images. At space-time level the space-time sheets having their ends at the light-like boundaries of CD serve as correlates for self. For a system characterized by a primary p-adic length scale $L_p \propto 2^{k/2}$ the size scale of CD is secondary p-adic scale $L_{p,2} = \sqrt{p}L_p \propto 2^k$. p-Adic length scale hypothesis follows if the proper time distance between the tips of CDs is quantized in powers of 2. This

quantization should relate directly to almost equivalence of octaves associated with music experience. It must be emphasized that this assumption is very probably too strong. If the distances come as integer multiples of CP_2 time, the U-matrices form a structure analogous to Kac-Moody algebra: the role of conformal weights is taken by the distances. NMP indeed selects preferred p-adic primes and thus also size scales for CDs.

2. At the level of space-time the identification of flux tubes (I called them earlier flux tubes) between space-time sheets (more precisely, between partonic 2-surfaces) as a correlate for bound state entanglement suggests itself. Flux tubes correspond typically to magnetic flux tubes in the TGD inspired quantum model of living matter. The size scale of the magnetic body of system is given by the size scale of CD and much larger than the size of the system itself.

3. The space-time sheets in the intersection of the real and p-adic WCWs characterized by the property that the mathematical representation of the partonic 2-surfaces at the ends representing holographically the state allows interpretation in both real and p-adic sense would correspond to the correlates for negentropic entanglement. Rational and algebraic 2-surfaces defined by partonic 2-surfaces and string world sheets (in preferred coordinates) would be the common points of realities and p-adicities.

Quantum classical correspondence allows also to generate new views about quantum theory itself. Many-sheeted space-time and p-adic length scale hierarchy force to generalize the notion of sub-system. The space-time correlate for the negentropic and bound state entanglement is the formation of flux tubes connecting two space-time sheets. The basic realization is that two disjoint space-time sheets can contain smaller space-time sheets topologically condensed at them and connected by flux tubes. Thus systems un-entangled at a given level of p-adic hierarchy - that is in the measurement resolution defined by the level considered - can contain entanglement subsystems at lower level not visible in the resolution used.

In TGD inspired theory of consciousness this makes possible sharing and fusion of mental images by entanglement. The resolution dependence for the notions of sub-system and entanglement means that the entanglement between sub-systems is not "seen" in the length scale resolution of unentangled systems. This phenomenon does not result as an idealization of theoretician but is a genuine physical phenomenon. Obviously this generalized view about sub-system poses further challenges to the detailed formulation of NMP. Note that the resulting mental image should depend on whether sub-selves are entangled by bound state entanglement or NE.

3.2.5 Connection With Standard Quantum Measurement Theory

TGD allows to deduce the standard quantum measurement theory involving the notion of classical variables and their correlation with quantum numbers in an essential manner. WCW ("world of classical worlds" is a union over zero modes labelling infinite-dimensional symmetric spaces having interpretation as classical non-quantum fluctuating classical variables such as the pointer of a measurement apparatus essential for the standard quantum measurement theory [K26]. Quantum holography in its origimnal form states that partonic 2-surfaces at the light-like boundaries of CDs plus the corresponding distributions of 4-D tangent spaces of space-time surfaces at carry the information about quantum state and space-time sheet. The recent formulation talks about partonic 2-surfaces and string world sheets intersection them at discrete points with string connecting partonic 2-surfaces and string boundaries at their orbits carrying fermion number. The distribution of values of induced Kähler form of CP_2 at these surfaces defines zero modes whereas quantum fluctuating degrees of freedom correspond to the deformations of space-time surface by the flows induced by Hamiltonians associated with the degenerate symplectic structure of $\delta M^4_\pm \times CP_2$.

There exists no well-defined metric integration measure in the infinite-dimensional space of zero modes, which by definition do not contribute to the line element of WCW. This does not lead to difficulties if one assumes that a complete localization in zero modes occurs in each quantum jump. A weaker condition is that wave functions are localized to discrete subsets in the space of zero modes. An even weaker and perhaps the most realistic condition is that a localization to a finite-dimensional 2n-dimensional manifold with induced symplectic form defining a positive definite integration volume takes place.

The fundamental formulation of quantum TGD in terms of the Kähler action and Kähler-Dirac action [K121] containing measurement interaction terms guarantees quantum classical correspondence in the sense that the geometry of the space-time surface correlates with the values of conserved quantum numbers. The boundary term of Kähler-Dirac action (1-D massless Dirac action) implies that fermion line is light-like geodesic of $M^4 \times CP_2$ and carries light-like $M^4 \times E^4$ 8-momentum ($SO(4)$) quantum numbers when one uses partial wavs). The modes of embedding space spinor field carry four momentum and color ($SU(3)$) quantum numbers are also massless in 8-D sense and if the two four-momenta are identical one has Equivalence Principle (EP). The mass squared in E^4 degrees of freedom equals to the eigenvalue of spinor Laplacian in CP_2 degrees of freedom. This defines a more abstract form of EP: $SO(4)$ quantum numbers label hadrons and $SU(3)$ quantum numbers quarks and gluons so that one has dual representations.

The resulting correlation of zero modes with the values of quantum numbers can be interpreted as an abstract form of quantum entanglement reduced in quantum jump for the standard definition of the entanglement entropy.

That state function can occur at both boundaries of CD localizing the boundary in question reducing the part of zero energy state associated with it is the new element of TGD inspired quantum measurement theory and allows to understand how the arrow of experienced time emerges and precisely define self - observer - as a part of system interacting with it. Also the possibility that the arrow of time changes at some level of the self hierarchy is predicted. In living matter this is expected to occur routinely as already Fantappie speculated [J97]: the first state function reduction in the sequence of them and changing the arrow of time is indeed naturally identified as a correlate for the volitional act.

3.2.6 Quantum Jump As Moment Of Consciousness

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

The general structure of quantum jump

It seems that TGD involves "holy trinity" of dynamics.

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

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

3. The dynamics of state function reductions at opposite boundary of CD defines the dynamics of volition (active aspects of consciousness).

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

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

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

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

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

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

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

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

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

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

$$\Psi_f^0 \rightarrow .... \rightarrow \Psi_f \quad ,$$

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

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

1. The assumption that localization occurs in zero modes of the WCW would pose very important consistency condition: there is one-one correlation between the quantum numbers in quantum fluctuating degrees of freedom in some state basis and the values of the zero modes. This in fact has interpretation in terms of holography: classical degrees of freedom in space-time interior correlate with fermionic degrees of freedom assignable to string world sheets and partonic 2-surfaces. This together with the fact that zero modes are effectively classical variables, implies that the localization in zero modes corresponds to a state function reduction.

2. Measurement theory requires an entanglement between zero modes and quantum jumps of the physical state. The addition of a measurement interaction term to the Kähler-Dirac action coupling to four-momentum and color quantum numbers of the state and also to more general conserved quantum numbers allows an explicit realization of this coupling and induces the addition of an analogous measurement interaction term to Kähler action [K121]. This term implies the entanglement of the quantum numbers of the physical states with zero modes.

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

Is the complete localization in zero modes really necessary?

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

1. QFT picture strongly suggests that sub-system must be defined as a tensor factor of the space of WCW spinors at given point Y^3 of WCW . This suggests that subsystem should be defined as a function of Y^3 and should be a local concept. An important consequence of this definition is that entanglement entropy gives information about space-time geometry.

2. WCW spinor field can be formally expressed as superposition of quantum states localized into the reduced configuration space consisting of 3-surfaces belonging to light cone boundary. Hence WCW spinor field can be formally written as

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

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

3. WCW has fiber space structure. WCW metric is non-vanishing only in the fiber degrees of freedom and since the propagator for small fluctuations equals to the contravariant metric, fiber degrees of freedom correspond to genuine quantum fluctuations. WCW metric vanishes in zero modes, which can be identified as fundamental order parameters in the spirit of Haken's theory of self organization. The requirement that various local symmetries act as gauge symmetries, provides good reasons to expect that *entanglement coefficients in the fiber degrees of freedom are gauge invariants and depend on the zero modes parametrically.* The one-one correlation between quantum numbers of the state assignable to fiber degrees of freedom and classical variables identified as zero modes would encourage the assumption the a complete localization occurs in zero modes. A weaker condition is that localization occurs only modulo a finite measurement resolution.

4. The original argument was that the non-existence of metric based volume element in zero modes forces the wave functions in zero modes to have a discrete locus. There however exists a symplectic measure defined by the symplectic form in zero modes. It does not however allow a complexification to Kähler form as it does in quantum fluctuating degrees of freedom. This symplectic from could define a hierarchy of integration measures coming as restrictions of $J \wedge J... \wedge J$ with n factors to $2n$-dimensional sub-manifolds. Under some additional conditions- maybe the homological non-triviality of J and the orientability of the sub-manifold are enough, this measure would define a positive definite inner product and one would have a hierarchy finite-dimensional sub-spaces of zero modes. The maxima of Kähler function with respect to zero modes replace naturally the continuum with a discrete set of points and define the counterpart of the spin glass energy landscape consisting of the minima of free energy. Effective finite-dimensionality and even effective discreteness would be achieved.

5. The time development by quantum jumps in zero modes is effectively classical: Universe is apparently hopping around in the space of the zero modes. This looks very attractive physically since zero modes characterize the size, shape and classical Kähler fields associated with 3-surface. Therefore each quantum jump gives very precise conscious geometric information about space-time geometry and about WCW in zero modes. This also means that Haken's classical theory of self-organization generalizes almost as such to TGD context. The probability for localization to given point of zero mode space is given by the reduced probability density Q defined by the integral of the probability density R defined by WCW spinor field over fiber degrees of freedom. The local maxima of Q with respect to zero modes appear as attractors for the time development by quantum jumps. Dissipative time development could be regarded as a sequence of quantum jumps leading to this kind of local maximum.

6. Effective localization in zero modes is completely analogous to spontaneous symmetry breaking in which scalar field attains vacuum expectation value with the difference that the number of degrees of freedom is infinite unlike in typical models of symmetry breaking. Thus the general structure of the WCW spinor field together with TGD based quantum jump concept automatically implies spontaneous symmetry breaking in its TGD version (note however that particle massivation results from both p-adic thermodynamics and coupling to Higgs like field of purely geometric origin in TGD framework). TGD Universe is superposition of parallel classical universes (3-surfaces). Therefore quantum entangled state can can be regarded as a superposition of parallel entangled states, one for each 3-surface. Formally entanglement coefficients can be regarded as coefficients containing the WCW coordinates of 3-surfaces as additional index. The analogy with the spin glass also supports the localization in the zero modes.

7. Effective localization in the zero modes provides simple explanation for why the universe of conscious experience looks classical: moment of consciousness makes it classical. It also explains why the physics treating space-time as a fixed arena of dynamics has been so successful. As already found, a further important consequence is first principle description of the state function reduction.

3.2.7   NMP And Negentropic Entanglement

The evolution of NMP has been a process in which formulation has become gradually more accurate. The final outcome is surprisingly near to the original picture.

Information measures for entanglement

The attempts to formulate NMP in p-adic physics led to the realization that one can distinguish between three kinds of information measures.

1. In real physics the negative of the entanglement entropy defined by the standard Shannon formula defines a natural information measure, which is always non-positive. The formula for Shannon formula is given by $S = -\sum_n P_n log(P_n)$, where P_n are the probabilities identifiable

as eigenvalues of the density matrix for a pair of system and its complement. Density matrix is defined as $\rho = C^{dagger}C$, C is the matrix defined by the entanglement coefficients for the system and its complement. In the original formulation of NMP the state function it was assumed that ρ defines the universal observable measured in state function reduction so that the sub-system (its complement) goes to an eigen state of ρ. This assumption is still kept.

2. In p-adic physics one can generalize entanglement entropy as (dis-)information measure to p-adic valued information measure by replacing the logarithms of p-adic valued probabilities with the p-based logarithms $log_p(|P|_p)$ which are integer valued and can be interpreted as p-adic numbers. This p-adic valued entanglement entropy can be mapped to a non-negative real number by the so called canonical identification $x = \sum_n x_n p^n \rightarrow \sum_n x_n p^{-n}$. In both cases a non-positive information measure results.

   When entanglement probabilities are rational numbers or at most finitely algebraically extended rational numbers one can still define logarithms of probabilities as p-based logarithms $log_p(|P|_p)$ and interpret the entropy as a rational or algebraic number. In this case the entropy can be however negative and positive definite information measure is possible. Irrespective of number field one can in this case define entanglement entropy as a maximum of number theoretic entropies S_p over the set of primes.

3. The consistency with quantum measurement theory forces to give up the most general identification of negentropic entanglement (NE). One could argue that it is not possible to distinguish between real and thus entropic entanglement and NE in any manner. One would need some signature for it. The internal consistency of quantum measurement theory indeed demands that the state function reduction occurs to an eigen space of density matrix, which in the most general case is characterized by an n-dimensional projector satisfying $P^2 = P$. Projector property of the final state density matriz would serve as a unique signature of negentropic entanglement.

   It seems that the third choice is the correct one. NE would thus correspond to a density matrix proportional to a projector (identity matrix). What would be new that P is higher-dimensional projector. In real context one can argue that this situation is practically never met in reality. In TGD however hierarchy of Planck constants labelling quantum critical phases identified as dark matter would correspond to this kind of situations. Density matrix decomposes to a direct sum of terms proportional to higher-D projectors only at criticality. The interpretation could be in terms of measurement resolution: experimental resolution does not allow to discern between the n state pairs in the superposition and their probabilities are identical.

   NE would result in the case of 2-particle system from entanglement coefficients defining a unitary matrix. This strongly suggests that quantum computing systems carry NE.

   There has been also the question about whether NE could be identified as bound state entanglement. It is obvious that this cannot be the case for NE defined by projector treating all entangled state pairs democratically.

Does entanglement negentropy have a classical space-time correlate?

Quantum classical correspondence (QCC) suggests that number theoretic entanglement negentropy or entropy could have a classical counterpart at space-time level. The interpretation of Kähler function as the analog of thermodynamical free energy with Kähler coupling strength playing the role of critical temperature leads to ask whether the Kähler function could define the counterpart of entanglement entropy or - negentropy. The standard formula for the entropy in terms of free energy suggests that entropy is positive also now, and the interpretation as entropy would look more natural. One must of course be very cautious: also the negative of Kähler function could be identified as the analog of free energy and in this case entropy would be negative.

Kähler function is identified as Kähler action in the region of space-time with Euclidian signature and is non-negative. Kähler function is not present in GRT like theories so that it is a new concept. It is not yet clear whether also the Euclidian regions correspond to n-sheeted coverings.

What happens in Minkowkian regions, where $\sqrt{g_4}$ is imaginary and Kähler function is replaced with the analog of Morse function? In Minkowskian regions Kähler action can have also

negative sign. Could Kähler action in these regions have information theoretic interpretation? If so then the magnetic flux tubes would naturally correspond to negentropic regions and electric flux quanta to entropic ones. In Minkowskian regions magnetic flux tubes with $h_{eff} = n \times h$ correspond to n-fold coverings and give rise to n-fold value of Kähler action so that the interpretation in terms of negentropy might make sense. Note however that one can ask whether the flux tubes are actually Euclidian regions connecting Euclidian regions bounded by partonic 2-surfaces. This is possible since the string world sheet associated with the string like objects can have also Euclidian signature of metric.

An interesting question is how the negentropy assignable with the inclusions of hyperfinite factors and determined by the logarithm for the index of inclusion (to be discussed later) could relate to the value spectrum of Kähler function.

Bound state entanglement and NE

It is almost trivial that bound state entanglement must be kinematically stable against NMP became obvious. One can imagine that the state function reduction proceeds step by step by reducing the state to two parts in such a way that the reduction of entanglement entropy is maximal.

1. If a resulting subsystem corresponds to a bound state having no decomposition to free subsystems the process stops for this subsystem. The natural assumption is that subsystems lose their consciousness when U process leads to bound state entanglement whereas bound state itself can be conscious.

2. If the entanglement is negentropic (and thus rational or algebraic) a more natural interpretation consistent with the teaching of spiritual practices is that subsystems experience a fusion to a larger conscious entity. The negentropic entanglement between free states is stabilized by NMP and negentropically entangled states need not reside at the bottom of potential well forbidding the reduction of entanglement. This makes possible new kinds of correlated states for which binding energy can be negative. Bound state entanglement would be like the jail of organized marriage and NE like a love marriage in which companions are free to leave but do not what it. The existence of this kind of NE is especially interesting in living matter, where metabolism (high energy phosphate bond in particular) and the stability of DNA and other highly charged polymers is poorly understood physically: NE could be responsible for stabilization making possible the transfer of metabolic energy [**?**].

Strong and weak forms of NMP

The *strong form of NMP* would state that negentropy of the universe is maximal in each state function reduction: we would live in the best possible world. This does not seem to be the case however. This leads to the *weak form of NMP* stating that in the case that maximal negentropy gain corresponds to n-dimensional projector, also the reductions to $n - k$-dimensional sub-spaces are possible and for $n - k = 1$ one has ordinary reduction. Self can choose between different projector terms in ρ and for the chosen term choose lower- than maximal-dimensional sub-space.

The interpretation is that this brings to the theory of consciousness free will, ethics, and moral [K116]. Good means generation of NE, evolution. The choice in which outcome is 1-dimension sub-space means isolation, breaking of contact, as a punishment for not generating NE. The number of different choices in state function reduction for a given value of n is $2^n - 1$, which suggests am interpretation in terms of a Boolean algebra with n bits and an emotional realization of Boolean algebra - kind of emotional intelligence.

The weak form of NMP leads allows also to understand how preferred p-adic primes suggested by the p-adic length scale hypothesis emerged. The point is that NE per dimension of space is maximal when n is power of p. If n is power of p and $n - k$ is prime then the NE per dimension of sub-space is very large for it. For $p = 2$ this would explained preferred role of Mersenne primes.

What if the eigenvalues of the density matrix go outside the algebraic extension used?

The following argument suggests that also more general algebraic entanglement could be reasonably stable against NMP, namely the entanglement for which the eigenvalues of the density matrix and

eigenvectors are outside the algebraic extension associated with the parameters characterizing string world sheets and partonic 2-surfaces as space-time genes.

The restriction to a particular extension of rationals - a central piece of the number theoretical vision about quantum TGD - implies that density matrix need not allow diagonalization. In eigen state basis one would have has algebraic extension defined by the characteristic polynomial of the density matrix and its roots define the needed extension which could be quite well larger than the original extension. This would make state stable against state function reduction.

If this entanglement is algebraic, one can assign to it a negative number theoretic entropy. This negentropic entanglement is stable against NMP unless the algebraic extension associated with the parameters characterizing the parameters of string world sheets and partonic surfaces defining space-time genes is allowed to become larger in a state function reduction to the opposite boundary of CD generating re-incarnated self and producing eigenstates involving algebraic numbers in a larger algebraic extension of rationals. Could this kind of extension be an eureka experience meaning a step forwards in cognitive evolution?

If this picture makes sense, one would have both the unitary NE with a density matrix, which is projector and the algebraic NE with eigen values and NE for which the eigenstates of density matrix outside the algebraic extension associated with the space-time genes. Note that the entanglement characterized by a unitary matrix is "meditative" in the sense that any state basis is possible and therefore in this state of consciousness it is not possible to make distinctions. This strongly brings in mind koans of Zen buddhism. The more general algebraic entanglement could represent abstractions as rules in which the state pairs in the superposition represent the various instances of the rule.

Is NE experienced directly?

Does the NE at the passive boundary of CD give automatically rise to a conscious experience or must one "measure" it somehow?

1. The assumption that repeated state function reductions measure the NE and give rise to a conscious experience of it, looks natural. That NE is experienced consciously as an experience with a positive emotional coloring (love, compassion, understanding, experience of beauty,...) looks rather natural assumption since a repeated measurement of this state is in question although only the state at the active boundary changes. This experience would correspond to that part of experience which defines experiencer as something stable and unchanging (the original proposal was that self is a subsystem able to remain un-entangled and thus having self identity). The changing part of the experience would come from the active boundary of CD and give rise to an experience about flow of time due to the average increase of the distance between the tips of CD. Self would correspond to sequence of repeated reductions and would die when the first reduction to the opposite boundary of CD would occur. This would be an re-incarnation of self as a new conscious entity.

2. An alternative view is that NE as such gives rise to a conscious experience only in what is known as interaction free experiment [B1]. This idea looks un-necessary in the proposed framework. Interaction free measurement would be too complex a process to appear at the fundamental level.

It has turned that interaction free measurement could read bits (but not qubits) and might be involved with long term memory recall and reading of sensory and cognitive representations. The values of bits would remain unaffected in the interaction free measurement at idealized limit.

1. Interaction free measurement for which Elizur-Weizman bomb tester is an excellent representation (see `http://tinyurl.com/y9zenssv`) involves ordinary state function reduction. The outcome of state function reduction tells whether the bomb can act as quantum measurement apparatus or not (is it active or not) and at idealized limit the state of bomb is not changed (it does not explode). The reading of bits from memory is possible if bit 1 (say) can take the role of active state of bomb and bit 0 that of dud. In the bomb tester model the measured state corresponds to a superposition of two photon paths such that the other one traverses the bomb and induces explosion if state function reduction to this path takes place. The reduction to the other path does not induce explosion.

2. Interaction free measurement is useful if the bit can be represented as active/passive dichotomy. Active/passive dichotomy can be indeed 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.

What happens to h_{eff} during state function reduction sequence?

What happens to h_{eff} during state function reduction sequence. Does it increase so that self would "become wiser" as it becomes older?

The natural assumption is that the value of h_{eff} stays constant during the life cycle of self and by NMP h_{eff} increasing phase transitions tend to occur as self dies and re-incarnates at opposite boundary of CD. In this process a state would be selected from the superposition of states having negentropic entanglement at the active boundary of CD.

The original idea about correlation between age and wisdom is not however wrong. h_{eff} increasing phase transitions can however occur for the sub-selves of self defining mental images of self. To these one can assign sub-CDs. Hence one can say that NE assignable to a given CD increases also during the repeated state function reductions.

It looks rather natural to assume that self does its best to stay alive by trying to gather somehow the NE needed to satisfy the demands of NMP: the easy solution is to eat other living beings! This is achieved by metabolic energy which has interpretation in terms of a transfer of NE carried by nutrients. Homeostasis in turn is a collection of mechanisms helping to stay at criticality.

Negentropic entanglement, NMP, braiding and TQC

Negentropic entanglement for which number theoretic entropy characterized by p-adic prime is negative so that entanglement carries information, is in key role in TGD inspired theory of consciousness and quantum biology.

1. The key feature of 2-particle negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) is that density matrix is projector and thus proportional to unit matrix so that the assumption that state function reduction corresponds to the measurement of density matrix does not imply state function reduction to one-dimensional sub-space. This special kind of degenerate density matrix emerges naturally for the hierarchy $h_{eff} = n \times h$ interpreted in terms of a hierarchy of dark matter phases. I have already earlier considered explicit realizations of negentropic entanglement assuming that E is invariant under the group of unitary or orthogonal transformations (also subgroups of unitary group can be considered -say symplectic group). One can however consider much more general options and this leads to a connection with topological quantum computation (TQC).

2. Entanglement matrix E equal to $1/\sqrt{n}$ factor times unitary matrix U (as a special case orthogonal matrix O) defines a density matrix given by $\rho = UU^{\dagger}/n = Id_n/n$, which is group invariant. One has NE respected by state function reduction if NMP is assumed. This would give huge number of negentropically entangled states providing a representation for some unitary group or its subgroup (such as symplectic group). In principle any unitary representation of any Lie group would allow representation in terms of NE. In principle any unitary representation of any Lie group would allow a representation in terms of NE.

3. In physics as generalized number theory vision, a natural condition is that the matrix elements of E belong to the algebraic extension of p-adic numbers used so that discreted algebraic subgroups of unitary or orthogonal group are selected. This realizes evolutionary hierarchy as a hierarchy of p-adic number fields and their algebraic extensions, and one can imagine that evolution of cognition proceeds by the generation of negentropically entangled systems with increasing algebraic dimensions and increasing dimension reflecting itself as an increase of the largest prime power dividing n and defining the p-adic prime in question.

4. One fascinating implication is the ability of TGD Universe to emulate itself like Turing machine: unitary S-matrix codes for scattering amplitudes and therefore for physics and negentropically entangled subsystem could represent sub-matrix for S-matrix as rules representing "the laws of physics" in the approximation that the world corresponds to n-dimension Hilbert space. Also the limit $n \to \infty$ makes sense, especially so in the p-adic context where real infinity can correspond to finite number in the sense of p-adic norm. Here also dimensions n given as products of powers of infinite primes can be formally considered.

One can consider various restrictions on E.

1. In 2-particle case the stronger condition that E is group invariant implies that unitary matrix is identity matrix apart from an overall phase factor: $U = exp(i\phi)Id$. In orthogonal case the phase factor is ± 1. For n-particle NE one can consider group invariant states by using n-dimensional permutation tensor $\epsilon_{i_1,...i_n}$.

2. One can give up the group invariance of E and consider only the weaker condition that permutation is represented as transposition of entanglement matrix: $C_{ij} \to C_{ij}$. Symmetry/antisymmetry under particle exchange would correspond to $C_{ji} = \epsilon C_{ij}$, $\epsilon = \pm 1$. This would give in orthogonal case $OO^T = O^2 = Id$ and $UU^* = Id$ in unitary case.

   In the unitary case particle exchange could be identified as hermitian conjugation $C_{ij} \to C_{ji}^*$ and one would have $U^2 = Id$. Euclidian gamma matrices γ_i define unitary and hermitian generators of Clifford algebra having dimension 2^{2m} for $n = 2m$ and $n = 2m + 1$. It is relatively easy to verify that the squares of completely anti-symmetrized products of k gamma matrices representing exterior algebra normalized by factor $1/\sqrt{k!}$ are equal to unit matrix. For $k = n$ the anti-symmetrized product gives essentially permutation symbol times the product $\prod_k \gamma_k$. In this manner one can construct entanglement matrices representing negentropic bi-partite entanglement.

3. The possibility of taking tensor products $\epsilon_{ij..k...n}\gamma_i \otimes \gamma_j..\otimes \gamma_k$ of k gamma matrices means that one can has also co-product of gamma matrices. What is interesting is that quantum groups important in topological quantum computation as well as the Yangian algebra associated with twistor Grassmann approach to scattering amplitudes possess co-algebra structure. TGD leads also to the proposal that this structure plays a central role in the construction of scattering amplitudes. Physically the co-product is time reversal of product representing fusion of particles.

4. One can go even further. In 2-dimensional QFTs braid statistics replaces ordinary statistics. The natural question is what braid statistics could correspond to at the level of NE. Braiding matrix is unitary so that it defines NE. Braiding as a flow replaces the particle exchange and lifts permutation group to braid group serving as its infinite covering.

   The allowed unitary matrices representing braiding in tensor product are constructed using braiding matrix R representing the exchange for two braid strands? The well-known Yang-Baxter equation for R defined in tensor product as an invertible element (http://tinyurl.com/yax3j6mr) expresses the associativity of braiding operation. Concretely it states that the two braidings leading from 123 to 321 produce the same result. Entanglement matrices constructed R as basic operation would correspond to unitary matrices providing a representation for braids and each braid would give rise to one particular NE.

   This would give a direct connection with TQC for which the entanglement matrix defines a density matrix proportional to $n \times n$ unit matrix: R defines the basic gate [B19]. Braids would provide a concrete space-time correlate for NE giving rise to "Akashic records". Note that in string theory-GRT framework this old idea of TGD has been recently introduced by Maldacena and Sussking as a proposal that wormholes connecting blackholes provide a description of entanglement.

   I have indeed proposed the interpretation of braidings as fundamental memory representations much before the vision about Akashic records. This kind of entanglement matrix need not represent only time-like entanglement but can be also associated also with space-like entanglement. The connection with braiding matrices supports the view that magnetic flux

tubes are carriers of negentropically entangled matter and also suggests that this kind of entanglement between -say- DNA and nuclear or cell membrane gives rise to TQC.

Some comments concerning the covering space degrees of freedom associated with $h_{eff} = n \times h$ viz. ordinary degrees of freedom are in order.

1. Negentropic entanglement with n entangled states would correspond naturally to $h_{eff} = n \times h$ and is assigned with "many-particle" states, which can be localized to the sheets of covering but one cannot exclude similar entanglement in other degrees of freedom. Group invariance leaves only group singlets and states which are not singlets are allowed only in special cases. For instance for $SU(2)$ the state $|j, m\rangle = |1, 0\rangle$ represented as 2-particle state of 2 spin 1/2 particles is negentropically entangled whereas the states $|j, m\rangle = |1, \pm 1\rangle$ are pure.

2. Negentropic entanglement associated with $h_{eff} = n \times h$ could factorize as tensor product from other degrees of freedom. Negentropic entanglement would be localised to the covering space degrees of freedom but there would be entropic entanglement in the ordinary degrees of freedom - say spin. The large value of h_{eff} would however scale up the quantum coherence time and length also in the ordinary degrees of freedom. For entanglement matrix this would correspond to a direct sum proportional to unitary matrices so that also density matrix would be a direct sum of matrices $p_n E_n = p_n Id_n/n$, $\sum p_n = 1$ correspond ing to various values of "other quantum numbers", and state function reduction could take place to any subspace in the decomposition. Also more general entanglement matrices for which the dimensions of direct summands vary, are possible.

3. One can argue that NMP in form does not allow halting of quantum computation. This is not true. The computation halts but in different manner since negentropic entanglement tends to be generated even for weak form of NMP. Weak form of NMP allows also ordinary state function reduction. State function reduction is not need if NE can be directly experienced and self represents this mental image as a kind of abstraction or rule with the state pairs in the superposition representing the instances of the rule.

   It might be also possible to deduce the structure of negentropically entangled state by an interaction free quantum measurement replacing the state function reduction with "externalised" state function reduction. One could speak of interaction free TQC. This TQC would be reading of "Akashic records".

4. One could also counter argue that NMP allows the transfer of NE from the system so that TQC halts. NMP allows this if some another system receives at least the negentropy contained by NE. The interpretation would be as the increase of information obtained by a conscious observer about the outcome of halted quantum computation.

   Metabolism could quite concretely correspond the transfer of NE associated with the NE between nutrient molecules and some system. This would satisfy the demands of NMP and make possible for the organism to avoid the first state function reduction to the opposite boundary of CD (death) In [K73] it is suggested that this system can be of astrophysical size, say gravitational Mother Gaia with magnetic flux tubes characterized by gravitational Planck constant $\hbar_{gr} = GMm/v_0 = \hbar_{eff} = n \times \hbar$, where v_0 is a parameter with dimensions of velocity. There is experimental evidence for dark matter shell around Earth [K97] and there are highly interesting connection to the hypothesis identifying bio-photons as decay products of dark photons located at magnetic flux tubes and having $h_{eff} = h_{gr}$.

The relationship to thermodynamics

The relationship with the ordinary thermodynamics is very interesting and my views about this have been fluctuating.

1. The basic point to notice is that entanglement (neg)entropy characterize the relationship of the system to its environment whereas thermodynamical entropy characterizes single particle in an ensemble. Hence these quantities are not directly comparable and NMP need not be in conflict with the second law. Ordinary state function reductions for an ensemble of

systems lead to a generation of thermodynamical entropy and this explains the second law of thermodynamics in the sector consisting of visible matter $h_{eff} = h$ provided that phase transitions generating negentropic entanglement and transforming ensembles to quantum coherent states are not too probable.

2. For the NE the outcome of the state function reduction ceases to be completely random as it is for the standard definition of entanglement entropy. For the strong form of NMP the outcome seems rather unique: the degenerate subspace for which number theoretic negentropy is maximal. For the weak form of NMP there is an additional randomness - one might speak about analog of thermodynamical fluctuations. The average increase of negentropy is positive if various choices for the dimension $n - k$ of the subspace are equally probable. Usually life is seen as a thermodynamical fluctuations, now its analog would prevent the world to be the best possible one.

   It can happen that the generation of NE transforms thermodynamical ensemble to a superposition of negentropically entangled subsystems and next state function reduction to the opposite boundary generates a negentropically entangled state. This could lead to the breaking of second law. The generation of NE means also phase transitions generating dark matter at magnetic flux tubes assumed to serve as correlates for entanglement. Since dark matter is not visible using the recent measurement technology, the breaking of second law could remain unseen. This could provide a new view to understand self-organization [K87] and evolution in living systems in which dark matter plays a key role according to the TGD inspired vision.

3. This suggests a weak formulation of the second law. In any process in which dark matter possibly created by phase transitions is observed by transforming it to ordinary matter second law holds true since the decay of dark matter to ordinary matter destroys macroscopic quantum coherence. If it is possible to develop technologies allowing to observe dark matter without this transformation, second law does not hold in the observable Universe. The decay of dark photons to ordinary photons identified as bio-photons would represent one example of this. Note also that one can transform only a small sample of dark matter to visible matter. By a book-keeping one can detect whether ordinary matter has transformed to dark matter and with some theory can deduce by taking this kind of samples about the distribution of dark matter.

NMP in adelic approach and two interpretational problems

There have been considerable progress in the understanding of NMP in Zero Energy Ontology (ZEO) and the latest progress is discussed in detail in [L30]. In adelic approach real and various p-adic sectors are combined to adelic structure at space-time level. State space is shared by all adelic sectors and corresponds to Hilbert space with a coefficient field, which is some extension of rationals. It defines an extension of p-adic numbers for all values of p. Algebraic extensions and also extensions by roots of e correspond to finite-dimensional extensions of p-adic numbers. Together these extensions define an adele.

At the level of WCW this means that the general coordinate - and Lorentz invariant coordinates of WCW have values in the algebraic extension making sense in all number fields. Strong form of holography means that string world sheets and partonic 2-surfaces (2-surfaces) serve as "space-time genes" determining the 4-D space-time surfaces so that these conformally invariant moduli parameters for these 2-surfaces serve as WCW coordinates.

In given p-adic sector entanglement entropy (EE) is defined by replacing the logarithms of probabilities in Shannon formula by the logarithms of their p-adic norms. The resulting entropy satisfies the same axioms as ordinary entropy but makes sense only for probabilities, which must be 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 EE is negative. The interpretation is that the entangled state represents quantally concept or a rule as superposition of its instances defined by the state pairs in the superposition. Identity matrix means that one can choose the state basis in arbitrary manner and the interpretation could be in terms of "enlightened" state of consciousness characterized by "absence of distinctions". In general case the basis is unique.

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

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

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

1. The Hilbert spaces defining state spaces has as their coefficient field always some algebraic extension of rationals so that number theoretic entropies make sense for all primes. p-Adic numbers as coefficients cannot be used and reals are not allowed. Since the same Hilbert space is shared by real and p-adic sectors, a given state function reduction in the intersection has real and p-adic space-time shadows.

2. State function reductions at these 2-surfaces at the ends of CD take place in the intersection of realities and p-adicities if the parameters characterizing these surfaces are in the algebraic extension considered. It is however not absolutely necessary to assume that the coordinates of WCW belong to the algebraic extension although this looks very natural.

3. NMP applies to the total EE. It can quite well happen that NMP for the sum of real and p-adic entanglement entropies does not allow ordinary state function reduction to take place since p-adic negative entropies for some primes would become zero and net negentropy would be lost. There is competition between real and p-adic sectors and p-adic sectors can win! Mind has causal power: it can stabilize quantum states against state function reduction and tame the randomness of quantum physics in absence of cognition! Can one interpret this causal power of cognition in terms of intentionality? If so, p-adic physics seems be also physics of intentionality as originally assumed.

   One could also say that Einstein was rather near to truth when he said that God does not play dice. Conscious entities play dice only whey they die and re-incarnate as time-revered selves at the opposite boundary of CD - that is perform the first state function reduction at the opposite boundary of CD.

3.2.8   Wigner's friend and Schrödinger's cat

I encountered in Facebook discussion Wigner's friend paradox (see http://tinyurl.com/jpnvtp5 and http://tinyurl.com/ze6bmem). Wigner leaves his friend to the laboratory together with Schrödinger's cat and the friend measures the state of cat: the outcome is "dead" or "alive". Wigner returns and learns from his friend what the state of the cat is. The question is: was the state of cat fixed already earlier or when Wigner learned it from his friend. In the latter case the state of friend and cat would have been superposition of pairs in which cat was alive and friend new this and cat was dead also now friend new this. Entanglement between cat and bottle would have been transferred to that between cat+bottle and Wigner's friend. Recall that this kind of

information transfer occur in quantum computation and quantum teleportation allows to transfer arbitrary quantum state but destroys the original.

The original purpose of Wigner was to demonstrate that consciousness is involved with the state function collapse.

TGD view is that the state function collapse can be seen as moment consciousness [K56, K7]. Or more precisely, self as conscious entity corresponds to a repeated state function reduction sequence to the same boundary of causal diamond (CD). One might say that self is generalized Zeno effect in Zero Energy Ontology (ZEO). The first reduction to the opposite boundary of CD means death of self and re-incarnation at opposite boundary as time reversed self. The experiencet flow of time corresponds to the shift of the non-fixed boundary of self reduction by reduction farther from the fixed boundary - also the state at it changes. Thus subjective time as sequence of reductions is mapped to clock time identifiable as the temporal distance between the tips of CD. Arrow of time is generated but changes in death-reincarnation.

In TGD inspired theory of consciousness the intuitive answer to the question of Wigner looks obvious. If the friend measured the state of cat, it was indeed dead or alive already before Wigner arrived. What remains is the question what it means for Wigner, the "ultimate observer", to learn about the state of the cat from his friend. The question is about what conscious communications are.

Consider first the situation in the framework of standard quantum information theory.

1. Quantum teleportation (see `http://tinyurl.com/omfkydh`) could make it possible to transfer arbitrary quantum state from the brain of Wigner's friend to Wigner's brain. Quantum teleportation involves generation of Bell state (see `http://tinyurl.com/z9g8rar` of qubits assignable with Wigner's friend (A) and Wigner (B).

2. This quantum state can be constructed by a joint measurement of component of spin in same direction at both A and B. One of the four eigenstates of (by convention) the operator $Q^z = J_x^{1)} \otimes J_y^{2)} - J_y^{1)} \otimes J_x^{2)}$ is the outcome. For spinors the actions of J_x and J_y change the sign of J_z eigenvalue so that it becomes possible to construct the Bell states as eigenstates of Q^z.

3. After that Wigner's friend measures both the qubit representing cat's state, which is to be communicated and the qubit at A. The latter measurement does not allow to predict the state at B. Wigner's friend communicates the two bits resulting from this measurement to Wigner classically. On basis of these two classical bits his friend performs some unitary operation to the qubit at his end and transforms it to qubit that was to be communicated.

This allows to communicate the qubit representing measurement outcome (alive/dead). But what about meaning? What guarantees that the meaning of the bit representing the state of the cat is the same for Wigner and his friend? One can also ask how the joint measurement can be realized: its seems to require the presence of system containing $A \otimes B$. To answer these questions one must introduce some notions of TGD inspired theory of consciousness: self hierarchy and subself=mental image identification.

TGD inspired theory of consciousness predicts that during communication Wigner and his friend form a larger entangled system: this makes possible sharing of meaning. Directed attention means that subject and object are entangled. The magnetic flux tubes connecting the two systems would serve as a correlate for the attention. This mechanism would be at work already at the level of molecular biology. Its analog would be wormholes in ER-EPR correspondence proposed by Maldacena and Susskind. Note that directed attention brings in mind the generation of the Bell entangled pair A-B. It would make also possible quantum teleportation.

Wigner's friend could also symbolize the "pointer of the measurement apparatus" constructed to detect whether cats are dead of alive. Consider this option first. If the pointer is subsystem defining subself of Wigner, it would represent mental image of Wigner and there would be no paradox. If qubit in the brain in the brain of Wigner's friend replaces the pointer of measurement apparatus then during communication Wigner and his friend form a larger entangled system experiencing this qubit. Perhaps this temporary fusion of selves allows to answer the question about how common meaning is generated. Note that this would not require quantum teleportation protocol but would allow it.

Negentropically entangled objects are key entities in TGD inspired theory of consciousness and the challenge is to understand how these could be constructed and what their properties could be. These states are diametrically opposite to unentangled eigenstates of single particle operators, usually elements of Cartan algebra of symmetry group. The entangled states should result as eigenstates of poly-local operators. Yangian algebras involve a hierarchy of poly-local operators, and twistorial considerations inspire the conjecture that Yangian counterparts of super-symplectic and other algebras made poly-local with respect to partonic 2-surfaces or end-points of boundaries of string world sheet at them are symmetries of quantum TGD [K37]. Could Yangians allow to understand maximal entanglement in terms of symmetries?

1. In this respect the construction of maximally entangled states using bi-local operator $Q^z = J_x \otimes J_y - J_x \otimes J_y$ is highly interesting since entangled states would result by state function. Single particle operator like J_z would generate un-entangled states. The states obtained as eigenstates of this operator have permutation symmetries. The operator can be expressed as $Q^z = f_{ij}^z J^i \otimes J^j$, where f_{BC}^A are structure constants of SU(2) and could be interpreted as co-product associated with the Lie algebra generator J^z. Thus it would seem that unentangled states correspond to eigenstates of J^z and the maximally entangled state to eigenstates of co-generator Q^z. Kind of duality would be in question.

2. Could one generalize this construction to n-fold tensor products? What about other representations of SU(2)? Could one generalize from SU(2) to arbitrary Lie algebra by replacing Cartan generators with suitably defined co-generators and spin $1/2$ representation with fundamental representation? The optimistic guess would be that the resulting states are maximally entangled and excellent candidates for states for which negentropic entanglement is maximized by NMP [K56].

3. Co-product is needed and there exists a rich spectrum of algebras with co-product (quantum groups, bialgebras, Hopf algebras, Yangian algebras). In particular, Yangians of Lie algebras are generated by ordinary Lie algebra generators and their co-generators subject to constraints. The outcome is an infinite-dimensional algebra analogous to one half of Kac-Moody algebra with the analog of conformal weight N counting the number of tensor factors. Witten gives a nice concrete explanation of Yangian [B9] for which co-generators of T^A are given as $Q^A = \sum_{i<j} f_{BC}^A T_i^B \otimes T_j^C$, where the summation is over discrete ordered points, which could now label partonic 2-surfaces or points of them or points of string like object (see `http://tinyurl.com/y727n8ua`). For a practically totally incomprehensible description of Yangian one can look at the Wikipedia article (see `http://tinyurl.com/y7heufjh`).

4. This would suggest that the eigenstates of Cartan algebra co-generators of Yangian could define an eigen basis of Yangian algebra dual to the basis defined by the totally unentangled eigenstates of generators and that the quantum measurement of poly-local observables defined by co-generators creates entangled and perhaps even maximally entangled states. A duality between totally unentangled and completely entangled situations is suggestive and analogous to that encountered in twistor Grassmann approach where conformal symmetry and its dual are involved. A beautiful connection between generalization of Lie algebras, quantum measurement theory and quantum information theory would emerge.

3.3 Generalization Of NMP To The Case Of Hyper-Finite Type II_1 Factors

The intuitive notions about entanglement do not generalize trivially to the context of relativistic quantum field theories as the rigorous algebraic approach of [C2] based on von Neumann algebras demonstrates. von Neumann algebras can be written as direct integrals of basic building blocks referred to as factors [A31]. Factors can be classified to three basic types labelled as type I, II, and III. Factors of type I appear in non-relativistic quantum theory whereas factors of type III_1 in relativistic QFT [C2]. Factors of type II_1 [A26], believed by von Neumann to be fundamental, appear naturally in TGD framework [K120].

3.3.1   Factors

Factors of type I

The von Neuman factors of type I correspond to the algebras of bounded operators in finite or infinite-dimensional separable Hilbert spaces. In the finite-dimensional case the algebra reduces to the ordinary matrix algebra in the finite-dimensional case and to the algebra of bounded operators of a separable Hilbert space in the infinite-dimensional case. Trace is the ordinary matrix trace. The algebra of projection operators has one-dimensional projectors as basic building blocks (atoms), the notion of pure state is well-defined, and the decomposition of entangled state to a superposition of products of pure states is unique. This case corresponds to the ordinary non-relativistic quantum theory. Ordinary quantum measurement theory and also the theory of quantum computation has been formulated in terms of type I factors. Also the discussion of NMP has been formulated solely in terms of factors of type I.

Factors of type II_1

The so called hyper-finite type II_1 factors, which are especially natural in TGD framework, can be identified in terms of the Clifford algebra of an infinite-dimensional separable Hilbert space such that the unit operator has unit trace. Essentially the fermionic oscillator operator algebra associated with a separable state basis is in question. The theory of hyper-finite type II_1 factors is rich and has direct connections with conformal field theories [A40], quantum groups [A17], knot and 3-manifold invariants [A37, A20, A42], and topological quantum computation [K3], [B14].

Factors of type III

For algebras of type III associated with non-separable Hilbert spaces all projectors have infinite trace so that the very notion of trace becomes obsolete. The factors of type III_1 are associated with quantum field theories in Minkowski space.

The highly counter-intuitive features of entanglement for type III factors are discussed in [C2].

1. The von Neumann algebra defined by the observables restricted to an arbitrary small region of Minkowski space in principle generates the whole algebra. Expressed in a more technical jargon, any field state with a bound energy is cyclic for each local algebra of observables so that the field could be obtained in entire space-time from measurements in an arbitrary small region of space-time. This kind of quantum holography looks too strong an idealization.

   In TGD framework the replacement of Minkowski space-time with space-time sheet seems to restrict the quantum holography to the boundaries of the space-time sheet. Furthermore, in TGD framework the situation is nearer to the non-relativistic one since Poincare transformations are not symmetries of space-time and because 3-surface is the fundamental unit of dynamics. Also in TGD framework M^4 cm degrees of 3-surfaces are present but it would seem that they appear as labels of type II_1 factors in direct integral decomposition rather than as arguments of field operators.

2. The notion of pure state does not make sense in this case since the algebra lacks atoms and projector traces do not define probabilities. The generalization of the notion of pure state as in II_1 case does not make sense since projectors have infinite trace.

3. Entanglement makes sense but has very counter-intuitive properties. First of all, there is no decomposition of density matrix in terms of projectors to pure states nor any obvious generalization of pure states. There exists no measure for the degree of entanglement, which is easy to understand since one cannot assign probabilities to the projectors as their traces.

4. For any pair of space-like separated systems, a dense set of states violates Bell inequalities so that correlations cannot be regarded as classical. This is in a sharp contrast with elementary quantum mechanics, where "de-coherence effects" are believed to drive the states into a classically correlated states.

5. No local measurement can remove the entanglement between a local system and its environment. In TGD framework local operations would correspond to operations associated with a given space-time sheet. Irreducible type II_1 entanglement between different space-time sheets, if indeed present, might have an interpretation in terms of a finite resolution at state space level due to spin glass degeneracy.

On basis of these findings, one might well claim that the axiomatics of relativistic quantum field theories is not consistent with the basic physical intuitions.

3.3.2 NMP Hyper-Finite Factors Of Type II_1

In the following hyper-finite factors of type II_1 (HFFs) will be discussed since they are certainly emerge in TGD as operator algebra defined by the fermionic oscillator operators.

The origin of hyper-finite factors of type II_1 in TGD

Infinite-dimensional Clifford algebra corresponds in TGD framework to the super-algebra generated by complexified WCW gamma matrices creating WCW spinor s from vacuum spinor which is the counterpart of Fock vacuum [K120]. By super-conformal symmetry also WCW degrees of freedom correspond to a similar factor. For type hyper-finite II_1 factors the trace is by definition finite and normalized such that the unit operator has unit trace. As a consequence, the traces of projection operators have interpretation as probabilities.

Finite-dimensional projectors have vanishing traces so that the notion of pure state must be generalized. The natural generalization is obvious. Generalized pure states correspond to states for which density matrix reduces to a projector with a finite norm. The physical interpretation is that physical measurements are never able to resolve completely the infinite state degeneracy identifiable in TGD framework as spin glass degeneracy basically caused by the vacuum degeneracy implying non-determinism of Kähler action. An equivalent interpretation is in terms of state space resolution, which can never be complete.

In TGD framework the relevant algebra can also involve finite-dimensional type I factors as tensor factors. For instance, the entanglement between different space-time sheets could be of this kind and thus completely reducible whereas the entanglement in configuration space spin and "vibrational" degrees of freedom (essentially fermionic Fock space) would be of type II_1. The finite state-space resolution seems to effectively replace hyper-finite type II_1 factors with finite-dimensional factors of type I.

Hyper-finite factors of type II_1 and quantum measurement theory with a finite measurement resolution

The realization that the von Neumann algebra known as hyper-finite factor of type II_1 is tailor made for quantum TGD has led to a considerable progress in the understanding of the mathematical structure of the theory and these algebras provide a justification for several ideas introduced earlier on basis of physical intuition.

Hyper-finite factor of type II_1 has a canonical realization as an infinite-dimensional Clifford algebra and the obvious guess is that it corresponds to the algebra spanned by the gamma matrices of WCW. Also the local Clifford algebra of the embedding space $H = M^4 \times CP_2$ in octonionic representation of gamma matrices of H is important and the entire quantum TGD emerges from the associativity or co-associativity conditions for the sub-algebras of this algebra which are local algebras localized to maximal associative or co-associate sub-manifolds of the embedding space identifiable as space-time surfaces.

The notion of inclusion for hyper-finite factors provides an elegant description for the notion of measurement resolution absent from the standard quantum measurement theory.

1. The included sub-factor creates in ZEO states not distinguishable from the original one and the formally the coset space of factors defining quantum spinor space defines the space of physical states modulo finite measurement resolution.

2. The quantum measurement theory for hyperfinite factors differs from that for factors of type I since it is not possible to localize the state into single ray of state space. Rather, the ray is replaced with the sub-space obtained by the action of the included algebra defining the measurement resolution. The role of complex numbers in standard quantum measurement theory is taken by the non-commutative included algebra so that a non-commutative quantum theory is the outcome.

3. This leads also to the notion of quantum group. For instance, the finite measurement resolution means that the components of spinor do not commute anymore and it is not possible to reduce the state to a precise eigenstate of spin. It is however perform a reduction to an eigenstate of an observable which corresponds to the probability for either spin state.

4. For HFFs the dimension of infinite-dimensional state space is finite and qual to $D = 1$ by convention. For included HFF $\mathcal{N} \subset \mathcal{M}$ the dimension of the tensor factor space containing only the degrees of freedom which are above measurement resolution is given by the index of inclusion $d = \mathcal{M} : \mathcal{N}$. One can say that the dimension associated with degrees of freedom below measurement resolution is $D = 1/d$. This number is never large than 1 for the inclusions and contains a set of discrete values $d = 4cos^2(2\pi/n)$, $n \geq 3$, plus the continuum above it. The fractal generalization of the formula for entanglement entropy gives $S = -log(1/D) = -log(d) \leq 0$ so that one can say that the entanglement negentropy assignable to the projection operators to the sub-factor is positive except for $n = 3$ for which it vanishes. The non-measured degrees of freedom carry information rather than entropy.

5. Clearly both HFFs of type I and II allow entanglement negentropy and allow to assign it with finite measurement resolution. In the case of factors its is not clear whether the weak form of NMP allows makes sense. Could the density matrix be expressed as a direct sum of projectors to subspaces multiplied by corresponding probabilities? Whether this is possible, is far from clear to me: in any case it would require new mathematics.

   A more natural looking option is that the decomposition of the density matrix to projectors is replaced with a particular hierarchy of inclusions and the state function reduction allows any finite sequence of inclusions. The negentropy gain would correspond to the total negentropy gain associated with the inclusion sequences obtained as sum of $S = -log(\prod_i d_i) = -\sum_i log(d_i)$. The larger the number of inclusions in the sequence, the larger the information gain. This makes sense since the measurement resolution would increase. The longer the sequence of inclusions, the higher the negentropy gain. This picture is different from that resulting from NE: in this case reduction to lower dimensional space tends to give smaller negentropy gain.

The topology of the many-sheeted space-time encourages the generalization of the notion of quantum entanglement in such a way that unentangled systems can possess entangled sub-systems. One can say that the entanglement between sub-selves is not visible in the resolution characterizing selves. This makes possible sharing and fusion of mental images central for TGD inspired theory of consciousness. These concepts find a deeper justification from the quantum measurement theory for hyper-finite factors of type II$_1$ for which the finite measurement resolution is basic notion.

3.4 Some Consequences Of NMP

In the sequel the most obvious consequences of self measurement and NMP are discussed from the point of view of physics, biology, cognition, and quantum computing. The recent discussion differs considerably from the earlier one since several new elements are involved. ZEO and the hierarchy of CDs, the hierarchy of Planck constants and dark matter, and - perhaps most importantly - the better understanding NE as something genuinely new and making sense in the intersection of real and various p-adic worlds at which living matter is assumed to reside.

3.4.1 NMP And P-Adic Length Scale Hypothesis

The original form of the p-adic length scale hypothesis stated that physically most interesting p-adic primes satisfy $p \simeq 2^k$, k prime or power of prime. It has however turned out that all positive

integers k are possible. Surprisingly few new length scales are predicted by this generalization in physically interesting length scales. p-Adic length scale hypothesis leads to excellent predictions for elementary particle masses (note that the mass prediction is exponentially sensitive to the value of k) and explains also some interesting length scales of biology: for instance, the thicknesses of the cell membrane and of single lipid layer of cell membrane correspond to $k = 151$ and $k = 149$ respectively.

Various explanations for the origin of p-adic length scale hypothesis

The big problem of p-adic TGD is to derive this hypothesis from the basic structure of the theory.

1. One argument is based on black hole-elementary particle analogy [K65] leading to the generalization of the Hawking-Bekenstein formula: the requirement leading to the p-adic length scale hypothesis is that the radius of the so called elementary particle horizon is itself a p-adic length scale. This argument involves p-adic entropy essentially and it seems that information processing is somehow involved.

2. Zero energy ontology predicts p-adic length scale hypothesis if one accepts the assumption that the proper time distances between the tips of CDs come as powers of 2 [K65]. A more general highly suggestive proposal is that the relative position between tips forms a lattice at proper time constant hyperboloid having as a symmetry group discrete subgroup of Lorentz group (which could reduce to a subgroup of the group $SO(3)$ acting as isotropy group for the time-like direction defined by the relative coordinate between the tips of CD [K98].

   p-Adic length scale hypothesis could be understood as a resonance in frequency domain -most naturally for massless particles like photons. The secondary p-adic time scale for favored p-adic primes must be as near as possible to the proper time distance between the tips of CD. Mersenne primes $M_n = 2^n - 1$ (n is prime) satisfy this condition. Also $log(p)$ is in this case as near as possible to $log(2^n)$ and in the sense that the unit of negentropy defined as $log(2^n - m(n))/log(2^n)$ is maximized. This argument might work also for Gaussian Mersennes $G_n = (1 + i)^n - 1$ (n is prime also now) if one restricts the consideration to Gaussian primes.

   A more general and more realistic looking hypothesis is that a given CD can have partonic light-like 3-surfaces ending at its boundaries for all p-adic length scales up to that associated with CD: powers of 2 would be favored by the condition of commeasurability very much analogous to frequency doubling.

3. An exciting possibility, suggested already earlier half seriously, is that evolution is present already at elementary particle level. This is the case if elementary particles reside in the intersection of real and p-adic worlds. The success of p-adic mass calculations and the identification of p-adic physics as physics of cognition indeed forces this interpretation. In particular, one can understand p-adic length scale hypothesis as reflecting the survival of the cognitively fittest p-adic topologies.

   I have discussed also other explanations.

1. A possible physical reason for the primes near prime powers of 2 is that survival necessitates the ability to co-operate, to act in resonance: this requirement might force commeasurability of the length scales for p-adic space-time sheet (p_1) glued to larger space-time sheet ($p_2 > p_1$). The hierarchy would state from 2-adic level having characteristic fractal length scales coming as powers of $\sqrt{2}$. When $p > 2$ space-time sheet is generated during cosmological evolution $L(p)$ for it must correspond to power of $\sqrt{2}$ so that one must have $p \simeq 2^n$.

2. A model for learning [K22] as a transformation of the reflective level of consciousness to proto level supports the view that evolution and learning occur already at elementary particle level as indeed suggested by NMP: the p-adic primes near power of prime powers of two are the fittest ones. The core of the argument is the characterization of learning as a map from 2^N many-fermion states to M association sequences. The number of association sequences should be as near as possible equal to 2^N. If M is power of prime: $M = p^K$, association sequences can be given formally the structure of a finite field $G(p, K)$ and p-adic length scale

hypothesis follows as a consequence of $K = 1$. NMP provides the reason for why $M = p^K$ is favored: in this case one can construct realization of quantum computer with entanglement probabilities $p_k = 1/M = 1/p^K$ and the negentropy gain in quantum jump is $Klog(p)$ while for M not divisible by p the negentropy gain is zero.

Generalization of p-adic length scale hypothesis suggested by NMP

The assumption that adelic physics has as its number theoretically universal core the physics for algebraic extensions of rationals inducing those of p-adic numbers fields allows to understand preferred p-adic primes as those which are ramified [K119]. Ramified prime decomposes into a product of primes involving higher powers of prime of the extension and maximally ramified primes correspond to irreducible extensions satisfying so called Eisenstein criterion.

In strong form of holography p-adic continuations of 2-surfaces to preferred extrmals identifiable as imaginations would be easy due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K64]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes. This does not yet explain p-adic length scale hypothesis [K65, K52] stating that p-adic primes near powers of 2 are favored.

A possible generalization of this hypothesis is that primes near powers of prime are favored. There indeed exists evidence for the realization of 3-adic time scale hierarchies in living matter [I50] (`http://tinyurl.com/jbh9m27`) and in music both 2-adicity and 3-adicity could be present, this is discussed in TGD inspired theory of music harmony and genetic code [K80].

The weak form of NMP might come in rescue here.

1. Entanglement negentropy for a NE [K56] characterized by n-dimensional projection operator is the $log(N_p(n))$ for some p whose power divides n. The maximum negentropy is obtained if the power of p is the largest power of prime divisor of p, and this can be taken as definition of number theoretic entanglement negentropy. If the largest divisor is p^k, one has $N = k \times log(p)$. The entanglement negentropy per entangled state is $N/n = klog(p)/n$ and is maximal for $n = p^k$. Hence powers of prime are favoured which means that p-adic length scale hierarchies with scales coming as powers of p are negentropically favored and should be generated by NMP. Note that $n = p^k$ would define a hierarchy of $h_{eff}/h = p^k$. During the first years of h_{eff} hypothesis I believe that the preferred values obey $h_{eff} = r^k$, r integer not far from $r = 2^{11}$. It seems that this belief was not totally wrong.

2. If one accepts this argument, the remaining challenge is to explain why primes near powers of two (or more generally p) are favoured. $n = 2^k$ gives large entanglement negentropy for the final state. Why primes $p = n_2 = 2^k - r$ would be favored? The reason could be following. $n = 2^k$ corresponds to $p = 2$, which corresponds to the lowest level in p-adic evolution since it is the simplest p-adic topology and farthest from the real topology and therefore gives the poorest cognitive representation of real preferred extremal as p-adic preferred external (Note that $p = 1$ makes formally sense but for it the topology is discrete).

3. Weak form of NMP [K56, K116] suggests a more convincing explanation. The density matrix of the state to be reduced is a direct sum over contributions proportional to projection operators. Suppose that the projection operator with largest dimension has dimension n. Strong form of NMP would say that final state is characterized by n-dimensional projection operator. Weak form of NMP allows free will so that all dimensions $n - k$, $k = 0, 1, ...n - 1$ for final state projection operator are possible. 1-dimensional case corresponds to vanishing entanglement negentropy and ordinary state function reduction isolating the measured system from external world.

4. The negentropy of the final state per state depends on the value of k. It is maximal if $n - k$ is power of prime. For $n = 2^k = M_k + 1$, where M_k is Mersenne prime $n - 1$ gives the maximum negentropy and also maximal p-adic prime available so that this reduction is favoured by NMP. Mersenne primes would be indeed special. Also the primes $n = 2^k - r$ near 2^k produce large entanglement negentropy and would be favored by NMP.

5. This argument suggests a generalization of p-adic length scale hypothesis so that $p = 2$ can be replaced by any prime.

This argument together with the hypothesis that preferred prime is ramified would correlate the character of the irreducible extension and character of super-conformal symmetry breaking. The integer n characterizing super-symplectic conformal sub-algebra acting as gauge algebra would depends on the irreducible algebraic extension of rational involved so that the hierarchy of quantum criticalities would have number theoretical characterization. Ramified primes could appear as divisors of n and n would be essentially a characteristic of ramification known as discriminant. An interesting question is whether only the ramified primes allow the continuation of string world sheet and partonic 2-surface to a 4-D space-time surface. If this is the case, the assumptions behind p-adic mass calculations would have full first principle justification.

3.4.2 NMP And Thermodynamics

The physical status of the second law has been a longstanding open issue in physics- in particular biophysics. In positive energy ontology the understanding of the origin of second law is simple. Quantum jumps involve state function reduction (or more generally, self measurement) with a random outcome and in the case of ensemble of identical system this leads to a probability distribution for the states of the members of the ensemble. This implies Boltzmann equations implying the second law. In TGD framework there are many elements which force to question this simple picture: zero energy ontology and CDs, effective four-dimensionality of the ensemble defined by states assignable to sub-CDs, hierarchy of Planck constants, and the possibility of negentropic entanglement.

Zero energy ontology and thermodynamical ensembles

Zero energy ontology means that the thermodynamics appears both at the level of quantum states and at the level of ensembles. At the level of quantum states this means that M-matrix can be seen as a complex square root of the density matrix: $\rho = MM^{\dagger}$, where M is expressible as a product of a positive and diagonal square root of density matrix and unitary S-matrix identifiable as the S-matrix used in quantum physics. U matrix can be seen as a collection of M-matrices as will be found later so that U-matrix fixes M-matrices contrary to what was believed originally. One can say that thermodynamics -at least in some sense- is represented at the level of single particle states. It is natural to assume that this density matrix is measured in particle physics experiment, and that this measurement corresponds to a state function reduction, which in standard physics picture corresponds to a preparation for the initial states and state function reduction for the final states.

The p-adic thermodynamics, which applies to conformal weights rather than energy, predicts successfully elementary particle masses [K62] and should reduce to this thermodynamics. That p-adic thermodynamics can be applied at all conforms with the view that even elementary particles (that is fermions serving as their basic building bricks) reside in the intersection of the real and p-adic worlds so that either p-adic thermodynamics or real thermodynamics with additional constraints on temperature implied by number theory applies.

M-matrix corresponds to a square root of density matrix, which suggests that also ordinary thermodynamics should be replaced with its square root bringing in phase factors. The imaginary part appearing in the exponent of the vacuum functional defined by Kähler action in Minkowskian regions could have interpretation in terms of a square root of thermodynamics. I have proposed this kind of description as a generalization of the model of cell membrane based on generalization of Josephson junction by bringing in dark currents flowing along magnetic flux tubes [K33].

Thermodynamical ensembles are 4-dimensional

The hierarchy of CDs within CDs defines a hierarchy of sub-systems and sub-CDs define in a natural manner 4-dimensional ensemble. If the state function reduction leads to unentangled states, the outcome is an ensemble describable by the density matrix assignable to the single particle states. The sequence of quantum jumps is expected to lead to a 4-D counterpart of thermodynamical ensemble and thermodynamics results when one labels the states by the quantum

numbers assignable to their positive energy part. Entropy is assigned with entire 4-D CD rather than to its 3-dimensional time=constant snapshots. The thermodynamical time is basically the subjective time and measured in terms of quantum jumps but has a correlation with geometric time as explained in [K7] and explained briefly below.

This picture differs from the standard views, and this might explain the paradoxical situation in cosmology resulting from the fact that the initial state of the universe in the standard sense of the word looks highly entropic whereas second law would suggest the opposite [K98]. The cosmological entropy is assigned with a CD of size scale defined by the value of the age of the universe. In this kind of situation each quantum jump replaces the zero energy state with a new one and also induces a drift in the space of CDs to the direction of larger CDs with size defined by the proper time distance between the tips of CD coming as power of 2. Entropy as a function of cosmic time corresponds in TGD framework to the increase of the 4-D entropy as a function of the quantized proper time distance between the tips of the CD.

In this framework it is possible to understand second law in cosmic time scales apart from the possible effects related to NE responsible for the evolution and breaking of second law in arbitrarily long time scales caused by the transformation of thermal ensembles to quantum coherent dark matter. For instance, the number of sub-CDs increases meaning the increase of the size of the ensemble and the emergence of new p-adic length scales as the size of cosmic CD increases. What is fascinating is that the TGD counterpart of cosmic time is quantized in powers of two. This might have predictable effects such as the occurrence of the cosmic expansion in a jump-wise manner. I have discussed an explanation of the accelerated cosmic expansion in terms of quantum jumps of this kind but starting from somewhat different picture [K98].

Does NMP replace second law?

In TGD NMP defines the fundamental law of evolution. If the maximal negentropy gain corresponds to n-dimensional projector and all outcomes for $m \leq n$ are equally probable (weak NMP) the average value of the dimension associated with the projector of the reduced sub-space is $n/2$. The average negentropy gain is average over the various values of m and has sensitive dependence on the prime number decomposition of m. If m is power of prime, the negentropy gain is large. Therefore the weak form of NMP makes it possible to have larger negentropy gain for $m < n$ than for n having factors if m is prime or has small number of factors.

Second law reflecting the non-determinism of state function reduction is expected to hold true when the reduction takes place to 1-D sub-space - dark matter is not generated in state function reductions. The process can have stages involving dark matter phases labelled by non-standard value of Planck constant but the system returns back to the state in which it consists of visible matter.

The generation of NE indeed breaks second law. Particles are not anymore independent members of a thermodynamical ensemble but form larger units. Since the number of particles is reduced also thermodynamical entropy is reduced and second law can be broken in the geometric time scale considered.

How second law must be modified?

Even in this case second law as such does not certainly apply in TGD framework without special restrictions. Many of these special prerequisites hold true also in the case of NMP.

1. The hierarchy of CDs forces to introduce a fractal version of the second law taking into account the p-adic length scale hypothesis and dark matter hierarchy. This means that the idea about quantum parallel Universes generalizes to that of quantum parallel dissipating Universes. For instance, the parton model of hadrons based on quarks and gluons relies on kinetic equations and is basically thermodynamical whereas the model for hadron applied at low energies is quantum mechanical. These two views are consistent if quantum parallel dissipation realized in terms of a hierarchy of CDs is accepted. p-Adic length scale hierarchy with p-adic length scale hypothesis stating that primes near powers of two are preferred corresponds to this dissipative quantum parallellism. Dark matter hierarchy brings in a further dissipative quantum parallelism.

2. Second law should always be applied only at a given level of p-adic and dark matter hierarchy and one must always take into account two time scales involved corresponding to the time scale assignable to the system identifiable as the time scale characterizing corresponding CD and the time scale in which the system is observed. Only if the latter time scale is considerably longer than the CD time scale, second law is expected to make sense in TGD framework - this provided one restricts the consideration to the entropic entanglement. The reason is that the Boltzmann equations implying the second law require that the geometric time scale assignable to quantum jump is considerably shorter than the time scale of observation: this guarantees that the random nature of quantum jump allows to use statistical approach.

3. The reduction of entanglement entropy at single particle level implies the increase of thermo-dynamical entropy at the level of ensemble in the case of entropic non-binding entanglement. This applies to bound state entanglement leading to a generation of entropy at the level of binding systems and a reduction of the contribution of the bound systems to the entropy of the entire system. Note however the emission of binding energy -say in form of photons-could take care of the compensation so that entropy would be never reduced for ensemble. For NE the situation is different.

4. One must be careful in distinguishing between geometric and subjective time. In the case of subjective time the negentropy increases in statistical sense forever unless the CD disappears in some quantum jump (highly non-probable for large enough CDs). If not, then endless evolution at the level of conscious experience is possible in the intersection of real and p-adic worlds and heat death is not the fate of the Universe as in ordinary thermodynamics.

   The arrow of geometric time changes in the state function reduction to the opposite boundary (act of free will of self leading to a death of sub-self) and negentropy increases. This implies that entropy increases in opposite time direction and behaves like syntropy.

5. In thermodynamics the breaking of second law must correspond to the breaking of ergodicity. Spin glasses are non-ergodic systems and TGD Universe is analogous to a 4-D quantum spin glass by the failure of strict non-determinism of Kähler action reflecting itself as vacuum degeneracy. Does the quantum spin glass property of the TGD universe imply the breaking of the second law? Gravitation has been seen as one possible candidate for the breaking second law because of its long range nature. It is indeed classical gravitational energy which distinguishes between almost degenerate spin glass states. The huge value of gravitational Planck constant associated with space-time sheets mediating gravitational interaction and making possible perturbative quantum treatment of gravitational interaction would indeed suggest the breaking of second law in cosmological time scales. For instance, black hole entropy which is inversely proportional to $GM^2/\hbar_{gr}$ would be for the values of gravitational Planck constant involved of the order of unity.

   This breaking of ergodicity implied by 4-D spin glass character of TGD might have an interpretation in terms of NE. The non-determinism implying the ergodicity is behind the hierarchy of quantum criticalities in turn realizing NE.

What do experiments say about second law?

That the status of the second law is far from settled is demonstrated by an experiment performed by a research group in Australian National University [D7]. The group studied a system consisting of 100 small beads in water. One bead was shot by a laser beam so that it became charged and was trapped. The container holding the beads was then moved from side to side 1000 times per second so that the trapped bead dragged first one way and then another. The system was monitored and for monitoring times not longer than.1 seconds second law did not hold always: entropy could also decrease.

1. What is remarkable that .1 seconds defines the duration τ of the memetic code word and corresponds to the secondary p-adic time scale $T_p(2) = \sqrt{p}L_p/c$ associated with Mersenne prime $p = M_{127}$ characterizing electron. This correspondence follows solely from the model of genetic code predicting hierarchy of codes associated with $p = 3, 7, 127$ (genetic code), $p = M_{127}, ...$ τ should be the fundamental time scale of consciousness. For instance, average

alpha frequency 10 Hz corresponds to this time scale and "features" inside cortex representing sensory percepts have average duration of .1 seconds.

For electrons the CDs would have spatial size $L = 3 \times 10^7$ meters, which is slightly smaller than the circumference of Earth ($L = cT$, $T = .1$ s, the duration of sensory moment) so that they would have a strong overlap. One can of course ask whether this is an accident. For instance, the lowest Schumann frequency is around 7.8 Hz and not far from 10 Hz. What is interesting that Bohr orbit model [K97] predicts that Universe might be populated by Earth like systems having same distance from their Sun (stars with mass near that of Sun are very frequent). Bohr orbitology applied to Earth itself could also lead to the quantization of the radius of Earth.

2. The first observation was made for more than 15 years ago. Even more remarkable is the recent observation that the time scale of CD associated with electron is.1 seconds. Can one assign the breaking of the second law with the field bodies of electrons?

3. The experiment involves also a millisecond time scale. I do not know whether it is essential that the time scale is just this but one can play with the though that it is. Millisecond time scale is roughly the duration of seventh bit of the genetic codeword if its bits correspond to CDs with sizes coming as subsequent octaves of the basic time scale. Millisecond defines also the time scale for the duration of the nerve pulse and the frequency of kHz cortical synchrony.

   At the level of CDs millisecond time scale would correspond to a secondary p-adic time scale assignable to $k = 120$. Only u and d quarks, which appear with several p-adic mass scales in hadron physics and are predicted to be present as light variants also in nuclear physics as predicted by TGD, could correspond to this p-adic length scale: the prediction for their mass scale would be 5 MeV. Does this mean that the basic time scales of living matter correspond directly to the basic time scales of elementary particle physics?

4. A further interesting point is that neutrinos correspond to.1 eV mass scale. This means that the p-adic length scale is around $k = 167$ which means that the corresponding CD has time scale which is roughly 2^{40} times that for electron and corresponds to the primary p-adic length scale of 2.5 μm (size of cellular nucleus) and tothe time scale of 10^4 years. I have proposed that so called cognitive neutrino pairs consisting of neutrino and antineutrino assignable to the opposite throats of wormhole contact could play key a role in the formation of cognitive representations [K80]. This assumption looks now un-necessarily restrictive but one could quite well consider the possibility that neutrinos are responsible for the longest time scales assignable to consciousness for ordinary value of $\hbar$ (not necessarily our consciousness!). Large value of $\hbar$ could make also possible the situation in which intermediate gauge bosons are effectively massless in cell length scale so that electro-weak symmetry breaking would be absent. This would require $\hbar \simeq 2^{33}$. For this value of $\hbar$ the time scale of electronic CD is of the order of the duration of human of human life cycle. This would scale up the Compton length of neutrino to about 10 kilometers and the temporal size of neutrino CD to a super-cosmological time scale.

3.4.3   NMP And Biology

The notion of self is crucial for the understanding of bio-systems and consciousness. It seems that the NE is the decisive element of life and that one can say that in metaphorical sense life resides in the intersection of real and p-adic worlds.

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

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

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

1. The facts that fermionic oscillator operators are correlates for Boolean cognition and that induced spinor fields are restricted to string world sheets and partonic 2-surfaces suggests that the intersection consists of these 2-surfaces.

2. Strong form of holography allows a rather elegant adelization of TGD by a construction of space-time surfaces by algebraic continuations of these 2-surfaces defined by parameters in algebraic extension of rationals inducing that for various p-adic number fields to real or p-adic number fields. Scattering amplitudes could be defined also by a similar algebraic contination. By conformal invariance the conformal moduli characterizing the 2-surfaces would defined the parameters.

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

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

A good guess is that algebraic entanglement is essential for quantum computation, which therefore might correspond to a conscious process. Hence cognition could be seen as a quantum computation like process, a more appropriate term being quantum problem solving [K2]. Living-dead dichotomy could correspond to rational-irrational or to algebraic-transcendental dichotomy: this at least when life is interpreted as intelligent life. Life would in a well defined sense correspond to islands of rationality/algebraicity in the seas of real and p-adic continua. Life as a critical phenomenon in the number theoretical sense would be one aspect of quantum criticality of TGD Universe besides the criticality of the space-time dynamics and the criticality with respect to phase transitions changing the value of Planck constant and other more familiar criticalities. How closely these criticalities relate remains an open question [K87].

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

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

That only algebraic extensions are possible is of course only a working hypothesis. Also finite-dimensional extensions of p-adic numbers involving transcendentals are possible and might in fact be necessary. Consider for instance the extension containing $e, e^2, .., e^{p-1}$ as units (e^p is ordinary p-adic number. Infinite number of analogous finite-dimensional extensions can be constructed by taking a function of integer variable such that $f(p)$ exists both p-adically and as a real transcendental number. The powers of $f(p)^{1/n}$ for a fixed value of n define a finite-dimensional transcendental extension of p-adic numbers if the roots do not exist p-adically.

Numbers like $log(p)$ and π cannot belong to a finite-dimensional extension of p-adic numbers [K38]. One cannot of course take any strong attitude concerning the possibility of infinite-dimensional extensions of p-adic numbers but the working hypothesis has been that they are absent. The phases $exp(i2\pi/n)$ define finite dimensional extensions allowing to replace the notion of angle in finite measurement resolution with the corresponding phase factors in finite measurement. The functions $exp(i2\pi q/n)$, where q is arbitrary p-adic integers define in a natural manner the physical counterparts of plane waves and angular momentum eigenstates not allowing an identification as ordinary p-adic exponential functions. They are clearly strictly periodic functions of q with a finite value set. If n is divisible by a power of p, these functions are continuous since the values of the function for q and $q + kp^n$ are identical for large enough values of n. This condition is essential and means in the case of plane waves that the size scale of a system (say one-dimensional box) is multiple of a power of p.

NMP and self-organization

NMP leads to new vision about self-organization about which adetailed vision is discussed in [K87]. Here only some key points are emphasized.

1. Dissipation selects the asymptotic self-organization patterns in the standard theory of self-organization and the outcomes are interesting in the presence of energy feed. The feed of energy can be generalized to feed of any kind of quantum numbers: for instance, feed of quantum numbers characterizing qualia. In fact, energy increment in quantum jump defines one particular kind of quale [K39]. Similar picture should apply now.

2. The fundamentally new element is that in ZEO basic objects are pairs of 3-D surfaces at the opposite boundaries of CDs. By holography the basic geometric objects are 4-dimensional or equivalently 3-dimensional. Strong form of holography allows also to identify the objects carrying information about quantum states as string world sheets and partonic 2-surfaces at the boundaries of CD. Self-organization leads to an asymptotic spatio-temporal pattern rather than spatial pattern, behavior or function. This picture is especially useful when one tries to understand morphogenesis and the emergence of functions and behaviors in biology and neuroscience [K77].

3. The notion of self relates very closely to self-organization in TGD framework [K87]. Self assignable to CD is a dissipative structure because it has sub-selves which dissipate quantum parallelly with it. Self as a perceiver maps the dissipation at the level of quantities in the external world to dissipation at the level of qualia in the internal world.

4. Dissipation leads to self-organization patterns and in the absence of external energy feed to thermal equilibrium. Thus thermodynamics emerges as a description for an ensemble of selves or for the time average behavior or single self when external energy feed to system is absent. One can also understand how the dissipative universe characterized by the presence of parameters like diffusion constants, conductivities, viscosities, etc.. in the otherwise reversible equations of motion, emerges. Dissipative dynamics is in a well defined sense the envelope for the sequence of reversible dynamical evolutions modelling the sequence of final state quantum histories defined by quantum jumps.

5. Quantum self-organization can be seen as iteration of the unitary process followed by state function reduction and leads to fixed point self-organization patterns analogous to the patterns emerging in Benard flow. Since selves approach "asymptotic selves", dissipation can be regarded as a Darwinian selector of both genes and memes. Thus not only surviving physical systems but also stable conscious experiences of selves, habits, skills, behaviors, etc... are a result of Darwinian selection.

6. In TGD one must distinguish between two kinds of self organizations corresponding to the entropic bound state entanglement and NE. Biological self-organization could be therefore fundamentally different from the non-biological one. The success of the p-adic mass calculations suggest that elementary particles reside in the intersection of real and p-adic worlds so that one should be very cautious in making strong conclusions. Certainly the intentional,

goal-directed behavior of the system in some time scale is a signature of negentropic self-organization but it is difficult to apply this criterion in time scales vastly different from human time scales. It is the field bodies (or magnetic bodies), which can be assigned naturally to CDs which suggests that the negentropic self organization occurs at this level. TGD based vision about living matter actually assumes this implicitly.

7. What is new that even quantum jump itself can be seen as a self-organization process analogous to Darwinian selection, which yields a state containing only bound state state entanglement or NE and representing analog of the self-organization patterns. By macro-temporal quantum coherence effectively gluing quantum jumps sequences to single quantum jump this pattern replicates itself fractally in various time scales. Thus self-organization patterns can be identified as bound states and states paired by a NE and the development of the self-organization pattern as a fractally scaled up version of single quantum jump. Second new element is that dissipation is not mere destruction of order but producer of jewels. A further new element is that dissipation can occur in quantum parallel manner in various scales.

8. The failure of the determinism in standard sense for Kähler action is consistent with the classical description of dissipation. In particular, the emergence of sub-selves inside self looks like dissipation from outside but corresponds to self-organization from the point of view of self. 4-dimensional spin glass degeneracy meaning breaking of ergodicity crucial for self-organization is highly suggestive on basis of the vacuum degeneracy of Kähler action, and this alone predicts ultra-metric topology for the landscape of the maxima of Kähler function defined in terms of Kähler action so that p-adicity emerges naturally also in this manner.

One particularly interesting concrete prediction is that the time scales assignable to CDs come as powers of two. This predicts fundamental frequencies coming as powers of two, and the hierarchy of Planck constants predicts rational or at least integer multiples of these frequencies. Could these powers of two relate to frequency doubling rather generally observed in hydrodynamical self-organizing systems?

Evolution and NMP

Evolution has many facets in TGD framework.

1. A key aspect of evolution relates to the hierarchy of Planck constants labelling a hierarchy of quantum criticalities. The phase transitions reducing criticality, increasing Planck constant, and generatic NE occur spontaneously so that evolution is unavoidable. This is in sharp conflict with the standard belief that life is a thermodynamical fluctuation.

2. In the adelic vision evolution reduce to the increase of the complexity of the algebraic extension of rationals defining the preferred primes which are primes near powers of prime by NMP. The value of n characterizing Planck constant would correspond to the product of ramified primes for a given extension. Infinite primes representing bound states in arithmetic quantum field theory could code for the irreducible polynomials characterizing the basic algebraic extension whose maximal Abelian extension is represented in terms of adeles [K119].

3. A further natural characterization of evolution is in terms of p-adic topology relating naturally to cognition. p-Adic primes near powers of two are favored if CDs have the proposed discrete size spectrum. From the point of view of self this would be essentially cosmic expansion in discrete jumps. CDs and can be characterized by powers of 2 and if partonic 2-surfaces correspond to effective p-adic p-adic topology characterized by a power of two, one obtains the commeasurability of the secondary p-adic time scale of particle and that of CD in good approximation.

4. The notion of infinite primes motivates the hypothesis that the many-sheeted structure of space-time can be coded by infinite primes [K102]. The number of primes larger than given infinite prime P is infinitely larger than the number of primes than P. The infinite prime P characterizing the entire universe decomposes in a well defined manner to finite primes and p-adic evolution at the level of entire universe is implied by local p-adic evolution at the

level of selves. Therefore maximum entanglement negentropy gain for p-adic self increases at least as $log(p)$ with p in the long run. This kind of relationship might hold true for real selves of p-adic physics is physics of cognitive representations of real physics as suggested by the success of p-adic mass calculations. Thus it should be possible to assign definite p-adic prime to each partonic 2-surface.

Just for fun one can play also with numbers.

1. The highest dark matter level associated with self corresponds to its geometric duration which can be arbitrarily long: the typical duration of the memory span gives an idea about the level of dark matter hierarchy involved if one assumes that the time scale.1 seconds assignable to electrons is the fundamental time scale. If the time scale T of human life cycle corresponds to a secondary p-adic time scale then $T = 100$ years gives the rough estimate $r \equiv \hbar/\hbar_0 = 2^{33}$ if this time scale corresponds to that for dark electron. The corresponding primary p-adic time length scale corresponds to $k = 160$ and is 2.2×10^{-7} meters.

2. If human time scale -taken to be $T = 100$ years- corresponds to primary p-adic time scale of electron, one must have roughly $r = 2^{97}$.

I have already discussed the second law in TGD framework and it seems that its applies only when the time scale of perception is longer than the time scale characterizing the level of the p-adic and dark matter hierarchy. Second law as it is usually stated can be seen as an unavoidable implication of the materialistic ontology.

Stable entanglement and quantum metabolism as different sides of the same coin

The notion of binding has two meanings. Binding as a formation of bound state and binding as a fusion of mental images to larger ones essential for the functioning of brain and regarded as one the big problems of consciousness theory.

Only bound state entanglement and NE are stable against the state reduction process. Hence the fusion of the mental images implies the formation of a bound entropic state- in this case the two interpretations of binding are equivalent- or a negentropic state, which need not be bound state.

1. In the case of NE bound state need not be formed and the interesting possibility is that the NE could give rise to stable states without binding energy. This could allow to understand the mysterious high energy phosphate bond to which metabolic energy is assigned in ATP molecule containing three phosphates and liberated as ATP decays to ADP and phosphate molecule. Negentropic entanglement could also explain the stability of DNA and other highly charged biopolymers. In this framework the liberation of metabolic (negentropic) energy would involve dropping of electrons to a larger space-time sheets accompanying the process $ATP \rightarrow ADP + P_i$. A detailed model of this process is discussed in [**?**].

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

2. The formation of bound state entanglement is expected to involve a liberation of the binding energy and this energy might be a usable energy. This process could perhaps be coined as quantum metabolism and one could say that quantum metabolism and formation of bound states are different sides of the same coin. It is known that an intense neural activity, although it is accompanied by an enhanced blood flow to the region surrounding the neural activity, does not involve an enhanced oxidative metabolism [J74] (that is $ATP \rightarrow ADP$ process and its reversal). A possible explanation is that quantum metabolism accompanying the binding is involved. Note that the bound state is sooner or later destroyed by the thermal noise so that this mechanism would in a rather clever manner utilize thermal energy by applying what might be called buy now–pay later principle.

If these interpretations are correct, there would be two modes of metabolism corresponding to two different kinds of fusion of mental images.

3.4.4 NMP, Consciousness, And Cognition

As already found NMP dictates the subjective time development of self and is therefore the basic law of consciousness. If p-adic physics is the physics of cognition, the most exotic implications of NMP relate to cognition rather than standard physics.

Thermodynamics for qualia

Concerning qualia one can consider two views.

1. If only entropic entanglement is assumed, second law would hold true also at the level of conscious experience of self, which can be seen as an ensemble of its sub-selves assignable to sub-CDs. The randomness of the state function reduction process implies that conscious experience involves statistical aspects in the sense that the experienced qualia correspond to the averages of quantum number and zero mode increments over the sub-selves assignable to sub-CDs. When the number of quantum jumps in the ensemble defining self increases, qualia get more entropic and fuzzy unless macro-temporal quantum coherence changes the situation.

2. ZEO and NE means departure from this picture if sub-CDs can generate NE. This is expected to be true if they overlap if one believes on standard argument for the formation of macroscopic quantum phases. In this case the flux tubes connecting space-time sheets assignable to the sub-CDs would serve as a space-time correlate for the NE.

   The basic questions are whether sensory qualia can really correspond to the increments of quantum numbers in quantum jump and whether these quantum jumps are assignable to entropic or negentropic qualia. What is clear that the sensory qualia such as colors are assigned to an object of external world rather predictably. This is not obvious if this process is based on quantum jump.

1. The original view inspired by standard view about state function reduction (positive energy ontology) was that qualia are determined basically as increments of quantum numbers [K39]. In ordinary statistical physics measured quantities would correspond to quantum numbers basically. The basic function of sensory organs would be to map quantum numbers to quantum number increments so that our sensory perception is in reasonable approximation about world rather than changes of the world.

2. Entropic entanglement is reduced to zero in state function reduction for individual sensory receptor and the outcome involves all possible values of quale, say different fundamental colors for which I have proposed a model in terms of QCD color [K39]. If the probability of particular value of quale is much larger than others, one can have statistical ensemble giving rise to predictable quale as ensemble average.

   What happens when ZEO based view about state function reduction is adopted?

1. Now sensory mental image corresponds to a sub-self, which in turn corresponds to a repeated state function reduction to a fixed (passive) boundary of sub-CD. Does sub-self without any sub-sub-selves correspond to conscious experience about quantum numbers instead of only change of quantum numbers? One cannot exclude this possibility. For instance, three colored states for quarks would correspond to three fundamental colors for this option.

   The alternative possibility is that quantum jumps of sub-selves give rise to the sensory mental images and the increments of quantum numbers define the qualia. Sub-selves without sub-selves would not give rise to sensory qualia. That consciousness involves always change could be seen as a support for this interpretation but one can ask what change is. Does change mean state function reduction in standard sense or does it mean a sequence of repeated state function reductions leaving the passive boundary of CD invariant but inducing sensation about flow of time and sensory experience?

2. In ZEO the increments must correspond to increments of quantum numbers for (say) positive energy part of the state. A sensation of (say) given color requires a continual feed of corresponding quantum number increment to the positive energy part of the system. Some kind of far from equilibrium thermodynamics seems to be necessary with external feed of quantum numbers generalizing the external feed of energy. The capacitor model of a sensory receptor [K39] realizes this idea in terms of generalized di-electric breakdown implying opposite charging of the capacitor plates in question. Note that in ZEO also the positive and negative energy parts of the zero energy state assignable to capacitor plates would be also analogous to a pair of oppositely charged capacitor plates and one can speak about capacitor also in time direction.

3. The flow of quantum numbers can be interpreted also in terms of feed of NE to the sub-CD of sub-self allowing it to satisfy the needs of NMP and avoid the lethal first state function reduction to the opposite boundary of its sub-CD. NE feed would accompany the feed of quantum numbers and would be accompanied by feed of metabolic energy and/or some other metabolite. Energy metabolism is indeed only one particular variant of metabolism. Metabolism would be always basically feed of NE assignable to system with quantum numbers producing the quale assignable to these quantum numbers. Each metabolite carrying NE would define its own quale. One can assign metabolites also to hearing and vision: the metabolite would be assigned with sound waves or photons and carry NE. Whether the metabolite could be identified with dark phonons or photons is an interesting question.

4. Note that in this picture quantum number increment corresponds to that for a subsystem due to the flow of quantum numbers to it rather than to the change of quantum numbers in state function reduction. Hence it is possible to assign qualia also to quantum numbers rather than their increments.

5. Also in this framework the analog of thermodynamical description is suggestive since chemical potentials provide natural thermodynamical description for the numbers of ions. In ZEO square root of thermodynamics is highly suggestive in order to take into account the macroscopic quantum coherence in living systems and I have proposed a model of cell membrane along these lines generalizing the usual thermodynamical model [K55]. Chemical potentials are in this framework replaced with the cyclotron energy differences over cell membrane.

The association of sensory qualia with the transfer of metabolites of various kinds is a powerful prediction and conforms at least in spirit with the early very naïve attempts to identify qualia in terms of biologically important charged particles assumed to form cyclotron condensates at dark magnetic flux tubes. If ATP (and GTP) are the universal carriers of metabolic energy and if energy quale must accompany any quale, one could try to identify the metabolites giving rise to qualia from the biochemistry of the sensory perception. The proposal that nutrients carry NE conforms with this picture.

3. "Final" solution to the problem of qualia

The TGD inspired theory of qualia [K39] has evolved gradually.

1. The original vision was that qualiaandother aspects of consciousness experience are determined by the change of quantum state in the reduction: the increments of quantum numbers would determine qualia. I had not yet realized that repeated state function reduction (Zeno effect) realized in ZEO is central for consciousness. The objection was that qualia change randomly from reduction to reduction.

2. Later I ended up with the vision that the rates for the changes of quantum numbers would determine qualia: this idea was realized in terms of sensory capacitor model in which qualia would correspond to kind of generalized di-electric breakdown feeding to subsystem responsible for quale quantum numbers characterizing the quale. The Occamistic objection is that the model brings in an additional element not present in quantum measurement theory.

3. The view that emerged while writing the critics of IIT of Tononi [L30] is that qualia correspond to the quantum numbers measured in the state function reduction. That in ZEO

the qualia remain the same for the entire sequence of repeated state function reductions is not a problem since qualia are associated with sub-self (sub-CD), which can have lifetime of say about .1 seconds! Only the generalization of standard quantum measurement theory is needed to reduce the qualia to fundamental physics. This for instance supports the conjecture that visual colors correspond to QCD color quantum numbers. This makes sense in TGD framework predicting a scaled variants of QCD type physics even in cellular length scales.

This view implies that the model of sensory receptor based on the generalization of dielectric breakdown is wrong as such since the rate for the transfer of the quantum numbers would not define the quale. A possible modification of the model simple: the analog of dielectric breakdown generates Bose-Einstein condensate and the quantum numbers for the BE condensate give rise to qualia assignable to sub-self.

Questions about various kinds of entropies and negentropies

In standard positive energy ontology and in absence of dark matter second law is natural for many-particle systems. In ZEO and accepting the hierarchy of dark matters NMP replaces second law and the modification of thermodynamics replaced entropy with negentropy is highly suggestive.

Consider first the situation in positive energy ontology. There are three kinds of entropies and the basic question is how these entropies relate.

1. Does the entropy characterizing the experience of self relate to the thermodynamical entropy of some system? The fact that non-geometric sensory qualia have a statistical interpretation, suggests that the entropy associated with the qualia of the mental image corresponds to the thermodynamical entropy for a system giving rise to the qualia via the sensory mapping. The thermodynamics of quantities in the external world would thus be mapped to the thermodynamics of qualia, increments of quantities, in the inner world. Selves could also represent the fundamental thermodynamical ensembles since they define also statistical averages of quantum numbers and zero modes although these are not directly experienced.

2. Could one interpret the entropies of the space-time sheets as entropies associated with the symbolic representations of conscious experiences of selves? Could one see the entire classical reality as a symbolic representation? Does the entropy of conscious experience correspond to the thermodynamical entropy of the perceived system, which in turn would correspond to the classical space-time entropy of the system representing the perceived system symbolically? Does this conclusion generalize to the case of p-adic entropy? Quantum-classical correspondence would encourage to cautiously think that the common answer to these questions might be yes.

One can repeat these questions almost as such for ZEO option. Now one would only speak about negentropy. Each quale would corresponding to its metabolite and to a chemical potential contribution to the differentials of thermodynamical functions. The thermodynamics of qualia could allow to have quantitative model correlating qualia with chemistry.

The arrow of psychological time and thermodynamics

In positive energy ontology and standard QM the arrow of psychological time is closely related to the second law and I have considered several alternative identifications for the arrow of psychological time. In ZEO [K116, K7] NMP replaces second law and the arrow of psychological time emerges as a prediction of the model for self as sequences of state function reductions to a fixed boundary of CD. The new element is that the arrow of geometric time chan change and that the moments for these changes define increases for the distance between the tips of CD defining a discrete flow of psychological time.

The latest option favored by ZEO involves two aspects. The one related to the arrow of time coordinate assignable to the space-time sheet and the other one to the relative proper time coordinate between the tips of CD. A simple argument show that this distance should increase gradually in statistical sense since the size of CD can also change in quantum jump. This would have have interpretation in terms of a flow of "cosmic time" (CD is analogous to big bang followed by

big crunch). Interestingly, CD with time scale of order 10^{11} years (age of the universe) corresponds primary p-adic length scale of only 10^{-4} meters, the size of a large neuron, and also the length scale in which the blob of water has Planck mass so that the quantization of gravitational Planck constant should become important [K97]. Could this mean that the CDs assignable to large neurons make possible to develop the idea about the cosmology and cosmology itself? Could it really be that our cognitive representations about Universe quite concretely have the size of the Universe itself as p-adic view about cognition requires?

Reductionism, holism and NMP

The fusion of sub-selves can take place in two ways: by real bound state entanglement and by NE. The resulting mental images must differ somehow, and the proposal is that the entanglement associated with the negentropic mental defines a conscious cognitive representation: kind of rule. Schrödinger cat negentropically entangled with the bottle of poison knows that it is not a good idea to open the bottle: open bottle-dead cat, closed bottle-living cat (note that thew weak form of NMP allows the cat to open the bottle so that the information is useful!). NE would generate rules and counterparts of conscious associations fundamental in brain functioning. For the mental image associated with bound state entanglement the information about bound systems would be lost. NE could give rise to stereo-consciousness essential for (say) stereo vision.

Analysis and conceptualization (synthesis) - formation of rules- could be seen as the reductionistic and holistic aspects of consciousness. The interpretation of quantum jump as a creation of a totally entangled holistic state, which is then analyzed to stable entangled pieces allows to interpret self measurement cascade as a conscious analysis. The resulting stable negentropic pieces give rise to experience of understanding and conceptualization - rules and abstractions. Perhaps the holistic character assigned to right brain hemisphere could be interpreted in terms of specialization to conceptualization and reductionist character of left brain to analysis to smallest possible pieces. This picture proposed originally in positive energy ontology makes sense also in ZEO.

Could one assume that left brain generates entropic bound state entanglement and right brain NE? This idea not so feasible as it looked originally. The reason is that only NE might be relevant for consciousness.

In ZEO the sequence of state function reductions at passive boundary of CD generates entangled holistic state at the active boundary and the reduction to opposite boundary generates the reductionistic state at it. The two boundaries of CD would seem to correspond to the reductionistic and analytic aspects of consciousness. Again one must be very cautious in making interpretations. One can also consider that holistic state corresponds to NE in long scales and with large h_{eff} whereas the reductionistic state would correspond to short scales and small values of h_{eff}.

If left and right brain work independently they should not differ unless their magnetic bodies are different in the sense that right brain correspond to a large magnetic body and to large values of h_{eff} and left brain to small values of h_{eff}. Could it be that the brain hemispheres work together quantum coherently and this allows specialization?

Could left brain produce less NE than right brain? Could left brain be the bad boy and right brain the saint? Or do both produce NE but that NE corresponds to short p-adic length scales in the case of left brain (dimension d of final state projectior is a large power of small prime p) and long p-adic length scales in the case of right brain hemisphere (d is a small power of large p)?

There are rather interesting connections with altered states of consciousness and states of macro-temporal quantum coherence.

1. Making mind empty of mental images could perhaps be interpreted as a mechanism of achieving irreducible self state. If self entangles negentropically with larger conscious entity this would lead to experiences characterized as expansion of consciousness, even cosmic consciousness. One could also consider the possibility the sub-selves representing mental images fuse to single long-lasting negentropic mental image. The absence of dissipation could relate to the reports of meditators about lowered metabolic needs.

2. The ordinary wake-up consciousness is identifiable as the analytical mode in which NE in short scales dominates. Together with weak form of NMP this would suggest that state

function reductions are carried out to rather sub-spaces with rather low dimension or alternatively to sub-spaces for which the dimension is larger power of small prime defining the p-adic length scale. The reason for this could be sensory input and motor activities, which would create effective heat bath destroying holistic mental images.

3. Krishnamurti has talked a lot about states of consciousness in which no separations and discriminations occur and timelessness prevails. These states could correspond to long-lived NE with large $\hbar$ with larger conscious entities giving rise to very long effective moments of consciousness. In this kind of situation NMP does not force cognitive self measurements to occur and analysis and separations can thus be avoided.

4. Sharing and fusion of mental images by entanglement of sub-selves of separate selves makes possible quantum realization of telepathy and could be a universal element of altered states of consciousness. Also this entanglement could be bound state entanglement or NE.

Cognitive codes

p-Adic length scale hypothesis leads to the idea that each $p \simeq 2^k$, k integer, defines a hierarchy of cognitive codes with code word having duration given by the n-ary p-adic time scale $T(n,k)$ and number of bits given by any factor of k. Especially interesting codes are those for which the number of bits is prime factor or power of prime factor of k. $n = 2$ seems to be in special position in ZEO. This is a strong quantitative prediction since the duration of both the code word and bit correspond to definite frequencies serving as signatures for the occurrence of commutations utilizing these codes.

If k is prime, the amount of information carried by the codon is maximal but there is no obvious manner to detect errors. If k is not prime there are several codes with various numbers of bits: information content is not maximal but it is possible to detect errors. For instance, $k = 252$ gives rise to code words for which the number of bits is $k_1 = 252, 126, 63, 84, 42, 21_2, 9, 7, 6_2, 4, 3_2, 2$: the subscript $_2$ tells that there are two non-equivalent ways to get this number of bits. For instance, $126 = 42 \times 3$-bit codon can have 42 -bit parity codon: the bits of this codon would be products of three subsequent bits of 126-bit codon. This allows error detection by comparing the error codon for communicated codon and communicated error codon.

The recent view about how NMP selects preferred primes [K119] supports this idea. The values of dimension for the sub-space defining the outcome of reduction which are primes near powers of prime p are favoured by NMP. $p = 2$ gives the p-adic length scale hypothesis. Large powers of small prime could give rise to cognitive codes. Not that the integers associated with code could also be in the range $[0, p^n]$. For instance, for microtubules $p = 13$ is suggestive. For genetic code $p = 127$ is suggestive.

Abstraction hierarchy and genetic code

Mersenne primes $M_n = 2^n - 1$, which seem to play fundamental role in elementary particle physics. This would put primes 3, 7, 31, 127, etc. in a special position. Primes appear frequently in various bio-structures and this might reflect the underlying p-adicity for the association sequences providing "plan" for the development of bio-system. For instance, we have actually 7 (!) fingers: two of them have degenerated during evolution but can be seen in the developing embryo. There are 31 subunits in our spinal chord, etc...

As already explained, the emergence of primes near powers of prime can be understood from NMP.

In the model of genetic code based on a simple model of abstraction process [K41] the so called Combinatorial Hierarchy $2, 3, 7, 127, 2^{127} - 1, \ldots$ of Mersenne primes emerges naturally. The construction for a model of abstraction process proceeds as follows.

1. At lowest level there are two digits. The statements Yes and No.

2. At the next level one considers all Boolean statements about these two statements which can be regarded as maps from 2-element set to 2-element set. There are 4 of them. Throw one away and you get 3 statements.

3. At the next level one considers all Boolean statements about these 3 statements and the total number of them is 2^3. Throw one away and you get 7 statements. And so on.

In this case one obtains what might be interpreted as a hierarchy of statements about statements about... The mystery is why one statement must be thrown away at each level of the construction. The answer might relate to a concrete model of quantum computation. The emotional realization of this code in terms of subs-spaces of n-dimensional space allows to understand this. The reason is that the outcome of the state function reduction corresponds to any $n - k$ dimensional sub-space for a fixed choices of basis with $k = 1, ..., n - 1$. $k = 0$ is obviously excluded and the number of choices is $2^n - 1$ rather than 2^n.

An open problem is how the emotional realization of Boolean algebra is mapped to its fermionic representation. The task is to map in a natural manner the outcome of the state function reduction to a corresponding many-fermion state (in ZEO it would be pair of many-fermion states at opposite boundaries of CD having opposite quantum numbers). Is it really possible to map different levels (reductions and states) to each other?

Is the sum of p-adic negentropies equal to real entropy?

I ended almost by accident to a fascinating and almost trivial theorem. Adelic theorem for information would state that conscious information represented as sum of p-adic negentropies (entropies, which are negative) is equal to real entropy. The more conscious information, the larger the chaos in the environment as everyone can verify by just looking around.

This looks bad! Luckily, it turned out that this statement is true for rational probabilities only. For algebraic extensions it cannot be true as is easy to see. That negentropic entanglement is possible only for algebraic extensions of rationals conforms with the vision that algebraic extensions of rationals characterize evolutionary hierarchy. The rationals represent the lowest level at which there is zero amount of conscious information.

It is not completely obvious that the notion of p-adic negentropy indeed makes sense for algebraic extensions of rationals. A possible problem is caused by the fact that the decomposition of algebraic integer to primes is not unique. Simple argument however strongly suggests that the various p-adic norms of the factors do not depend on the factorization. Also a formula for the difference of the total p-adic negentropy and real entropy is deduced.

1. p-Adic contribution to negentropy equals to real entropy for rational probabilities but not for algebraic probabilities

The following argument shows that p-adic negentropy equals to real entropy for rational probabilities.

1. The fusion of real physics and various p-adic physics (identified as correlates for cognition, imagination, and intentionality) to single coherent whole leads to what I call adelic physics [K119]. 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 point 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.

2. Negentropy Maximization Principle (NMP) [K56] is the variational principle of consciousness in TGD framework reducing to quantum measurement theory in Zero Energy Ontology assuming adelic physics. 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. Furthermore, all non-vanishing p-adic negentropies are positive and the number of

primes contributing to negentropy is finite since any algebraic number can be expressed using a generalization of prime number decomposition of rational number. These p-adic primes characterize given systen, say elementary particle.

NMP states that the negentropy gain is maximal in the quantum jump defining state function reduction. How does one define the negentropy? As the sum of p-adic negentropies or as the sum of real negative negentropy plus the sum of p-adic negentropies? The latter option I proposed for some time ago without checking what one obtains.

3. The adelic theorem says that the norm of rational number is equal to the product of the inverses of its p-adic norms. The statement that the sum of real and p-adic negentropies is zero follows more or less as a statement that the logarithms of real norm and the product of p-adic norms for prime factors of rational sum up to zero.

   The core formula is adelic formula stating that the real norm of rational number is product of its p-adic norms. This implies that the logarithm of the rational number is sum over the logarithms of its p-adic norms. Since in p-adic entropy assigned to prime p logarithms of probabilities are replaced by their p-adic norms, this implies that for rational probabilities the real entropy equals to p-adic negentropy.

   It would seem that the negentropy appearing in the definition of NMP must be the sum of p-adic negentropies and real entropy should have interpretation as a measure for ignorance about the state of either entangled system. The sum of p-adic negentropies would serve as a measure for the information carried by a rule with superposed state pairs representingt the instances of the rule. The information would be conscious information and carried by the negentropically entangled system.

4. What about probabilities in algebraic extensions? The probabilities are now algebraic numbers. The induced p-adic norm $N_p(x)$ for n-dimensional extension of Q is defined as the determinant $det(x)$ of the linear map defined by multiplication with x. $det(x)$ is rational number. The corresponding p-adic norm is defined as the n:th root $N_p(det(x))^{1/n}$ of the ordinary p-adic norm. Root guarantees that the norm co-incides with the ordinary p-adic norm for ordinary p-adic integers. One must perform now a factorization to algebraic primes. Below an argument is given that although the factorization to primes is not always unique, the product of p-adic norms for given algebraic rational defined as ratio of algebraic integers is unique.

   The p-adic norms of probabilities are however always powers of primes so that the adelic formula *cannot* be true since on the real side one has logarithms of algebraic numbers and on the p-adic side only logarithms of primes.

   What could be the interpretation?

1. If conscious information corresponds to $N - P$, it accompanies the emergence of algebraic extensions of rationals at the level of Hilbert space.

2. If N corresponds to conscious information, then at the lowest level conscious information is necessary accompanied by entropy but for algebraic extensions $N - P$ could be positive since N is maximized.

Both interpretations conform with the number theoretic vision about evolution. One expects that the value of real entropy correlates strongly with the value of negentropy. This would conform with the observation that large entropy seems to be a prerequisite for life by providing large number of states with degenerate energies providing large representative capacity. For instance, Jeremy England has made this proposal [I61]: I have commented this proposal from [L22] (see `http://tinyurl.com/zjp3bp6`).

2. Formula for the difference of total p-adic negentropy and real entanglement entropy

Can one write an explicit formula the difference of total p-adic entanglement negentropy (positive) and real entanglement entropy using prime factorization in finite dimensional algebraic extension (note that for algebraic numbers defining infinite-dimensional extension of rationals

factorization does not even exist since one can write $a = \sqrt{a}\sqrt{a} = ...$)? This requires that total p-adic entropy is uniquely defined. There is a possible problem due to the non-uniqueness of the prime factorization.

1. For Dedekind rings, in particular rings of integers, there exists by definition a unique factorization of proper ideals to prime ideals (see `http://tinyurl.com/h3oufpp`). In contrast, the prime factorization in the extensions of Q is not always unique. Already for $Q(\sqrt{-5})$ one has $6 = 2 \times 3 = (1 + \sqrt{-5})(1 - \sqrt{-5})$ and the primes involved are not related by multiplication with units.

   Various factorizations are characterized by so called class group and class field theory (see `http://tinyurl.com/zdnw7j3`) is the branch of number theory studying factorizations in algebraic extensions of integer rings. Factorization is by definition unique for Euclidian domains. Euclidian domains allow by definition so called Euclidian function $f(x)$ having values in R_+ with the property that for any a and b one has either $a = qb$ or $a = qb + r$ with $f(r) < f(b)$. It seems that one cannot restrict to Euclidian domains in the recent situation.

2. Even when the factorization in the extension is not unique, one can hope that the product of various p-adic norms for the factors is same for all factorizations. Since the p-adic norm for the extensions of primes is induced by ordinary p-adic number this requires that the p-adic prime for which the induced p-adic norm differs from unity are same for all factorizations and that the products of p-adic norms differing from unity are same. This independence on the representative for factorization would be analogous to gauge invariance in physicist's conceptualization.

   The probabilities P_k belongs to a unique product of ideals labelled by primes of extension. The ideals are characterized by norms and if this norm is product of p-adic norms for any prime factorization as looks natural then the independence on the factorization follows. Number theorist can certainly immediately tell whether this is true. What is encouraging that for $Q(\sqrt{-5})$ $z = x + \sqrt{-5}y$ has determinant $det(z) = x^2 + 5y^2$ and for $z == 1 \pm \sqrt{-5}$ one has has $det(z) = 6$ so that for the products of p-adic norms for the factorizations $6 = 2 \times 3$ and $(1 + \sqrt{-5})(1 - \sqrt{-5})$ are equal.

3. If this this guess is true, one can write the the difference of total p-adic negentropy N and real entanglement entropy S as

$$N - S = \sum P_k log(\frac{P_k}{\prod_p N_p(P_k)}) \ . \tag{3.4.1}$$

   Here $\prod_p N_p(P_k)$ would not depend on particular factorization. The condition $\sum P_k = 1$ poses an additional condition. It would be nice to understand whether $N - S \geq 0$ holds true generally and if not, what are the conditions guaranteeing this. The p-adic numbers of numerators of rationals involved give positive contributions to $N - S$ as the example $P_k = 1/N$ in rational case shows.

   3. An ansatz for entanglement probabilities guaranteeing $N - S > 0$

   What about entanglement probabilities in algebraic extension of rationals? In this case real number based entanglement entropy is not maximal since entanglement probablities are different. What can one say about p-adic entanglement negentropies: are they still maximal under some reasonable conditions? The logarithms involved depend on p-adic norms of probabilities and this is in the generic case just inverse of the power of p. Number theoretical universality suggests that entanglement probabilities are of form

$$P_i = \frac{a_i}{N}$$

with $\sum_i a_i = N$ with algebraic numbers a_i not involving natural numbers and thus having unit p-adic norm.

With this assumption the p-adic norms of P_i reduce to those of $1/N$ as for maximal rational entanglement. If this is the case the p-adic negentropy equals to $log(p^k)$ if p^k divides N. The total adelic negentropy equals to $log(N)$ and is maximal and has the same value as for rational probabilities equal to $1/N$.

The real entanglement entropy is now in general however smaller than $log(N)$, which would mean that p-adic negentropy is larger than the real entropy as conjectured earlier [K59] (see `http://tinyurl.com/jozwqxk`). For *rational* entanglement probabilities the generation of entanglement negentropy - conscious information during evolution - would be accompanied by a generation of equal entanglement entropy measuring the ignorance about what the negentropically entangled states representing selves are.

This conforms with the observation of Jeremy England that living matter is entropy producer [L27] (see `http://tinyurl.com/jff33xk`). For algebraic extensions of rationals this entropy could be however smaller than the total negentropy. Second law follows as a shadow of NMP if the real entanglement entropy corresponds to the thermodynamical entropy. Algebraic evolution would allow to generate conscious information faster than the environment is polluted, one might concretize! The higher the dimension of the algebraic extension rationals, the larger the difference could be and the future of the Universe might be brighter than one might expect by just looking around! Very consolating! One should however show that the above described situation can be realized as NMP strongly suggests before opening a bottle of champaigne.

4. Cloning of maximally negentropic states is possible: DNA replication as cloning of this kind of states?

In Facebook discussion with Bruno Marchal and Stephen King the notion of quantum cloning as copying of quantum state popped up and I ended up to ask about approximate cloning and got a nice link about which more below. From Wikipedia article (see `http://tinyurl.com/oyvklde`) one learns some interesting facts cloning. No-cloning theorem states that the cloning of *all* states by unitary time evolution of the tensor product system is not possible. It is however possible clone *orthogonal basis of states*. Does this have some deep meaning?

As a response to my question I got a link to an article of Lamourex *et al* (see `http://tinyurl.com/zq4kgda`) showing that the *cloning of entanglement* - to be distinguished from the cloning of quantum state - is not possible in the general case. Separability - the absence of entanglement - is not preserved. Approximate cloning generates necessarily some entanglement in this case, and the authors give a lower bound for the remaining entanglement in case of an unentangled state pair.

The cloning of maximally entangled state is however possible. What makes this so interesting is that maximally negentropic entanglement for *rational* entanglement probabilities in TGD framework corresponds to maximal entanglement - entanglement probabilities form a matrix proportional to unit matrix- and just this entanglement is favored by Negentropy Maximization Principle. Could maximal entanglement be involved with say DNA replication? Could maximal negentropic entanglement for algebraic extensions of rationals allow cloning so that DNA entanglement negentropy could be larger than entanglement entropy?

The impossibility of cloning of entanglement in the general case makes impossible the transfer of information as any kind of entanglement. Maximal entanglement - and maybe be even negentropic entanglement maximal in p-adic sectors - could however make the communication without damaging the information at the source. Since conscious information is associated with p-adic sectors responsible for cognition, one could even allow the modification of the entanglement probabilities and thus of the real entanglement entropy in the communication process since the maximal p-adic negentropy depends only weakly on the entanglement probabilities.

NE is assigned with conscious experiences with positive emotional coloring: experience of understanding, experience of love, etc... There is an old finnish saying, which can be translated to "Shared joy is double joy!". Could the cloning of NE make possible generation of entanglement by loving attitude so that living entities would not be mere thieves trying to steal NE by killing and eating each other?

3.4.5 NMP And Quantum Computer Type Systems

In ZEO there are 3 basic matrices. U-matrix between zero energy states, M-matrices and defining entanglement coefficients between positive and negative energy states at opposite boundaries of CD. The mutually orthonormal M-matrices are assumed to be expressible as "square root" of a density matrix expressible as a product of a hermitian diagonal square root of density matrix and unitary S-matrix. Quantum theory can be see as a square root of thermodynamics in this framework.

The original mathematically attractive hypothesis that U-matrix has M-matrices as its rows turned out to be wrong. The physical picture about U-matrix as unitary matrix between states represented by M-matrices allowing also dispersion in the moduli space for the CDs with the passive boundary fixed leads with rather general assumptions to the identification of U-matrix as a representation for the unitary scalings of CDs [K61].

This is the original picture and every updating forces to challenge the earlier picture.

1. What about M-matrix? Can one really regard it as an orthonormal row of U or is M completely free? The defence for this assumption is that the orthonormality for hermitian square roots of density matrix is extremely powerful constraint. M-matrices could correspond to orthonormal basis of hermitian generators of some symmetry algebra. If symmetry algebra commutes with the S-matrix, the square roots of density matrices would be invariant under S-matrix. This assumption might be however physically unfeasible. Besides the hermitian basis one the degrees of freedom defined by the discrete moduli of CD with second (passive) boundary fixed would label M-matrices.

2. Weak form of NMP suggests that TGD Universe can be regarded as a quantum computer. CD as quantum computer is a local version of the same idea. Unitarity process U could relate closely to quantum computation. The state function reduction process represents a stepwise halting of the computation proceeding to shorter scales (sub-CDs) until the resulting states are either bound states or negentropically entangled states.

3. The question is whether it is U-matrix or M-matrix, which defines quantum computation. In other words, which kind of transitions do the repeated state functions leaving the passive boundary of CD and states at it invariant, correspond? It would seem that U-matrix is the correct identification since a repeated de-localization in the moduli space of CDs followed by a localization (but no reduction) is involved at the active boundary of CD. Note that the moduli of CD consist of discrete Lorentz boosts and proper time translations for CD. The argument of [K61] suggests that S-matrix reduces to a unitary representation for the scalings of CD by a power of S-matrix assignable to the CD with minimal size: $S(n) = S^n$, where n characterizes the size scale of CD as a temporal distance between its tips. This makes possible quantum computations.

4. In ZEO quantum computation can be associated with the sequence of repeated reductions at fixed boundary of CD defining self. NE would be realized in terms of an entanglement characterized by a multiple of unitary matrix for a two-body system at the passive boundary of CD and would be stable during computation. The computation would end with a state function reduction at opposite boundary giving the outcome of the process. It could be a state with higher entanglement negentropy but weak form of NMP allows also ordinary state function reduction. Strong form of NMP would make the halting of the quantum computation impossible. Bio-systems would be especially attractive candidates for performers of quantum computation like processes.

5. The action of U-matrix in this picture would be trivial at the passive boundary and affect only the moduli of the upper boundary and the M-matrices. U-matrix cannot be however the direct counterpart of the ordinary S-matrix since there is non-trivial action in the moduli space of CDs. The matrix elements of U-matrix are however expressible in terms of S-matrix and the orthonormal basis of hermitian square roots of density matrices.

It is useful to list the basic differences with respect to ordinary quantum computation. Ordinary quantum computation utilizes unitary evolution of quantum states in positive energy

ontology. In this case quantum coherence is extremely fragile. In TGD framework NMP and ZEO allow to circumvent this problem. The outcome of the computation is however realized at the level of dark matter unless ordinary state function reduction takes place. This means that n reductions from $2^n - 1$ correspond to computations, whose outcome can be verified with the existing technology. A further new element is that the computation is conscious and this aspect might be the important one in living matter.

How quantum computation in ZEO differs from ordinary quantum computation

Quantum computation in ZEO differs in several respects from ordinary quantum computation.

1. The time parameter defining quantum computation as a unitary time evolution in standard quantum physics disappears and corresponds to the U-matrix for single repeated reduction followed by a localization in moduli of the active boundary of CD (but no reduction at the active boundary). Large number of these steps occur. This process occurs for sub-CDs of given CD and the outcome of the quantum computation as seen by CD would be determined statistically from the distribution of the outcomes of state function reductions for over sub-CDs.

   One can assign to the quantum computation a duration equal to the increase of the proper time distance between the tips of CD. For instance, .1 seconds could be the time scale assignable to quantum computations possibly assignable to electrons.

   The hierarchies of CDs and Planck constants make possible zoomed up variants of quantum computations. This kind of zooming might be essential for intelligent behavior since it is useful to simulate dynamics of the external world in the time scales natural for brain and shorter than the time scale during which it is necessary to react in order to survive. The geometric duration of the shortest possible quantum computation is of order CP_2 time about 10^4 Planck times, if the simplest estimate is correct.

2. The classical space-time correlates for the quantum computation are four-dimensional unlike in the case of ordinary quantum computation. In living matter nerve pulses and EEG frequencies would be very natural correlates of this kind. The model for DNA as topological quantum computer [K2] has as its space-time correlates magnetic flux tubes connecting DNA nucleotides and lipids of nuclear and cell membranes defining the braiding coding for the topological quantum computation. Dynamical flow of lipids defines the braiding in time direction and the memory representation is in terms of the braiding of the flux tubes induced by this flow. A good metaphor is in terms of dancers connected to a wall by threads. Dancing is the correlate for the running quantum computer program and the geometric entanglement of threads the correlate for the storage of the program to computer memory.

3. The outcome of quantum computation is described statistically in terms of a large set of quantum computations. The statistical description of the conscious experience of ensemble of sub-selves implies that mathematically the situation is very much analogous with that encountered in the standard quantum computation and it is attractive to assume that conscious experience codes for the outcome of quantum computation via the average quantities assignable to the distribution of zero energy quantum states assignable to sub-CDs.

4. A further new element is macro-temporal quantum coherence involving several aspects. One of these aspects is that the time scale of CD defines macrotemporal quantum coherence at least at the level of the field body assignable to the physical system such as electron. It is not quite clear whether electrons correspond to distinct overlapping CDs of size scale defined by.1 second time scale and of the order of Earth circumference and thus satisfying the basic criterion of quantum coherence or whether one should speak about anyonic many particle states assignable to single CD or whether both interpretations can make sense depending on situation.

   In living matter also millisecond time scale is important and would correspond naturally to the CDs assignable to u and d quarks in nuclei and perhaps also with the ends of magnetic flux tubes in the model of DNA as topological quantum computer. In the proposed model quarks

and antiquarks at the ends of flux tubes represent genetic codons and their entanglement is responsible for the realization of the program at quantum level. The millisecond time scale of synchronous cortical firing and of nerve pulse could correspond to the time scale of CDs associated with u and d quarks at the ends of the flux tube. Note that larger value of $\hbar$ would scale up this time scale. Quantum parallel dissipation taking place at various size scales for CD is a further new element.

5. One must generalize the standard quantum computer paradigm since ordinary quantum computers represent only the lowest, 2-adic level of the p-adic intelligence. This suggests that qubits must be replaced by qupits since for algebraic entanglement two-state systems are naturally replaced with p-state systems. For primes of order say $p \simeq 2^{167}$ (the size of small bacterium) this means about 167 bits, which would mean gigantic quantum computational resources. The secondary p-adic time scale $T_2(127) \simeq .1$ seconds basic bit-like unit corresponds to $M_{127} = 2^{127}-1$ M_{127}-qupits making about 254 bits. The size of neuron corresponds to CD with time scale equal to the age of the universe and in this case the maximum the number of pinary digits is 171.

   The finite measurement resolution for qubits of course poses strong limitations to the actual number of bits since the negentropic zero energy qubits must be in reasonable approximation pure qubits distinguishable from each other and could correspond CDs with time scales coming as powers of two from $n = k_{min}$ to k so that the effective number of qubits would go like 2-based logarithm of the p-adic prime. For instance, electron could correspond to six bits assignable to genetic code plus parity bit corresponding to time scale range from 1 ms to 100 ms. In any case the idea about neuron as a classical bit might be completely wrong!

6. Spin glass degeneracy also provides the needed huge number of degrees of freedom making quantum computations very effective. These degrees of freedom are associated with the flux tubes -say magnetic flux tubes- and are essentially gravitational so that a connection with Penrose-Hameroff hypothesis suggests itself. The space-time sheets mediating gravitational interaction are predicted to have a huge gravitational Planck constant $\hbar_{gr} = GMm/v_0$, $v_0/c < 1$, particles at these space-time sheets are predicted to have huge Compton wavelengths and the plausible looking identification is in terms of dark energy [K97, K70]. This would make quantum computation like activities possible in super-astronomical time scales.

Negentropic quantum computations, fuzzy qubits, and quantum groups

1. The possibility of NE is certainly the basic distinction making in the intersection of real and p-adic worlds possible a conscious process at least analogous to a quantum computation and accompanied by a conscious understanding. What makes this possible is the fact that the negentropically entangled states of N basic states have permutation of the basis states as a symmetry. For instance, states for which bit 1 appears with almost unit probability gives by permutation a state for which bit 0 appears with almost unit probability. This suggests that the outcome of quantum computation is expressed in terms of almost bits with a small mixing implying that the outcome has interpretation both as a rule and as almost bit in the ordinary sense. The conscious quantum computation would utilize states with NE in time direction. Also the analogies of bound states for time-like entanglement are possible and might make possible the counterpart of ordinary quantum computation without the higher level conscious experience about rules defined by the entangled states.

2. NE for positive and negative energy parts of bits stable and pinary digits stable under NMP means that the logic is always fuzzy. I have proposed the mathematical description of this in terms of quantum spinors for which the components do not commute anymore implying that only the probability for either spin state is is an observable [K120]. This suggests that NE might be describable in terms of quantum spinors and that it would be the unavoidable fuzziness which would make possible the representation conscious rules. What is interesting that for quantum spinors the spectrum of the probabilities for given spin is universal and depends only on the integers characterizing the quantum phase $q = exp(i2\pi/n)$. An alternative interpretation is that fuzzy logic relates to a finite measurement resolution. These interpretation need not be in conflict with each other. Since quantum groups are

associated with anyonic systems, this suggests that negentropic quantum computations take place in anyonic systems assignable to phases with large value of $\hbar$. This encourages to consider the possibility that quantum phases define algebraic extensions of p-adic numbers.

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

3.4.6 Quantum Measurement And Quantum Computation In TGD Universe

It is interesting to test how the view about quantum computation must be modified in TGD Universe. There are considerable deviations from the standard view. Zero Energy Ontology (ZEO), weak form of NMP dictating the dynamics of state function reduction [K56], negentropic entanglement, and hierarchy of Planck constants [?] define the basic differences between TGD based and standard quantum measurement theory. TGD suggests also the importance of topological quantum computation (TQC) like processes with braids represented as magnetic flux tubes/strings along them.

The natural question is how NMP and Zero Energy Ontology (ZEO) could affect the existing view about TQC. The basic observation is that the phase transition to dark matter phase reduces dramatically the noise affecting quantum quits. This together with robustness of braiding as TQC program raises excellent hopes about TQC in TGD Universe. The restriction to negentropic space-like entanglement (NE) defined by a unitary matrix is something new but does not seem to have any fatal consequences as the study of Shor's algorithm shows.

NMP strongly suggests that when a pair of systems - the ends of braid - suffer state function reduction, the NE must be transferred somehow from the system. How? The model for quantum teleportation allows to identify a possible mechanism allowing to achieve this. This mechanism could be fundamental mechanism of information transfer also in living matter and phosphorylation could represent the transfer of NE according to this mechanism: the transfer of metabolic energy would be at deeper level transfer of negentropy.

NE defines an excellent candidate for an analog of error correcting code. If only the diagonal form of the unitary entanglement matrix carries information, the quantization of phases as roots of unity provides a scenario in which Nature itself would take care of error correction.

ZEO based quantum measurement theory

Consider first the quantum measurement theory based on ZEO.

1. Sub-system–complement pair defining larger system defines the counterpart for the pair observer-measured system in standard quantum measurement theory. In TGD framework density matrix for a sub-system–complement pair defines the universal observable. As a matter of fact, for a given system all sub-system-complement pairs defining possible splitting of this kind and the state function reduction is realized for the pair giving rise to maximum of maximal negentropy gain (NMP). A further essential assumption is that the reduction proceeds from a system inside CDE to subsystems as a cascade obeying this basic rule.

2. ZEO implies that state function reductions occur at either boundary of causal diamond (CD) - the active boundary. The sequence of reductions leaving passive boundary and state at it unaffected gives rise to a conscious entity - self. What is new that at the active boundary the state changes. Even the active boundary itself drifts to the geometric future so that the size of CD increases. This gives rise to the experience about flow of time.

This is the TGD counterpart for the unitary time evolution and its duration corresponds to the increases of the proper time distance between the tips of CD. Eventually NMP forces the first state function reduction to the opposite boundary: this corresponds to a genuine state

function reduction. The self dies and re-incarnates at the opposite boundary as time reversed self since CD increases after than at the opposite boundary to the direction of geometric past.

In the standard quantum models for quantum computation one assumes that measurement can be realized by some interaction Hamiltonian: the state of entangled system-observer pair develops to an eigen state of the interaction Hamiltonian. The time development by this interaction Hamiltonian gives entangled state defined by the density matrix. This description can be seen as an approximation to TGD based description in which one can assign definite duration to the analog of the unitary evolution.

3. Negentropic entanglement (NE) is possible for entanglement coefficients in algebraic extension of rationals since in this case number theoretic entropy having negative values is well-defined. If the density matrix does not belong to the same algebraic extension, state function reduction requires a phase transition extending the algebraic extension of rationals used and could be seen as kind of evolutionary jump. This kind of NE could be therefore rather stable and could be interpreted as a kind of cognitive entanglement representing a rule with instances represented as state pairs in the superposition. If the state function reduction occurs it leads to a ray of state space if density matrix is non-degenerate.

   If the density matrix contains as a direct summand a higher-dimensional projector, a reduction giving rise to a projector to this sub-space is allowed by the interpretation as measurement of density matrix producing its eigen space. The state remains negentropically entangled by the unitary matrix giving rise to the projector. Weak form of NMP [K56] however allows reductions also to the subspaces of this sub-space assuming preferred state basis so that also the reduction to a ray of state space is possible as a special case. In this case any state basis is eigenbasis for the sub-space and this suggests an interpretation in terms of meditative states in which distinctions disappear.

TQC in TGD

How could (topological) quantum computation be realized in TGD framework?

1. In standard quantum theory unitary time evolution realizes the quantum computation. Unitary time evolution is engineered in terms of gates performing standardized operations for qubits. For TQC braiding defines the space-time entanglement between the systems A and B at the ends of the braid. Call this system $A \otimes B$. One can speak about evolution a kind of "space-like" topological quantum computer program with negentropically entangled "initial" and "final" states at the ends of the braid. Basic braiding operation defines the basic gate in terms of so called R-matrix and the desired NE can be build using an appropriate braiding. For the sake of concreteness the following considerations assume TQC. In fact, if there is entanglement between ends, it must be unitary entanglement since only this entanglement is respected by NMP.

2. In TQC the program is defined by braid and is robust against perturbations. The quantum states at the ends of the braid are however sensitive to noise and this requires complex error correction procedures to eliminate the errors, which are basically spin flip changing the value of qubit and change of its phase. If only phase ± 1 is allowed phase change actually reduces to spin flip in suitable basis.

   In standard quantum computation the small value of Planck constant is the basic problem. Coherence times tend to be very short and the control of external noise is a tough challenge. In TGD quantum criticality gives rise to phases of matter with effective value $h_{eff} = n \times h$ of Planck constant identified as dark matter. These phases are involved also with NE. Only systems with same value of $h_{eff} = n \times h$ have direct interactions with each other. This should dramatically reduce the noise since visible matter particle must transform to dark matter particle to interact directly with dark matter to produce noise. Also the scaling up of interaction time scales gives hopes that quantum coherence times are long enough to perform TQC.

3. The value of h_{eff} is expected to correlate with the duration of self defined as the increase ΔT of the temporal distance during the sequence of state function reductions to the same

passive boundary of CD. ΔT could be interpreted as quantum coherence time. Coherence time for classical fields could be identified as the temporal distance between the tips of CD increasing during quantum computation.

4. TGD promises to guarantee the reduction of noise in terms of darkness of the particles involved with the computation: this instability is the weakness of TQC although TQC program itself is robust. TGD also promises the understanding of the role of quantum criticality in quantum measurement. The very fact that quantum measurements necessarily involve the amplification of small quantum effects to macroscopic "classical" effect, indeed strongly suggests quantum criticality.

5. The key challenge is to prepare a desired kind of negentropically entangled state - say a dark many-particle state associated with a braid system. One should be able to manipulate of dark matter, which we are not yet able to even detect! That dark matter appears at quantum criticality could be extremely helpful in the attempts to get grasp on the dark matter. A simple clue is that the disappearance of visible matter could serve as a signature for the emergence of dark matter.

One should somehow be able to perform state function reduction of the negentropically entangled system to one of the eigenstates of the density matrix associated with an entanglement matrix proportional to a unitary matrix (in the following I will speak of unitary entanglement). This requires TGD counter part of time evolution. One can imagine two options.

1. One can couple the negentropically entangled system pair AB to a measurement apparatus C, whose function is to develop ordinary entanglement with both systems during the repeated sequence of state function reductions at fixed boundary. In the state function reduction to the opposite boundary a time reversed reduced state results and gives rise to rays of state space for both A and B. One can however argue that the situation cannot be so simple: NMP requires that entanglement negentropy increases so that NE should be transferred somewhere. This will be discussed below.

2. The measurement interaction must be able to achieve ordinary state function reduction by generating entanglement with the system formed by negentropically entangled system. One must have interaction between ordinary and dark matter and this requires transformation of ordinary matter to dark matter with the same value of h_{eff}. Quantum criticality allows the transformation of ordinary matter to dark matter so that the measuring system should be quantum critical [?].

3. Could one do without a third system? Weak form of NMP allows also a reduction to the lower dimensional sub-spaces of the N-D sub-space considered and also 1-D ray is possible. This process corresponds to a duration of single self, which dies when the first reduction to the opposite boundary of its CD occurs. If the braid system is not changed in the state function to the opposite boundary one can hope that a reduction to a 1-D ray can occur with some probability. By waiting long enough one can obtain state function reductions which determine the probabilities for the reduction to a given ray or sub-space. The important difference to the standard picture would be that the system does it itself. No external measurements at the end of braid would be carried out. This is however too good to be true. Only one of the two quantum measurements required by Shor algorithm can be both carried out in his manner.

The interpretation in terms of consciousness theory allows also to consider the possibility that the measurement corresponds at deeper level to transfer of negentropic entanglement.

1. One has besides AB also the third system C. The NE for AB is transferred to NE for AC and can be transferred further - say to entanglement to NE for CD. In TGD framework the iteration of this process makes possible a transfer of conscious information associated with NE for AB to that of conscious observer.

2. If the state of C is eigenstate of spin in the basis used, the final state of B is also an eigenstate of spin. Hence the transfer of NE could be thus interpreted as a measurement of the state of B or as the measurement of state of AC in Bell basis. This conforms with the fact that state function reduction for a subsystem can be interpreted as a state function reduction for its complement. Could the deeper interpretation of quantum measurement be as a transfer of NE so that essentially quantum information theory would be in question.

3. The measurement is performed for the negentropically entangled Bell states for the pair AC and performs the transfer of entanglement inducing a unitary rotation. Since in the case of NE defined by a unitary matrix any state basis is allowed, one could ask whether the outcomes are equivalent from the point of view of consciousness theory at least. The knowledge of the final state of B allows to deduce the unitary rotation needed to rotate AC state to the original AB state so that this information is enough to realize a faithful NE transfer. Since the conscious experience is dictated both by the bit telling the state of B and by the state of AC one can ask whether the conscious experience and is same for all four outcomes.

Where and how the NE could be transferred?

NMP demands that entanglement negentropy increases. An interesting question is, where and how the entanglement negentropy is transferred.

1. Does NE correspond to information transferred to the performer of quantum measurement? If so, the quantum measurement process would be basically transfer of information realized as NE. Living systems would be carrying out this all the time and ATP-ADP transformation defining the basic step of energy metabolism would be just this kind of transfer. The transfer corresponds at the level of space-time geometry the transfer of the end of magnetic flux tubes plus particles from a donor to the acceptor.

2. A possible manner to carry out the transfer of negentropic entanglement is inspired by the quantum teleportation protocol (`http://tinyurl.com/omfkydh`). In the simplest situation this protocol is as follows. Alice wants to send qubit C to Bob. A Bell state (`http://tinyurl.com/z9g8rar`) is shared between Alice and Bob by mutual agreement in advance so that both know it. Alice can achieve the teleportation by a quantum measurement in the tensor product of the qubit C with the AB Bell state.

   Alice reduces the system AC to one of the four Bell states and communicates the result classically to Bob. The factored out state of B is the original state or one of three states related to it by unitary rotation. Alice sends classically two bits telling what the measurement outcome was. If the outcome was the original state to be sent, Bob does nothing. If it was one of the three remaining states, Bob performs a unitary rotation giving as a result the original state.

3. What makes this protocol so interesting is that in the reduction the NE for AB is transferred to NE for AC as such or modified by a unitary rotation so that four different outcomes are possible. Since the states of C and AB are in 1-1-correspondence it is indeed obvious that the information about the state of B resulting from the measurement of Alice allows the rotation of the Bell state AC to the original state AB. For instance, if the state of B is the original state of C, the state is the original state AB.

   One can apply this procedure by introducing four system D - call it Doris - so that AC NE is transferred to CD NE and AB is now product state. This kind of transfer of negentropic entanglement might be a key event in in phosphorylation and in the utilization of metabolic energy coming from nutrients. The NE between phosphate P of ATP ==B and third system A would be transferred to NE between acceptor molecule and C and A. Also the NE between nutrient B and third system A could bnd third system A could be transferred to NE between phosphate and A.

Shor's algorithm from TGD point of view

Is the unitary of the entanglement matrix guaranteeing NE too strong an assumption? Just for fun I m (`http://tinyurl.com/ppxvcsd`) for the factorization of a given integer, call it N, which has been shown to work for $N = 15$. It turns out that unitary entanglement is not a problem. Furthermore, ordinary quantum measurements are needed for the two systems involved and require interaction coupling negentropically entangled pair of systems to external world so that both negentropically entangled systems generate entanglement with external world.

Consider now the Shor's algorithm. The genuinely quantal step of algorithm is that of finding the period r of the function $f(x) = a^x \mod N$, for integers $1 < a < N$ and $1 < x < N$.

1. According to the Wikipedia article , the computation involves the construction of quantum function $f(x) = a^x$ as

$$\frac{1}{Q} \sum_x |x, f(x)\rangle \ .$$

   Here Q is normalization factor. Since $a^r = 1 \mod N$, $f(x)$ is not a bijection. Unless r divides Q (we do not however know r!), the number $N(z)$ of values of x satisfying $f(x) = z$ varies and the variation is one unit at most. Therefore the entanglement is not unitary and the density matrix of the state is not unit matrix since the norms of states

$$|Z| = \sum_x |x, f(x) = z\rangle$$

   is given by $N(z)$- the number of x mapped to z and varies somewhat. NE would be obtained by normalizing the states $|Z\rangle$ to unit norm and replacing Q by the the number $N(Z)$ of points z to get

$$\frac{1}{\sqrt{N(Z)}} \sum_z \frac{1}{\sqrt{N(z)}} \sum_x |x, f(x) = z\rangle \ .$$

2. Second step in the computation is discrete quantum Fourier transform using as counterparts of plane waves powers of the root of unity defined as $\omega = exp(i2\pi/Q)$, where Q satisfies $N^2 \leq Q < 2N^2$. This operation is unitary and gives rise to entanglement matrix proportional to a unitary matrix. Since the entire entanglement matrix is product of unitary matrices, it is also unitary. The action of unitary transformation is given for given value of z by the following formula.

$$\sum_x |x, f(x) = z)\rangle \rightarrow \sqrt{1}\sqrt{N} \sum_y \sum_{z=f(x)} \omega^{xy} |y, z = f(x)\rangle \ .$$

   The entire state is transformed to

$$\frac{1}{\sqrt{N(Z)}} \frac{1}{\sqrt{N}} \sum_z \frac{1}{\sqrt{N(z)}} \sum_y \omega^{xy} \sum_x |y, z = f(x)\rangle \ .$$

   In this expression the state paired $|Z\rangle$ is a superposition of several values of y since the number of different values of z is smaller than those of y by a factor which in ideal situation is the sought four value of r.

3. Quantum measurement should reduce this state to a state with fixed values of y and z. This implies that the normalization factors do not matter. Weak NMP allows a self-reduction a state Z with fixed value of z. The self reduction of the system is however not able to reduce the state Z to $|y, z\rangle$.

   One must couple at least the "y" part of the system to external measurement apparatus generating ordinary or negentropic entanglement with non-degenerate density matrix belonging

to the extension used and having $|y\rangle$ as eigenstates. This would force y-reduction. One can of course perform the same for both y and z. The ordinary quantum measurement theory seems to be a necessary part of the picture. In TGD framework additional constraints come from the condition that the measurement involves negentropy transfer. This requires explicit introduce of systems C and D receiving the NE.

About negentropic entanglement as an analog of error correction code

In classical computation, the simplest manner to control errors is to take several copies of the bit sequences. In quantum case no-cloning theorem prevents this. Error correcting codes (`http://tinyurl.com/oq7hl37`) code n information qubits to the entanglement of $N > n$ physical qubits. Additional contraints represents the subspace of n-qubits as a lower-dimensional sub-space of N qubits. This redundant representation is analogous to the use of parity bits. The failure of the constraint to be satisfied tells that the error is present and also the character of error. This makes possible the automatic correction of the error is simple enough - such as the change of the phase of spin state or or spin flip.

Negentropic entanglement (NE) obviously gives rise to a strong reduction in the number of states of tensor product. Consider a system consisting of two entangled systems consisting of N_1 and N_2 spins. Without any constraints the number of states in state basis is $2^{N_1} \times 2^{N_2}$ and one as $N_1 + N_2$ qubits. The elements of entanglement matrix can be written as $E_{A,B}$ $A \equiv \otimes_{i=1}^{N_1}(m_i, s_i)$, $B \equiv \otimes_{k=1}^{N_2}(m_k, s_k)$ in order to make manifest the tensor product structure. For simplicity one can consider the situation $N_1 = N_2 = N$.

The un-normalized general entanglement matrix is parametrized by 2×2^{2N} independent real numbers with each spin contributing two degrees of freedom. Entanglement matrix proportional to a unitary matrix is characterized by 2^{2N} real numbers. One might perhaps say that one has $2N$ real bits instead of almost $2N + 1$ real qubits. If the time evolution according to ZEO respects the negentropic character of entanglement, the sources of errors are reduced dramatically.

The challenge is to understand what kind of errors NE eliminates and how the information bits are coded by it. NE is respected if the errors act as unitary transformations $E \to UEU^\dagger$ of the entanglement matrix unitary apart from a normalization factor. One can consider two interpretations.

1. The unitary automorphisms leave information content unaffected only if they commute with E. In this case unitary automorphisms acting non-trivially would give rise genuine errors and an error correction mechanism would be needed and would be coded to quantum computer program.

2. One can also consider the possibility that the unitary automorphisms *do not affect* the information content so that the diagonal form of entanglement matrix coded by N phases would carry of information. Clearly, the unitary automorphisms would act like gauge transformations. Nature would take care that no errors emerge. Of course, more dramatic things are in principle allowed by NMP: for instance, the entanglement matrix proportional to unitary matrix could reduce to a tensor product of several unitary matrices. Negentropy could be transferred from the system and is indeed transferred as the computation halts.

   By number theoretic universality the diagonalized entanglement matrix would be parametrized by N roots of unity with each having n possible values so that n^N different NEs would be obtained and information storage capacity would be $I = log(n)/log(2) \times N$ bits for $n = 2^k$ one would have $k \times N$ bits. Powers of two for n are favored. Clearly the option for which only the eigenvalues of E matter, looks more attractive realization of entanglement matrices. If overall phase of E does not matter as one expects, the number of full bits is $k \times N - 1$. This option looks more attractive realization of entanglement matrices.

   In fact, Fermat polygons for which cosine and sine for the angle defining the polygon are expressible by iterating square root besides basic arithmetic operations for rationals (ruler and compass construction geometrically) correspond to integers, which are products of a power of two and of different Fermat primes $F_n = 2^{2^n} + 1$. l

This picture can be related to much bigger picture.

1. In TGD framework number theoretical universality requires discretization in terms of algebraic extension of rationals. This is not performed at space-time level but for the parameters characterizing space-time surfaces at the level of WCW. Strong form of holography is also essential and allows to consider partonic 2-surfaces and string world sheets as basic objects. Number theoretical universality (adelic physics) forces a discretization of phases and number theoretically allowed phases are roots of unity defined by some algebraic extension of rationals. Discretization can be also interpreted in terms of finite measurement resolution. Notice that the condition that roots of unity are in question realizes finite measurement resolution in the sense that errors have minimum size and are thus detectable.

2. Hierarchy of quantum criticalities corresponds to a fractal inclusion hierarchy of isomorphic sub-algebras of the super-symplectic algebra acting as conformal gauge symmetries. The generators in the complement of this algebra can act as dynamical symmetries affecting the physical states. Infinite hierarchy of gauge symmetry breakings is the outcome and the weakening of measurement resolution would correspond to the reduction in the size of the broken gauge group. The hierarchy of quantum criticalities is accompanied by the hierarchy of measurement resolutions and hierarchy of effective Planck constants $h_{eff} = n \times h$.

3. These hierarchies are argued to correspond to the hierarchy of inclusions for hyperfinite factors of type II$_1$ labelled by quantum phases and quantum groups. Inclusion defines finite measurement resolution since included sub-algebra does induce observable effects on the state. By Mac-Kay correspondence the hierarchy of inclusions is accompanied by a hierarchy of simply laced Lie groups which get bigger as one climbs up in the hierarchy. There interpretation as genuine gauge groups does make sense since their sizes should be reduced. An attractive possibility is that these groups are factor groups G/H such that the normal subgroup H (necessarily so) is the gauge group and indeed gets smaller and G/H is the dynamical group identifiable as simply laced group which gets bigger. This would require that both G and H are infinite-dimensional groups. An interesting question is how they relate to the super-symplectic group assignable to "light-cone boundary" $\delta M_{\pm}^4 \times CP_2$. I have proposed this interpretation in the context of WCW geometry earlier.

4. Here I have spoken only about dynamical symmetries defined by discrete subgroups of simply laced groups. I have earlier considered the possibility that discrete symmetries provide a description of finite resolution, which would be equivalent with quantum group description.

Summarizing, these arguments boil down to the conjecture that discrete subgroups of these groups act as effective symmetry groups of entanglement matrices and realize finite quantum measurement resolution. A very deep connection between quantum information theory and these hierarchies would exist.

Gauge invariance has turned out to be a fundamental symmetry principle, and one can ask whether entanglement matrices proportional to unitary matrices assuming that only the eigenvalues matter, could give rise to a simulation of discrete gauge theories. The reduction of the information to that provided by the diagonal form be interpreted as an analog of gauge invariance?

1. The hierarchy of inclusions of hyper-finite factors of type II$_1$ suggests strongly a hierarchy of effective gauge invariances characterizing measurement resolution realized in terms of hierarchy of normal subgroups and dynamical symmetries realized as coset groups G/H. Could these effective gauge symmetries allow to realize entanglement matrices proportional to unitary matrics invariant under these symmetries?

2. A natural parametrization for single qubit errors is as rotations of qubit. If the error acts as a rotation on *all* qubits, the rotational invariance of the entanglement matrix defining the analog of S-matrix is enough to eliminate the effect on information processing.

   Quaternionic unitary transformations act on qubits as unitary rotations. Could one assume that complex numbers as the coefficient field of QM is effectively replaced with quaternions? If so, the multiplication by unit quaternion for states would leave the physics and information content invariant just like the multiplication by a complex phase leaves it invariant in the standard quantum theory.

One could consider the possibility that quaternions act as a discretized version of local gauge symmetry affecting the information qubits and thus reducing further their number and thus also errors. This requires the introduction of the analog of gauge potential and coding of quantum information in terms of SU(2) gauge invariants. In discrete situation gauge potential would be replaced with a non-integrable phase factors along the links of a lattice in lattice gauge theory. In TGD framework the links would correspond the fermionic strings connecting partonic two-surfaces carrying the fundamental fermions at string ends as point like particles. Fermionic entanglement is indeed between the ends of these strings.

3. Since entanglement is multilocal and quantum groups accompany the inclusion, one cannot avoid the question whether Yangian symmetry crucial for the formulation of quantum TGD [K110] could be involved.

3.5   p-Adic physics and consciousness

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

3.5.1   From quantum measurement theory to a theory of consciousness

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

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

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

1. Self corresponds to a sequence of quantum jumps integrating to single unit as in the original proposal, but these quantum jumps correspond to state function reductions to a fixed boundary of causal diamond CD leaving the corresponding parts of zero energy states invariant - "small" state function reductions. The parts of zero energy states at second boundary of CD change and even the position of the tip of the opposite boundary changes: one actually has wave function over positions of second boundary (CD sizes roughly) and this wave function changes. In positive energy ontology these repeated state function reductions would have no effect on the state (Zeno effect) but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and self: self is generalized Zeno effect.

2. The first quantum jump to the opposite boundary corresponds to the act of "free will" or birth of re-incarnated self. Hence the act of "free will" changes the arrow of psychological time at some level of hierarchy of CDs. The first reduction to the opposite boundary of CD means "death" of self and "re-incarnation" of time-reversed self at opposite boundary at which the the temporal distance between the tips of CD increases in opposite direction. The sequence of selves and time reversed selves is analogous to a cosmic expansion for CD. The repeated birth and death of mental images could correspond to this sequence at the level of sub-selves.

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

One can identify several rather abstract state function reductions selecting a sector of WCW.

1. There are quantum measurements inducing localization in the moduli space of CDs with passive boundary and states at it fixed. In particular, a localization in the moduli characterizing the Lorentz transform of the upper tip of CD would be measured. The measured moduli characterize also the analog of symplectic form in M^4 strongly suggested by twistor lift of TGD - that is the rest system (time axis) and spin quantization axes. Of course, also other kinds of reductions are possible.

2. Also a localization to an extension of rationals defining the adeles should occur. Could the value of $n = h_{eff}/h$ be observable? The value of n for given space-time surface at the active boundary of CD could be identified as the order of the smallest Galois group containing all Galois groups assignable to 3-surfaces at the boundary. The superposition of space-time surface would not be eigenstate of n at active boundary unless localization occurs. It is not obvious whether this is consistent with a fixe value of n at passive boundary.

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

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

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

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

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

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

2. Can one assume that a mere localization in the moduli space or for the extension of rationals (producing an eigenstate of n) takes place for a fixed CD - a kind of self measurement possible for even unentangled system? If there is entanglement in these degrees of freedom between two systems (say CDs), it would be reduced in these self measurements but the outcome would not be an eigenstate of density matrix. An interpretation as a realization of intention would be approriate.

3. If one allows both options, the interpretation would be that state function reduction as a measurement of density matrix is only a reaction to environment and self-measurement represents a realization of intention.

4. Self measurements would occur at higher level say as a selection of quantization axis, localization in the moduli space of CD, or selection of extension of rationals. A possible general rule is that measurements at space-time level are reactions as measurements of density matrix whereas a selection of a sector of WCW would be an intentional action. This because formally the quantum states at the level of WCW are as modes of classical WCW spinor field single particle states.

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

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

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

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

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

1. Self experiences its sub-selves as mental images and even we would represent mental images of some higher level collective self. Everything is conscious but consciousness can be lost or at least it is not possible to have memory about it. The flow of consciousness for a given self could be due to the quantum jump sequences performed by its sub-selves giving rise to mental images.

2. By quantum classical correspondence self has also space-time correlates. One can visualize sub-self as a space-time sheet "glued" by topological sum to the space-time sheet of self. Subsystem is not described as a tensor factor as in the standard description of subsystems. Also sub-selves of selves can entangle negentropically and this gives rise to a sharing of mental images about which stereo vision would be basic example. Quite generally, one could speak of stereo consciousness. Also the experiences of sensed presence [J122] could be understood as a sharing of mental images between brain hemispheres, which are not themselves entangled. This is possible also between different brains. In the normal situation brain hemispheres are entangled.

3. At the level of 8-dimensional embedding space the natural correlate of self would be CD (causal diamond). At the level of space-time the correlate would be space-time sheet or light-like 3-surface. The contents of consciousness of self would be determined by the space-time sheets in the interior of CD. Without further restrictions the experience of self would be essentially four-dimensional. Memories would be like sensory experiences except that they would be about the geometric past and for some reason are not usually colored by

sensory qualia. For instance .1 second time scale defining sensory chronon corresponds to the secondary p-adic time scale characterizing the size of electron's CD (Mersenne prime M_{127}), which suggests that Cooper pairs of electrons are essential for the sensory qualia.

3.5.2 NMP and self

The view about Negentropy Maximization Principle (NMP) [K56] has co-evolved with the notion of self and I have considered many variants of NMP.

1. The original formulation of NMP was in positive energy ontology and made same predictions as standard quantum measurement theory. The new element was that the density matrix of sub-system defines the fundamental observable and the system goes to its eigenstate in state function reduction. As found, the localizations at to WCW sectors define what might be called self-measurements and identifiable as active volitions rather than reactions.

2. In p-adic physics one can assign with rational and even algebraic entanglement probabilities number theoretical entanglement negentropy (NEN) satisfying the same basic axioms as the ordinary Shannon entropy but having negative values and therefore having interpretation as information. The definition of p-adic negentropy (real valued) reads as $S_p = -\sum P_k log(|P_k|_p)$, where $|.|_p$ denotes p-adic norm. The news is that $N_p = -S_p$ can be positive and is positive for rational entanglement probabilities. Real entanglement entropy S is always non-negative.

   NMP would force the generation of negentropic entanglement (NE) and stabilize it. NNE resources of the Universe - one might call them Akashic records- would steadily increase.

3. A decisive step of progress was the realization is that NTU forces all states in adelic physics to have entanglement coefficients in some extension of rationals inducing finite-D extension of p-adic numbers. The same entanglement can be characterized by real entropy S and p-adic negentropies N_p, which can be positive. One can define also total p-adic negentropy: $N = \sum_p N_p$ for all p and total negentropy $N_{tot} = N - S$.

   For rational entanglement probabilities it is easy to demonstrate that the generalization of adelic theorem holds true: $N_{tot} = N - S = 0$. NMP based on N_{tot} rather than N would not say anything about rational entanglement. For extensions of rationals it is easy to find that $N - S > 0$ is possible if entanglement probabilities are of form X_i/n with $|X_i|_p = 1$ and n integer [L27]. Should one identify the total negentropy as difference $N_{tot} = N - S$ or as $N_{tot} = N$?

   Irrespective of answer, large p-adic negentropy seems to force large real entropy: this nicely correlates with the paradoxical finding that living systems tend to be entropic although one would expect just the oppositecite [L27]: this relates in very interesting manner to the work of biologists Jeremy England [I61]. The negentropy would be cognitive negentropy and not visible for ordinary physics.

4. The latest step in the evolution of ideas NMP was the question whether NMP follows from number theory alone just as second law follows form probability theory! This irritates theoretician's ego but is victory for theory. The dimension n of extension is positive integer and cannot but grow in statistical sense in evolution! Since one expects that the maximal value of negentropy (define as $N - S$) must increase with n. Negentropy must increase in long run.

Number theoretic entanglement can be stable

Number theoretical Shannon entropy can serve as a measure for genuine information assignable to a pair of entanglement systems [K56]. Entanglement with coefficients in the extension is always negentropic if entanglement negentropy comes from p-adic sectors only. It can be negentropic if negentropy is defined as the difference of p-adic negentropy and real entropy.

The diagonalized density matrix need not belong to the algebraic extension since the probabilities defining its diagonal elements are eigenvalues of the density matrix as roots of N:th order polynomial, which in the generic case requires n-dimensional algebraic extension of rationals. One

can argue that since diagonalization is not possible, also state function reduction selecting one of the eigenstates is impossible unless a phase transition increasing the dimension of algebraic extension used occurs simultaneously. This kind of NE could give rise to cognitive entanglement.

There is also a special kind of NE, which can result if one requires that density matrix serves a universal observable in state function reduction. The outcome of reduction must be an eigen space of density matrix, which is projector to this subspace acting as identity matrix inside it. This kind NE allows all unitarily related basis as eigenstate basis (unitary transformations must belong to the algebraic extension). This kind of NE could serve as a correlate for "enlightened" states of consciousness. Schrödingers cat is in this kind of state stably in superposition of dead and alive and state basis obtained by unitary rotation from this basis is equally good. One can say that there are no discriminations in this state, and this is what is claimed about "enlightened" states too.

The vision about number theoretical evolution suggests that NMP forces the generation of NE resources as NE assignable to the "passive" boundary of CD for which no changes occur during sequence of state function reductions defining self. It would define the unchanging self as negentropy resources, which could be regarded as kind of Akashic records. During the next "re-incarnation" after the first reduction to opposite boundary of CD the NE associated with the reduced state would serve as new Akashic records for the time reversed self. If NMP reduces to the statistical increase of $h_{eff}/h = n$ the consciousness information contents of the Universe increases in statistical sense. In the best possible world of SNMP it would increase steadily.

Does NMP reduce to number theory?

The heretic question that emerged quite recently is whether NMP is actually needed at all! Is NMP a separate principle or could NMP reduced to mere number theory [K56]? Consider first the possibility that NMP is not needed at all as a separate principle.

1. The value of $h_{eff}/h = n$ should increase in the evolution by the phase transitions increasing the dimension of the extension of rationals. $h_{eff}/h = n$ has been identified as the number of sheets of some kind of covering space. The Galois group of extension acts on number theoretic discretizations of the monadic surface and the orbit defines a covering space. Suppose n is the number of sheets of this covering and thus the dimension of the Galois group for the extension of rationals or factor of it.

2. It has been already noticed that the "big" state function reductions giving rise to death and reincarnation of self could correspond to a measurement of $n = h_{eff}$ implied by the measurement of the extension of the rationals defining the adeles. The statistical increase of n follows automatically and implies statistical increase of maximal entanglement negentropy. Entanglement negentropy increases in statistical sense.

   The resulting world would not be the best possible one unlike for a strong form of NMP demanding that negentropy does increaes in "big" state function reductions. n also decrease temporarily and they seem to be needed. In TGD inspired model of bio-catalysis the phase transition reducing the value of n for the magnetic flux tubes connecting reacting bio-molecules allows them to find each other in the molecular soup. This would be crucial for understanding processes like DNA replication and transcription.

3. State function reduction corresponding to the measurement of density matrix could occur to an eigenstate/eigenspace of density matrix only if the corresponding eigenvalue and eigenstate/eigenspace is expressible using numbers in the extension of rationals defining the adele considered. In the generic case these numbers belong to N-dimensional extension of the original extension. This can make the entanglement stable with respect to state the measurements of density matrix.

   A phase transition to an extension of an extension containing these coefficients would be required to make possible reduction. A step in number theoretic evolution would occur. Also an entanglement of measured state pairs with those of measuring system in containing the extension of extension would make possible the reduction. Negentropy could be reduced but higher-D extension would provide potential for more negentropic entanglement and NMP would hold true in the statistical sense.

4. If one has higher-D eigen space of density matrix, p-adic negentropy is largest for the entire subspace and the sum of real and p-adic negentropies vanishes for all of them. For negentropy identified as total p-adic negentropy SNMP would select the entire sub-space and NMP would indeed say something explicit about negentropy.

Or is NMP needed as a separate principle?

Hitherto I have postulated NMP as a separate principle [K56]. Strong form of NMP (SNMP) states that Negentropy does not decrease in "big" state function reductions corresponding to death and re-incarnations of self.

One can however argue that SNMP is not realistic. SNMP would force the Universe to be the best possible one, and this does not seem to be the case. Also ethically responsible free will would be very restricted since self would be forced always to do the best deed that is increase maximally the negentropy serving as information resources of the Universe. Giving up separate NMP altogether would allow to have also "Good" and "Evil".

This forces to consider what I christened weak form of NMP (WNMP). Instead of maximal dimension corresponding to N-dimensional projector self can choose also lower-dimensional sub-spaces and 1-D sub-space corresponds to the vanishing entanglement and negentropy assumed in standard quantum measurement theory. As a matter fact, this can also lead to larger negentropy gain since negentropy depends strongly on what is the large power of p in the dimension of the resulting eigen sub-space of density matrix. This could apply also to the purely number theoretical reduction of NMP.

WNMP suggests how to understand the notions of Good and Evil. Various choices in the state function reduction would correspond to Boolean algebra, which suggests an interpretation in terms of what might be called emotional intelligence [K116]. Also it turns out that one can understand how p-adic length scale hypothesis - actually its generalization - emerges from WNMP [K119].

1. One can start from ordinary quantum entanglement. It corresponds to a superposition of pairs of states. Second state corresponds to the internal state of the self and second state to a state of external world or biological body of self. In negentropic quantum entanglement each is replaced with a pair of sub-spaces of state spaces of self and external world. The dimension of the sub-space depends on which pair is in question. In state function reduction one of these pairs is selected and deed is done. How to make some of these deeds good and some bad? Recall that WNMP allows only the possibility to generate NNE but does not force it. WNMP would be like God allowing the possibility to do good but not forcing good deeds.

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

   For the maximal dimension of this sub-space the negentropy gain is maximal. This deed would be good and by the proposed criterion NE corresponds to conscious experience with positive emotional coloring. Interestingly, there are $2^k - 1$ possible choices, which is almost the dimension of Boolean algebra consisting of k independent bits. The excluded option corresponds to 0-dimensional sub-space - empty set in set theoretic realization of Boolean algebra. This could relate directly to fermionic oscillator operators defining basis of Boolean algebra - here Fock vacuum would be the excluded state. The deed in this sense would be a choice of how loving the attention towards system of external world is.

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

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

The cautious conclusion is that NMP as a separate principle is not necessary and follows in statistical sense from the unavoidable increase of $n = h_{eff}/h$ identified as dimension of extension of rationals define the adeles if this extension or at least the dimension of its Galois group is observable.

3.5.3   p-Adic physics as correlate of cognition and imagination

The items in the following list give motivations for the proposal that p-adic physics could serve as a correlate for cognition and imagination.

1. By the total disconnectedness of the p-adic topology, p-adic world decomposes naturally into blobs, objects. This happens also in sensory perception. The pinary digits of p-adic number can be assigned to a p-tree. Parisi proposed in the model of spin glass [B15] that p-adic numbers could relate to the mathematical description of cognition and also Khrennikov [J32] has developed this idea. In TGD framework that idea is taken to space-time level: p-adic space-time sheets represent thought bubbles and they correlate with the real ones since they form cognitive reprentations of the real world. SH allows a concrete realization of this.

2. p-Adic non-determinism due to p-adic pseudo constants suggests interpretation in terms of imagination. Given 2-surfaces could allow completion to p-adic preferred extremal but not to a real one so that pure "non-realizable" imagination is in question.

3. Number theoretic negentropy has interpretation as negentropy characterizing information content of entanglement. The superposition of state pairs could be interpreted as a quantum representation for a rule or abstracted association containing its instances as state pairs. Number theoretical negentropy characterizes the relationship of two systems and should not be confused with thermodynamical entropy, which characterizes the uncertainty about the state of single system.

The original vision was that p-adic non-determinism could serve as a correlate for cognition, imagination, and intention. The recent view is much more cautious. Imagination need not completely reduce to p-adic non-determinism since it has also real physics correlates - maybe as partial realizations of SH as in nerve pulse pattern, which does not propagate down to muscles.

A possible interpretation for the solutions of the p-adic field equations would be as geometric correlates of cognition, imagination, and perhaps even intentionality. Plans, intentions, expectations, dreams, and possibly also cognition as imagination in general could have p-adic cognitive space-time sheets as their geometric correlates. A deep principle seems to be involved: incompleteness is the characteristic feature of p-adic physics but the flexibility made possible by this incompleteness is absolutely essential for imagination and cognitive consciousness in general.

The most feasible view is that the intersections of p-adic and real space-time surfaces define cognitive representations of real space-time surfaces (PEs, [K13, K8, K10]). One could also say that real space-time surface represents sensory aspects of conscious experience and p-adic space-time surfaces its cognitive aspects. Both real and p-adics rather than real or p-adics.

The identification of p-adic pseudo constants as correlates of imagination at space-time level is indeed a further natural idea.

1. The construction of PEs by SH from the data at 2-surfaces is like boundary value problem with number theoretic discretization of space-time surface as additional data. PE property in

real context implies strong correlations between string world sheets and partonic 2-surfaces by boundary conditions a them. One cannot choose these 2-surfaces completely independently in real context.

2. In p-adic sectors the integration constants are replaced with pseudo-constants depending on finite number of pinary digits of variables depending on coordinates normal to string world sheets and partonic 2-surfaces. The fixing of the discretization of space-time surface would allow to fix the p-adic pseudo-constants. Once the number theoretic discretization of space-time surface is fixed, the p-adic pseudo-constants can be fixed. Pseudo-constant could allow a large number of p-adic configurations involving string world sheets, partonic 2-surfaces, and number theoretic discretization but not allowed in real context.

   Could these p-adic PEs correspond to imaginations, which in general are not realizable? Could the realizable intentional actions belong to the intersection of real and p-adic WCWs? Could one identify non-realistic imaginations as the modes of WCW spinor fields for which 2-surfaces are not extendable to real space-time surfaces and are localized to 2-surfaces? Could they allow only a partial continuation to real space-time surface. Could nerve pulse pattern representing imagined motor action and not proceeding to the level of muscles correspond to a partially real PE?

   Could imagination and problem solving be search for those collections of string world sheets and partonic 2-surfaces, which allow extension to (realization as) real PEs? If so, p-adic physics would be there as an independent aspect of existence and this is just the original idea. Imagination could be realized in state function reduction, which always selects only those 2-surfaces, which allow continuation to real space-time surfaces. The distinction between only imaginable and also realizable would be the extendability by using strong form of holography.

3. An interesting question is why elementary particles are characterized by preferred p-adic primes (primes near powers of 2, in particular Mersenne primes). Could the number of realizable imaginations for these primes be especially large?

   I have the feeling that this view allows respectable mathematical realization of imagination in terms of adelic quantum physics. It is remarkable that SH derivable from - you can guess, SGCI (the Big E again!), plays an absolutely central role in it.

3.6 Negentropy Maximization Principle and Second Law

This article was inspired by a birthday gift. The gift was a highly inspiring book "Lifespan" by David Sinclair and Matthew LaPlante [I25]. The book tells about the recent understanding concerning aging. The general vision about aging represented in the book can be summarized as follows.

1. The key idea is that genes do not determine everything. DNA has also continuum degrees of freedom characterized by its shape. These degrees of freedom are related to epigenesis which is higher level control activity controlling what genes are expressed. The basic mechanisms are prevention and allowance of gene expression. Acetylization [I2], methylation [I14] and many other modifications affect the gene expression by attaching to proteins known as histones forming kind of pearls in the necklace defined by DNA: genes follow nucleosomes in the DNa strand. Also the reversals of these processes - for instance, deacetylation [I7, I36]and demethylation [I14] are essential for the control of gene expressions.

2. Aging involves the emergence of various diseases. Usually the attention is directed to dealing with these diseases. Now the view is however more general. Aging is seen as a gradual approach to chaos manifesting as various diseases. In order to prevent the diseases one should slow down the approach to chaos.

3. Epigenetic chaos hypothesis suggests that some control systems associated with information molecules and related to the control of DNA transcription and translation by epigenesis must

approach chaos. This is seen as the gradual randomization of DNA conformations causing problems in the transcription of DNA: DNA becomes loopy. The DNA coding for the ribosome acting as the translation machinery of DNA is of special importance and becomes also loopy. What comes first in physicist's mind, is an approach to thermal equilibrium. Is there some system controlling epigenesis which approaches thermal equilibrium with the environment? In standard chemistry it is difficult to identify this kind of system.

4. Biology has invented ingenious mechanisms to slow down aging. For instance, there are molecules having two functions. There are proteins making the translation of the genes related to cell replication possible.

   When the DNA coding for the ribosome gets loopy their function changes. The translation of genes ceases as the proteins leave the histone molecules and enter the damaged DNA and freeze it so that it can be prepared. This however slows down cell replication and also causes other problems leading to various diseases related to aging. One can say that a cell is like a hospitalized patient.

   The slowing down of aging would be in this framework basically fighting against the thermo-dynamical arrow of time. Is it really possible to understand the processes involved in the framework of standard bio-chemistry with a single arrow of time?

   Even the understanding of the biocatalysis is difficult: how the reacting molecules are able to find each other in the molecular soup and how the huge increase for the rate of these processes is possible. The TGD based solution of these problems will be discussed later.

What could TGD inspired theory of consciousness and quantum biology rely on zero energy ontology (ZEO) inspired biology allow to say about the mechanism behind aging?

1. Negentropy Maximization Principle (NMP) as the variational principle of consciousness replaces the second law and implies it for ordinary matter. State function reduction (SFR) means a reduction of the entanglement for a pair $S_a - S_b$ of sub-system S_a and its complement S_b in S. Measurement cascade proceeding from long to short scales decomposes at each step a system to a pair of unentangled subsystems is in question. NMP as a variational principle of consciousness states that negentropy gain in these reductions is maximized and selects the pair $S_a - S_b$ at given step.

   In adelic physics [L37, L36] the negentropy $N = -S_1 - S_2$ is sum of real and various p-adic negentropies but p-adic negentropy can be positive so that for non-trivial extensions of rationals one can have $N > 0$. This kind of entanglement is stable against NMP so that the process stops. One can assign positively colored emotions to this kind of entanglement and it distinguishes between living and inanimate matter and also between dark and ordinary matter.

2. TGD inspired theory of consciousness is basically an extension of quantum measurement theory allowing to get rid of the basic paradox of quantum measurement theory. There are two kinds of state function reductions (SFRs) "big" SFR and "small" SFR (briefly BSFR and SSFR) [L58].

   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. BSFRs are counterparts of ordinary quantum measurements and have a dramatic effect: in a very general sense one can say that self dies and reincarnates with an opposite arrow of geometric time.

3. There is a hierarchy of magnetic bodies carrying dark matter as phases of ordinary matter with effective value $h_{eff} = nh_0$ of Planck constant. n corresponds to the dimension of an extension of rationals. The extensions define evolutionary hierarchies with increasing complexity. n serves as a measure of algebraic complexity and as a universal IQ, and also characterizes the scale of quantum coherence. For instance, genes are characterized by the value of h_{eff} associated with their MB.

Since MBs have higher universal IQ than ordinary biomatter, they control the biochemistry. In particular, they would control DNA and DNAs MB would actually realize genetic codons in terms of dark proton triplets. Also dark photon triplets would provide this kind of realization crucial for control of and communication with ordinary biomatter.

4. ZEO implies a theory of self-organization [L56] and of self-organized quantum criticality (SOQC) relying on time reversal [L92]. The dissipation of a system looks like in reversed time direction extraction of energy from the environment. Also SOQC becomes possible since criticality, since a state, which is a repeller, becomes an attractor in reversed time direction. The system seems to tend to criticality for an observer with an opposite arrow of time.

5. In this framework the aging could be seen as the approach of the system formed by MBs of the information molecules and of ordinary biomatter to a thermal equilibrium. The temperature of MB gradually grows and eventually reaches a maximal temperature (due to the stringy character of flux loops) known as Hagedorn temperature and identifiable as the physiological temperature. System dies.

3.7 Very brief summary about some aspects of aging?

The book of Sinclair and LaPlante [I25] is about aging and how to slow down it. The basic hypothesis is that aging need not mean getting sicker and sicker all the time. Biology has developed molecular tools for slowing down aging and there are longevity genes analogs to SPs taking care of this. It might be possible to help them by a healthy lifestyle.

The books represents a vision involving the following pieces.

1. Aging is information loss and molecular level, in particular DNA level. Ribosomal DNA seems to be in a special role assignable to nucleolus. Physicist could try to understand this from the second law: entropy un-avoidably increases . Entropy increases for isolated system but it is perhaps not so simple.

2. It has been learned that damage to DNA alone cannot explain aging. There must be additional degrees of freedom assignable to epigenesis as a control of genome. Besides genetic code there should exist additional continuous information carrying degrees of freedom.

   Epigenesis involves these degrees of freedom and DNAs conformation (involving coilings of coilings of ..) represents these degrees of freedom. Histones appear tangles along the DNA double strand selecting which genes are expressed. Acetyl tag in the histome allows gene expression to take place. When acetyl is absent, nothing happens. The effect of acetyl tag can be also silenced.

3. There are enzymes Sirn, $n = 1, 2, ..7$, called sirtuins [I18, I47] (`https://cutt.ly/HjkhOia`). In particular, Sir2 silences so-called mating type genes so that the cell replicates normally. If Sir2 is not present in mating type genes, they are expressed and replication does not take place normally. I understood that for yeast, the cell loses its sexual identity and does not replicate.

   During this non-replication period the cell would concentrate on maintenance. Under stress situations this would occur quite generally and make survival possible. If you cannot eat and replicate, sleep, and generate metabolic energy from thermal energy for instance. Also SPs would be at work. On the basis of [L92], one could guess that a kind of hibernation state with a reversed arrow of time could be in question. To live longer it is good to die sufficiently often!

4. This is not the only function of Sir2. When DNA double strand is broken, Sir2 must leave its job and hurry to the broken DNA and catalyze expression of SIRn coding for histone deacetylase HDAC, which removes acetyl tags from histones and deactivates DNA. After this the broken DNA is prepared. This is like putting a victim of a traffic accident to a hospital bed or even artificial coma.

As cells get older, this kind of DNA breaks occur more often and Sir2 must leave its basic job more often and the cell loses its ability to replicate more often. It can also happen that Sir2 does not find its original position in the mating gene and starts to silence a wrong gene. This leads to epigenetic noise inducing aging.

5. In particular, ribosomal DNA in the nucleolus, the largest structure of the nucleus, can end up with chaos. Loops are formed and recombination between portions of the same strand can occur (remember the reconnection mechanism and time reversal). Ribosome plays a fundamental role in translation so that there is no wonder that difficulties emerge. Important class of damage consists of breaking DNA double strands. This leads to a chaotic conformation involving loops. Sir2 must rush to the nucleolus and this means that mating genes activate and the replication stops. When these accidents occur too often, the cell becomes senescent.

The first cognitive measurement leads to a product decomposition in $F(G/(G_2...G_n)) \times F(G_2..G_n)$ if the entanglement coefficients between $G_1 = G/(G_2...G_n)$ and $F(G_2..G_n)$ are in the extension of rationals considered. Same can happen at the next step and leads to a similar decomposition of $F(G_2,...G_n)$. The maximal cognitive measurement cascade leads to a product of wave functions in $F(G_i)$ but it can happen that there is no measurement cascade at all.

Suppose that the time evolution following SSFR for individual mutually unentangled subsystems is in good approximation unitary (their interactions with other such subsystems can be neglected) so that they do not entangle, the density matrix of an individual system suffers a unitary automorphism so that entanglement entropies remain unaffected and the negentropy gain vanishes. One could speak of "asymptotic freedom" as a condition for the cognitive fixed point.

The cognitive fixed point would define the "silent wisdom" of the re-incarnate having the formerly active boundary of CD as a passive boundary of CD. What would be learned during life would help during the next life cycle.

3.8   Negentropy Maximization Principle (NMP) and Second Law

The natural expectation is that second law relates to aging. This motivates a section devoted to the recent view about Negentropy Maximization Principle (NMP) [K56] defining the variational principle of consciousness in the TGD framework and implying in adelic physics [L36, L37] second law in the case of non-negentropic entanglement (in standard physics entanglement is always non-negentropic).

Mathematically NMP is analogous to the second law in that it is not deterministic like the variational principles of classical physics. For a given entangled system NMP allows state function reduction (SFR) for that sub-system-complement pair for which the negentropy gain is maximal. The state function reduction can occur to any eigenstate of the density matrix of the selected subsystem in accordance with standard quantum measurement theory. This would lead to a product of pure states and the negative entanglement negentropy of the initial state would become vanishing in the final state so that negentropy would increase. The inclusion of p-adic contribution to negentropy identifiable in terms of cognitive information assignable to entanglement changes the situation and the entanglement can be stable against NMP and state function reduction cascade stops to entangled state representing cognitive fixed point. Since negentropy gain is not anymore popssible in SSFRs, death is bound to take place.

3.8.1   General observations about second law

First some general observations about second law.

1. Second law is an empirical fact. Second law forces the increase of entropy in statistical sense. Thermo-dynamical equilibrium is the most probable equilibrium. Second law in the standard form assumes a fixed arrow of time. Zero energy ontologuy (ZEO) forces to give up this assumption and allow both arrows of time.

2. Quantum physics is certainly behind second law. If you have an entangled system state, SFRs occur for subsystems with reduction probabilities determined by its entanglement with the environment. This eventually leads to a loss of entanglement and quantum coherence and one must apply statistical using density matrix for individual sub-system and eventually justifies thermo-dynamical description.   It is important to notice that in SFR the entanglement entropy of an individual system is reduced in SFR but that in the case of ensemble of identical systems this generates entanglement entropy identical to the entanglement entropy of single particle giving thermo-dynamical entropy as a special case.

    One can consider two interpretations: a) the generation of entanglement generates single particle entropy although actually the entropy of the entire system does not increase in unitary evolution or b) the transformation of this entropy to ensemble entropy corresponds to second law. Option b) looks more realistic.

    This is however only a description for what happens.   One can ask what is behind second law. Is there some deeper principle as one might suspect because quantum measurement is so poorly defined theory.   For instance, von Neumann proposed that only humans cause SFRs. It is often assumed that decoherence occurs without making any proposal how this happens. What is known and well-tested is that reduction probabilities for a measurement reducing the entanglement are coded by the measured density matrix, and one can say that the system goes to an eigenstate of the density matrix as the entanglement is reduced. For an ensemble of identical particles this process transforms entanglement entropy to ensemble entropy with the same value. Negentropy Maximization Principle (NMP) is the TGD based proposal for the variational principle behind SFRs.

3.8.2   The new physics elements involved with NMP

NMP involves several new physics elements.

1. What is new is the hierarchy of systems having the hierarchy of space-time sheets as a geometric correlate. At the level of consciousness theory it would have self hierarchy as a correlate. Quantum measurements are assumed to correspond to SFR cascades proceeding from higher to lower levels of the hierarchy.

2. ZEO brings in the notions of "small" SFR (SSFR) as counterpart of "weak" measurement and "big" SFR (BSFR) as counterpart of ordinary quantum measurement [L58] and forces giving up the assumption about a fixed arrow of time. This modifies standard thermodynamics and leads to a new view about self-organization self-organized quantum criticality [L56, L92].

3. In the standard physics framework there is no definition of negentropy as a measure of conscious information. Negentropy can be only defined as the negative of ordinary entropy and is therefore non-positive. The best that one could have would be vanishing negentropy. This failure is understandable since standard physics does not even try to describe cognition. One manner to solve the problem is to claim that only entropy gradients, whose sign can be also negative matter and thus consider only information flows. In TGD different view is adopted.

4. To bring in conscious information one must introduce cognition. In the TGD framework it is assumed to be described by adelic physics [L37, L36]. This brings in p-adic space-time surfaces as correlates of cognition. Real space-time surfaces are replaced with their adelic counterparts forming a kind of Cartesian product of real and various p-adic space-time surfaces obeying the same algebraic equations.

    By $M^8 - H$ duality [L63, L64] one can regard space-time surfaces as surfaces in M^8 or in $H = M^4 \times CP_2$. M^8 is a subspace of the space of complexified octonions O_c and space-time surface is determined as a 4-D "root" of a real polynomial algebraically continued to an octonionic polynomial. If the coefficients of the polynomial are rational numbers, the polynomial makes sense for both real and p-adic number fields implying number theoretical universality. The dynamical principle is simple: the normal space of the space-time surface is associative/quaternionic.

$M^8 - H$-duality maps these 4-surfaces to 4-surfaces in H. In both cases one has minimal surfaces. Also the notion of cognitive representation emerges and is essential for the number theoretical universality. It is also crucial for the construction of the scattering amplitudes [L69, L63, L64].

3.8.3 Detailed formulation of NMP

Consider now the formulation of NMP [K56] in this conceptual framework.

1. In adelic physics cognition is described in terms of p-adic degrees of freedom. Entropy is a sum of two terms: $S = S_1 + S_2$.

   S_1 is the ordinary entropy describing the amount of ignorance of the observer about the state of either entangled system - say Schrödinger cat and the bottle of poison.

   S_2, as the p-adic variant of entropy (also real valued) assignable to cognitive information has an analogous formula and similar defining properties but can be *negative*(!) and is interpreted as a measure for the information carried by entanglement.

   Thr possibility of having negative sign is basically due to the fact that the logarithms $log(p_k)$ of probabilities p_k in the Shannon formula $S = -\sum_k p_k log(p_k)$ for entropy are replaced by the logarithms of their p-adic norms $|p_k|_p$ given by p^{-n} for $p_k = p^n(a_0 + a_1 p + ...)$ (note that the exponent changes sign!): $log(p_k) \to log(|p_k|_p)$. Entropy remains additive since the p-adic norm of product is product of p-adic norms.

   A more general formula for the real Shannon entropy S_1 is as $S_1 = -Tr(\rho log(\rho))$ (ρ is the density matrix). Even in the case that the matrix elements of ρ are in the extension of rationals used, this formula need not generalize for S_2 since also $log(\rho)$ should have this property. The manner to avoid the problem is to diagonalize ρ. This is possible if the eigenvalues of ρ - having an interpretation as entanglement probabilities p_k (equivalently reduction probabilities) - belong to the extension of rationals considered.

   At the fundamental level this extension is defined by the space-time surface determined by a polynomial with rational coefficients ($M^8 - H$ duality [L63, L64]): the roots of the polynomial determine the extension and space-time surface (number theoretic holography). If the entanglement probabilities are not in the extension, one might argue that the entanglement is stable - note however that NMP alone could make it stable.

   Quantum coherence involves stable entanglement carrying cognitive information measured by S_2. The destruction of coherence if allow by NMP destroys information defined as the sum $N = -S = -S_1 - S_2$. In absence of cognition one would have $N = -S_1$ and NMP would transform to second law.

2. The cascade of "small" state function reductions (SSFRs) eventually leads to a state in which the remaining entanglement is stable. There is no subsystem-complement pair for which SSFR could take place in such a way that negentropy $N = -S = -S_1 - S_2$ would increase. The resulting states are analogous to bound states.

3. Remarkably, in its adelic formulation NMP states that the total entropy, which tends to be negative for extensions of rationals, gets smaller and negative: information is generated! The pessimistic second law transforms to an optimistic NMP! The gloomy character of second law would be due to the neglect of cognition from physics.

   Cognitive entropy gets more and more negative but real entropy which is closely related to it but tending to have a smaller magnitude than p-adic entropy for extensions of rationals also increases [K56] [L58]. Hence their sum tends to increase with the dimension $n = h_{eff}/h_0$ of the extension.

   What makes entanglement stable against SSFR? One can consider two mechanisms.

1. Adelic physics allows negentropic entanglement, which tends to be stable against SSFRs since it can only become even more negentropic.

2. One can also consider another stabilization mechanism. The rule would state that if the density matrix of the subsystem-complement pair does not allow eigenvalues in the extension of rationals considered, the reduction is not possible. For a stable entanglement density matrix would not allow eigenvalues in the extension of rationals considered. One can of course criticize this rule as somewhat *ad hoc* and the first option might be enough. One can also ask whether this mechanism is equivalent with the first mechanism.

3. What could be the interpretation of the negentropic entanglement? I have assigned positive emotions like love to this entanglement, also experience of understanding, etc...

One can raise an objection against entanglement coefficients in an extension of rationals, call it E.

1. Entanglement coefficients would be in E characterizing the polynomial determining space-time surface in M^8 and by $M^8 - H$-duality this would be the case also in $H = M^4 \times CP_2$. The problem is that this does not seem to allow smooth time evolution of entanglement coefficients.

2. At the level of M^8 the construction of scattering amplitudes relies on discretization - cognitive representation [L63, L64]. M^8 is analogous to momentum space and dynamics is purely algebraic at the level of M^8. The algebraic view about solutions of Dirac equation is analogous to momentum space view about ordinary Dirac equation: the spinor mode is localized to a point of momentum space. Many-fermion state corresponds naturally to a cognitive representation. This allows getting rid of the problems since no such evolutions exist at M^8 level.

3. What about the situation at the level of $H = M^4 \times CP_2$? Should one only assume that entanglement coefficients for many-fermion state are transformable to a number theoretic entanglement by a unitary matrix leaving the eigenvalues of the density matrix representing entanglement invariant? Since the induced spinors in H satisfy partial differential equations, this seems to be a reasonable option.

   Algebraic entanglement coefficients are needed only at the level of the scattering amplitudes. $M^8 - H$ duality allows to map cognitive representation in M^8 to H. This also applies to entanglement coefficients so that they would be in an extension of rationals at the points of cognitive representation containing point-like fermions at both sides.

NMP implies increase of ordinary entanglement entropy

NMP implies increase of the ordinary entanglement entropy. The hasty conclusion would be that this implies also increase of thermal entropy and thus second law. Here one must be however cautious.

1. Second law as an increase of ordinary entropy would still hold true but the increase of cognitive information would be larger than the increase of the real entropy for non-trivial extensions of rationals (this is always the case).

   The asymptotic states with maximum negentropy and with stable entanglement would have maximal real and minimal p-adic entanglement entropy and their sum would be negative - and $N = -S$ would therefore serve as a measure for the amount of conscious information.

2. One might argue that intelligent systems tend to pollute their environment: they are entanglement entropy generators and by witnessing what has been happening to our environment, it would be easy to agree.

   One must be however extremely cautious with formulas. The stability of negentropic entanglement means that the real entanglement entropy cannot transform to ensemble entropy and cannot therefore actualize! Is this what distinguishes loving attention as something unique and positive: the entanglement is stable and cannot transform to ordinary entropy?

Could NMP allow the failure of second law in some situations?

The dream about eternal youth seems to be in conflict with the second law. For physicist second law is usually the absolute authority. Working with the details of NMP however force to challenge this view.

A generalization of second law taking into account time reversals is required in ZEO and already this implies apparent breakings of second law. Furthermore, NMP implies second law as the increase of entanglement entropy. NMP does not allow SFRs transforming negentropic entanglement entropy to thermodynamic ensemble entropy unless the SFRs occurs at higher level of hierachy so that the local reduction of negentropy is compensated by its increase in a longer scale. The implications of this fact remain to be understood.

Could NMP break the second law? Can this be consistent with empirical facts? Could the breaking of second law occur at the level of dark matter only? Second law would apply only to the entropy transformable to thermal entropy. The sum $N = -S_1 - S_2$ is what matters: for a trivial extension one has $N = 0$ so that this transformation is possible. $N = 0$ can be however true also for non-trivial extensions. Could the total entanglement negentropy assignable to the ordinary matter satisfy $N = 0$ and be therefore transformable to thermal entropy whereas "dark" entanglement negentropy satisfying $N > 0$ would not allow this. Could one identify dark/living matter as negentropic matter and ordinary/inanimate matter as non-negentropic thermalizable matter? Note that also the phases with $h_{eff}/h_0 = n$ could in principle have $N = 0$. The stability of dark entanglement could directly relate to the failure to observe dark matter.

Comparison with the proposal of Jeremy England

Jeremy England [I61] has noticed that living systems increase entropy and has proposed it as a basic principle of biology. England's proposal is discussed from TGD point of view in [**?**]. I did not however realize in this article the fact, that negentropic entanglement entropy need not allow a transformation to thermal entropy.

One can represent several objections against England's idea.

1. Second law cannot force or even allow the generation of life. Second law relates to the occurrence of SFRs but we do not have a real theory of quantum measurement.

2. Second law assumes preferred arrow of time and there is a lot of support for its violation in living matter as realized first by Fantappie [J97]: in particular, self-organization processes could involve dissipation with reversed arrow of time.

3. To understand life one must take it seriously. Living system is somehow different from inanimate matter. The emergence of life means the generation of conscious information but in the framework of standard physics there is no definition of conscious information.

These objections raise several questions. Why the emergence of life would be accompanied by a generation of entropy? What could serve as a measure for conscious information? How to describe cognition? To these questions adelic physics provides a possible answer. If entropy that England talks about is identified as the entropy produced in SFRs of systems having $N = 0$, TGD view is consistent with the proposal of England.

Cognitive fixed point instead of thermal equilibrium?

The analogy with the second law strongly suggests that the system approaches a cognitive fixed point (negentropy maximum) during the sequence of SSFRs followed by the analog of unitary time evolution. SSFRs cannot generate negentropy anymore. Since the system does not learn anymore, BSFR is bound to occur. A possible number theoretic formulation for the fixed point could be following.

1. The time evolution following SSFR generates entanglement. This entanglement is maximally reduced in measurements of observables, which correspond to operators, whose action does not affect the states at the passive boundary.

2. Cognitive measurements define an important class of such measurements [L68]. The cognitive quantum states correspond to wave functions in the Galois group G of the extension - that is elements of the group algebra $F(G)$ of G. G can be decomposed to a product $G = \prod G_i$ of subgroups defined by the hierarchy of normal subgroups of G defined by the representation of the extension as an extension of an extension of ... of rationals.

Elements of $F(G)$ decompose to superpositions of products of functions in G_i and the factors are entangled. Note that the order of G_i matters and is induced by the inclusion hierarchy for the extensions considered: the largest extension is at the top of the hierarchy. One has "ordered" entanglement. This is analogous to the directedness of attention which is difficult to understand in the standard physics framework.

Eastern philosophies speak also of states of consciousness in which there is no distinction between observer and observed and not division. Could this kind of attention involve negentropic entanglement between systems, which correspond to the same extension of rationals so that the. attention cannot be directed? Or could it correspond to negentropic cognitive entanglement allowing cognitive SSFRs?

3.9 TGD based model for aging

In this section the TGD based view about aging is discussed. The king idea is that the magnetic bodies (MBs) of information molecules and linear molecules formed from them (DNA,RNA, amino-acids,tRNA) are at very low temperature in the beginning. The temperature of MB starts to raise and approach the physiological temperature. The entropy of MB increases. Since the MB of the molecule controls the molecule, the control by MB starts to fail and this leads to the diseases accompanying aging.

3.9.1 Aging as approach of MB and BB to thermal equilibrium

Ordinary entropy increases for an isolated system, it approaches thermal equilibrium - thermalizes. Aging must correspond to thermalization in some sense. There are two views about this.

1. The weak form of the proposal making sense in the standard physics context would identify aging as thermalization. For ordinary biomatter, which already is in thermal equilibrium in good approximation, this idea does not lead to anything interesting.

2. Ordinary matter and the dark matter at MBs carrying dark matter as phases of ordinary matter with $h_{eff} = nh_0$ have widely different temperatures at the moment of birth. Aging means that these systems approach thermal equilibrium in the sense that temperatures become identical . MB has infinite number of degrees of freedom and therefore maximal temperature known as Hagedorn temperature identifiable naturally as physiological temperature [L92]. This option will be considered in the sequel.

Consider the situation in TGD.

1. What are the continuous degrees of freedom whose entropy growth would lead to aging. In the TGD framework they would be naturally the geometric degrees of freedom associated with the flux tubes of dark DNA controlling ordinary DNA. Their number is infinite implying that temperature is below Hagedorn temperature around physiological temperature. One can assign a temperature to the flux tubes and also to these degrees of freedom and this is below Hagedorn temperature. When temperature at flux tubes increases, the geometric shape starts to thermally fluctuate and the overall size increases. Cells indeed increase in aging as do also we!

2. For information molecules the temperature of MB must be very low: dark DNA flux tubes have a very precise shape and therefore also ordinary DNA. For SPs the situation is different and this makes possible their basic functions.

3. Aging could simply mean that the dark genome approaches thermal equilibrium with ordinary biomatter at physiological (Hagedorn) temperature and entropy of dark genes and magnetic flux tubes increases. Flux tubes get more and more irregular shaped and induce a development of loops for ordinary DNA and breaks DNA double strand. Nucleosomes are loop like structures associated with histones and also these are known to be lost. Epigenetic chaos is induced. When thermal equilibrium is achieved death as heat death occurs and changes the arrow of time at the level of the entire body which is left in the geometric past of the standard observer to continue life with an opposite arrow of time.

4. There is a connection to the article [L90] about DNA and arrow of time. One can argue as follows. As the electric field along DNA double strand decreases by the shortening of the sticky ends, the string tension as density of electric energy per length decreases, the stiffness of DNA decreases, and the fluctuations start to develop. Second possibility is that the shortening of telomeres and sticky ends is a controlled process causing a programmed aging.

5. There are molecules devoted to preparation of the damaged DNA. The epigenetic tags on histones of mating genes could control the arrow of time for the gene involved. If the tag is present, the gene is expressed. If not or if inhibited by say Ser2, the arrow of time is reversed.

Objections related to metabolism

Metabolic energy feed is needed to keep the distribution of h_{eff}:s and even increase the values of h_{eff} - defining universal IQ and characterizing quantum coherence scale. This relates to the second important aspect of life: quantum coherence in long length scales is needed to generate the coherent behavior of ordinary biomatter and is not possible in standard bio.chemistry framework. Ageing would be a gradual reduction of this quantum coherence by thermalization of MBs of the basic information molecules, in particular the dark variants of the basic biomolecules. If you want to live long, take care of your personal quantum coherence!

One can develop some objections against the vision about ageing as thermalization of the MBs of information molecules.

1. Aging is viewed as changes of the body after birth. What about the processes before birth? When sperm and gametes inoculate and divide and divide and form some distinguished organs, this process needs a high amount of energy; that is why mothers get to eat more during pregnancy.

    Fetus generates new structures - parts of MBs containing dark matter as $h_{eff} = n \times h_0$ phases of ordinary matter with increasing value of h_{eff}. This requires high metabolic energy feed provided by mother. Information molecules are however still very far from thermal equilibrium and the gradual increase of the temperature of MBs has practically no effects. The situation remains the same also at the young age. At later age MBs approach thermal equilibrium and problems with the bio-control by MB emerge.

2. Reactive Oxygen Species (ROS) cause also damage for DNA: the more ROS, the shorter the life of the cell. That is why food with low calories content or fastings or low carbohydrates (which need less oxygen to burn) diets are good for longevity.

    ROS have been also seen as a cause of aging and one could argue that they should cause a lot of damage during the fetus period involving intense metabolism. The repair mechanisms of MB work almost optimally for fetus and at young age and allow handling of the problems due to ROS. The authors of [I25] argue that it is now known that ROS are not the basic reason for aging. As a matter of fact, ROS are essential for the demethylation [I9].

Is apoptosis as programmed cell death consistent witht he proposal?

Also programmed cell death - apoptosis - could be treated as an objection against aging as approach to thermal equilibrium. Apoptosis as a programmed cell death cannot be purely thermal event. It could be induced by MB at the higher level of hierarchy as BSFRs. Perhaps

by MB of cell group as in the development of fingers from the cell mass. Apoptosis could have several motivations.

1. The basic prediction is that giving systems are intentional systems having free will at all levels. MB at the higher level could act like dictator and destroy quantum coherence locally leading to the death of the cells but generating quantum coherence and generation of structures in longer scales which would also take the metabolic energy resources used by the dead cells.

   Negentropy Maximization Principle (NMP) would be the deeper principle behind the second law. Apoptosis would be consistent with the NMP which implies second law as a by-product and as its name tells, implies negentropy increase. Therefore thermalization would not the only cause of cell death.

   Apoptosis would indeed generate more complex structures when fingers develop from tissue. Destruction of lower level structure would be the price paid for the generation of a higher level structure and negentropy gain in longer scales.

2. Evolution means steps in which h_{eff} increases in BSFRs and longer scales of quantum coherence at the level of MB emerge. Extinction of cells and sauri would be part of evolution.

A controlled BSFR causing the analog of death/hibernation of a subsystem could be also represented as an objection. The BSFR would have the survival of a larger system as a motivation [L92]. In fact, all motor actions can be seen as BSFRs at some lower level so that life is continual dying! Death/hibernation of a subsystem means savings of metabolic energy and can be seen as one manner to fight against second law since the dead subsystem lives with the opposite arrow of time: living system is basically 4-D entity in ZEO - not just the time slice which corresponds to conscious experience!

Is the biochemical approach trying to describe dissipation as a controlled process?

A general comment related to the distinction of the standard approach and the TGD approach relying on ZEO is in order. Standard approach does its best to identify control mechanisms leading from state A to state B. Huge amount of information exists about reaction pathways and one can only admire these data mountains.

This approach is very natural as long as time reversal is not involved. If this is the case, there are processes, basically healing and repair processes, that occur in a reversed time direction as dissipative processes and each BSFR leading to a time reversed state involves its own reaction pathways. The tragedy would be that the standard approach tries desperately to understand loss of order as a controlled process inventing endlessly reaction pathways!

Of course, this work would not be useless. The problem is however that a deeper understanding is missing and prevents seeing how incredibly simple the picture is at the fundamental level.

1. The increase of entropy in reverse time direction apparently breaks second law in the standard time direction. Stress proteins (SPs) discussed in [L92] are involved with this battle. The magnetic bodies of SPs can extract heat energy from the environment in heat shock and heat DNA and proteins in cold shock, and also act as heat engines for molecular motors.

2. As also the authors of [I25] emphasize: diseases are a consequence of a loss of information. Disorder increases as quantum coherence is lost, and manifests as numerous diseases. Quite concretely, the h_{eff} distribution flattens in the sequence of SSFRs. System gets less intelligent and is unable to cope with the hard reality! Second law would eventually win although this process can be slowed down by BSFRs of subsystems.

3. Things can go wrong in very many ways: as Tolstoy said, families can be unhappy in myriads of different ways but there are very few ways to be a happy family! Therefore the disease centered thinking of medicine is perhaps not the best approach. One should do something which helps to prevent all diseases simultaneously. One can avoid diseases by choosing a healthy lifestyle. Also a medicine relying on the idea that BSFRs for subsystems could

help. BSFR could be seen also as falling sleep and resting and gathering metabolic energy - even from thermal energy.

4. Time reversed dissipative evolution looks like healing in the reversed arrow of time. If this is the case, the tragedy of biology would be the attempt to understand time reversed dissipation in terms of complex control actions based on complex reaction pathways or even as some kind of computer programs.

5. MB would be in a key role since most diseases would be problems in the control performed by MB and basically due to the reduction of h_{eff} and therefore of information contents. About detailed criteria for when one has a disease this approach cannot say much.

Loss of the control of housekeeping genes causes vicious circle leading to death

The basic problem from the point of view of longevity would be that during aging MB gradually loses control of not only methylation, acetylation and their reversals but also other modification processes.

A possible explanation for hypermethylation is that the control actions inducing demethylation fail. The observed hypomethylation in the complement of CpG islands could be due the failure of methylation so that the state becomes stable. More generally, this suggests that the loss of control of all modifications is the mechanism leading to the situation in which the modifications cannot be changed. For instance, the differential methylation of hippocampus is known to be relevant for memory recall, which could relate to the emergence of memory problems at the old age.

CpG:s which are hypermethylated appear in the promoter regions of almost all housekeeper genes so that housekeeping [I12] (`https://cutt.ly/2jQgOSD`), in particular transcription and translation machineries, metabolism, functioning of stress proteins, etc.... becomes difficult.

The enzymes responsible for the methylation and demethylation are especially important for housekeeping genes [I12] whose promoter regions contain CpG islands. Metabolism related enzymes like Cytochrome P450 are involved also with demethylation as enzymes. Methylation of the promoter region of housekeeping genes means also methylation of genes coding for demethylase. This vicious circle - not so positive positive feedback - leads to death.

What causes the loss of the control of these modifications? The mechanisms leading to the loss of control would relate to modifications of the chromatin and DNA organization. These include reduced global heterochromatin, nucleosome remodeling and loss, changes in histone marks, global DNA hypomethylation with CpG island hypermethylation, and the relocalization of chromatin modifying factors [I55, I21, I38]. In the TGD framework these changes would be caused by the thermalization of the MBs of DNA and chromosomes.

Also cancer induces these changes about which the appearance of additional chromosomes in the mitochondrial DNA in cancer is an example. It has been found that a very weak oscillating magnetic field with strength in nanotesla range and with oscillation frequency around 60 Hz (Schumann frequency) leads to the disappearance of additional chromosomes [I71]. The loss of quantum coherence is the general explanation but it is not clear whether this can be due to thermalization at the level of DNA in this case. A possible explanation is that the control by MB at a higher level of hierarchy is lost and the presence of magnetic field re-establishes a connection with this MB in turn re-establishing quantum coherence [L41].

MB controls the conformations of DNA and chromosomes. MB is identifiable as a flux tube network and its control relies on its motor actions involving reconnections and shortenings of the flux tubes by a temporary reduction of h_{eff}. These motor actions of MB would become fuzzy by the thermal motion. The precise motor performance of MB is crucial for the realization of modifications occurring at the promoter regions near histones and at histone tails. Therefore the thermalization of the flux tube degrees of freedom of MB could be the basic reason for the problems.

When does death occur?

Aging could simply mean that the dark genome approaches thermal equilibrium with ordinary biomatter at physiological (Hagedorn) temperature [L92] and entropy of dark genes and magnetic

flux tubes increases. Flux tubes get more and more irregular shaped and induce a development of loops for ordinary DNA and breaks DNA double strand. Epigenetic chaos is induced. When thermal equilibrium is achieved death as an analog of heat death occurs and changes the arrow of time at the level of the entire body which is left in the geometric past of the standard observer to continue life with an opposite arrow of time.

BSFR means death and death is bound to occur. But when? TGD proposes a general criterion: at a given step either SSFR or BSFR occurs and the SFR that means maximum negentropy gain takes place. This SFR is not unique. It can be either SSFR or BSFR and in both cases there are a lot of options for the final state.

When would BSFR win in the comparison?

1. Total entropy can be defined as the sum of p-adic and real Shannon entropies. p-Adic Shannon entropies involving p-adic norms $N_p(p_k)$ of probabilities p_k in the logarithmic factors $log(N_p(p_k))$ can be negative. In this case they characterize the information (associated with cognition) assignable to the entanglement.

2. Real entropy characterizes the lack of information about the state of either entangled system and is associated with sensory input (is the cat dead or alive?). The sum of the real and p-adic entropies can be negative for non-trivial extensions of rationals so that one would have genuine cognitive information. One could also speak of mere cognitive information as the p-adic contribution to the entropy and this can be negative.

3. Intuitively it seems obvious that thermalization meaning that the temperature difference between MBs and systems such as genes is reduced, means loss of information defined in this manner. Information molecules cease to be information molecules at least in the geometric degrees of freedom.

4. BSFR becomes the winner if SSFRs can give only very small negentropy gain or if the negentropy gain becomes negative. The fact that we do not learn much anymore at the old age, could reflect the reduction of the negentropy gain in SSFRs.

Also the distribution of $h_{eff} = n \times h_0$ values could reduce IQ. As found in [L68], a complete cognitive measurement inducing maximal reduction of entanglement for an extension with dimension n would reduces the state to a product state with state space with dimensions n. which are factors of n and thus smaller than n: instead of single MB with high IQ several with lower IQs. It might happen that the next SSFRs are not anymore able to regenerate larger values of n and the system becomes less intelligent.

An objection against this picture is that there are also situations when resurrection seems to occur: this has happened for people having had near-death experiences. One can also slow down the process of aging by a appropriate diet.

1. The slowing down of the aging process is possible by the reversal of the arrow of time at lower levels so that time reversed dissipative processes at these levels look like self-organization and generate order from the point of view of the organism. This would be a general. mechanism used by living matter to slow down the approach of MB to thermal equilibrium with MB.

2. This does not however explain resurrection. The opposite BSFR can however occur at the level of the entire organism but with a suitable stimulation like resuscitation opposite BSFR can take place. Taking into account the fact that also the organism is only one level in the hierarchy of conscious entities, this reduces to the first option.

   The analog of resuscitation occurs at the atomic level in the experiments of Minev *et al* [L51]. Although the deterministic process apparently leading to the final state of BSFR had already occurred, it could be stopped by a suitable stimulus. In TGD framework the interpretation is that the BSFR had already occurred and the time reversed time evolution apparently leading to the final was observed. A suitable stimulation however induced the opposite BSFR so that the process apparently stopped [L51].

DNA and the arrow of time

There is a connection with the article about DNA and arrow of time by Rastmanesh and Pitkänen [L91]. The proposal is as follows. As the electric field along DNA double strand (with dark DNA strands included) decreases by the shortening of the sticky ends, the string tension as density of electric energy per unit length decreases, the stiffness of DNA is reduced, and thermal fluctuations start to develop.

Biologist might wonder how various biological and homeostatic maneuvers like weakening of acetylation/phosphorylation/methylation eventually translate to a decrease of the electric field strength along DNA! In the TGD framework one can see the situation in a different manner: chemistry is not the boss now but is controlled by MB.

1. Modifications (or rather, the loss of the control of modifications) are not the primary cause of the weakening of the electric field. What happens at the control level, at MB, is the primary cause.   The weakening of the electric field along DNA would correlate with the shortening of the sticky ends carrying electric charges creating the longitudinal electric field.

   This would also correlate with the reduction of the level of consciousness at the level of DNA if one is ready to generalize Becker's findings [J35] about the correlation of the strength of the longitudinal electric field along the body axis with the level of consciousness. Similar correlation with consciousness can be assigned to the electric field directed from visual cortex to frontal lobes.

2. The reduction of the electric field strength reduces   energy density of DNA and therefore string tension. DNA begins to fluctuate geometrically, which generates epigenetic noise. Initially dark DNA is like a tense guitar string but transforms gradually to spaghetti. Basically the reduction of string tension reflects the dissipation accompanying the approach of MB to thermal equilibrium with the ordinary bio-matter.

   One could perhaps say that the reduction of string tension of MB flux tubes forces the reduction of electric field strength and the internal consistency (Maxwell equations) requires reduction of the sticky end lengths proportional to the charges generating the electric field along DNA. Note that also charge separations tend to disappear in the approach to thermal equilibrium.

3. An interesting question is whether hyper-methylation accompanying aging [I33, I70, I66] could be seen as an attempt to minimize the effects of DNA damage - analogous to an amputation of a leg to prevent necrosis. Hyper-methylation accompanies also cancer [I23, I54].

   Second view is that hypermethylation is due to the loss of control of MB caused by the approach to thermal equilibrium.   Hyper-methylation could be seen as the failure of demethylation caused by the low level of demethylase activated by MB and caused by methylation of the genes coding for demethylase! This positive feedback loop would lead to the failure of the control of MB.

Is the shortening of the telomeres a controlled process or due to thermalization?   The first option could be argued to be realistic since otherwise the population would end up to fight about metabolic resources. Second law could of course solve the problem without any need for a controlled action.   If the length of telomeres correlates with the charges of the sticky ends proportional to its length which in turn would be proportional to the length of the telomere as proposed in [L91], the conclusion would be that the shortening is not a controlled process.

3.10   Epigenesis and aging in TGD framework

In the TGD framework epigenesis would be control of the biological body by MB consisting of ordinary biomatter. The basic control tool would be dark photon 3N-plets coupling resonantly to the dark proton sequences of proteins serving as enzymes and RNAs serving as ribozymes. The coupling would be precise and based on the addresses defined by dark proton 3N-sequences defining emitting dark 3N-photons.

These would in turn catalyze the basic biochemical processes and here TGD suggests a mechanism explaining why the reactants find each other and where the energy needed to overcome the energy barrier to make reaction fast enough come. The reduction of h_{eff} for flux tubes would be the needed mechanism.

Also other catalysts than enzymes and ribozymes can be considered. For these catalysts and organic and non-organic molecules in general, the coupling with MB could be single photon resonant coupling transforming 3N-photon to bio-photon.

3.10.1 How MB could control biochemistry

How does the general biochemistry picture involving biomolecules and reaction pathways relate to the multi-resonance vision about how MB controls ordinary biomatter? Can one reduce this picture to a description in terms of multir-resonance frequencies - that is to the level of MB and MB-BB communications alone.

1. Suppose that MB of DNA, RNA, or protein controls DNA, RNA or protein by signals from dark genes using multi-resonance mechanism allowing to select the target and use modulation of dark photon signal to code control signals. Also the MB of DNA, RNA, or protein can be controlled by a higher level of the hierarchy.

   If all control takes place in this manner, epigenetic control would be control of proteins acting as enzymes, of RNA, in particular ribozymes, and of DNA. MB would also activate genes coding for various enzymes, in particular housekeeping enzymes.

   The controlled proteins would be naturally enzymes catalyzing various biochemical reactions.

2. Could the MB of DNA just change its geometric conformation inducing change of DNA conformation and changing also the epigenetic patterns determined by methylation, etc...? This would represent something new: in TGD one has a network of molecules connected by flux tubes, in biochemistry approach one has only molecules.

   The first basic mechanism for the change of the conformation would be the reduction of h_{eff} leading to the shortening of the flux tubes and liberation of energy and its reversal. The reduction of h_{eff} is crucial in the TGD based model of bio-catalysis. The opposite process would feed metabolic energy to MB. The formation of reconnection would be another key process and allow to change the topology of the flux tube network. This would be the basic mechanism of the immune system and also of biocatalysis in which the U-shaped flux tubes associated with the reacting molecules would reconnect.

   For instance, the actions of cells during say catastrophic events mean typically that proteins like Sir2 come in rescue by travelling along flux tubes or pairs of them serving as highways: these highways do not exist in standard biology. The existing pattern of flux tubes determines the road network. MB would control the topology of this network by reconnecting and by controlling the lengths of the flux tubes by h_{eff} changing transitions: motor actions of MB would be in question.

3. TGD leads to a view about emotions as sensory perceptions of MB. The model for genetic code emerging from a model of bio-harmony [L18, L49, L66, L71] based on icosahedral and tetrahedral geometries and the observation that music expresses and induces emotions leads to the proposal that the bio-harmony characterized by 64 allowed 3-chords in one-one correspondence with DNA codons has 3N-resonances assignable to the 3-chords of the harmony as a correlate. These resonant interactions induce transitions of selected bio-molecules and possibly also specific transitions of a given biomolecule characterizing the harmony. Could epigenesis be regarded as expressions of emotions by music of light?

BSFR would create a superposition of deterministic time evolutions leading to the geometric past. It would define an average time evolution described in terms of reaction pathways. Could the final state of MB in BSFR dictate also the epigenetic patterns - say bio-harmony determined by frequencies of cyclotron transitions of protons? They are indeed determined by the strengths of the magnetic fields at flux tubes. This would conform with the proposal that the outcome

of volitional action as BSFR dictates what happens in the brain of geometric past explaining the findings of Libet [J34] [L51].

SSFRs give rise to an approximately classical time evolution and generation of entropy, and therefore aging. h_{eff} distribution becomes flatter and MBs of information molecules and ordinary matter approaches thermal equilibrium. The distribution for the conformations of the magnetic flux tubes thermalizes and cell size increases. Basically string tensions decrease since the electric fields involved weaken and the electric and also magnetic contribution to the tension weakens.

What could be the general mechanism of bio-catalysis? The MB of the enzyme could activate the enzyme when the value of h_{eff} of a flux tube connecting it to other reactants is reduced and induces the shortening of the flux tube and liberation of energy.

Depending in what direction energy flows, one can imagine two scenarios for what happens.

1. The energy could flow from higher levels of hierarchy to lower levels. The flux tube at the highest level would be shortened and liberate energy transferred to a lower level. At the lowest level enzyme would be excited and return to the ground state and liberate the energy needed to overcome the potential wall making reaction slow. Now the shortening of the flux tube of enzyme's MB does not seem to be necessary energetically.

   The process would proceed from higher to lower levels in the hierarchy of MBs by this kind of excitations and de-excitations transferring the energy to the lower level, somewhat like in photosynthesis. The flow of money from top towards bottom in a big project serves as a second metaphor for the course of events.

2. If the process is a generalized motor action involving BSFRs and time reversals, the higher levels in the hierarchy of MBs extract energy from shorter scales (very much like higher levels extract work of lower levels in the social hierarchies!). One could also say that negative energy is sent to the lower levels of the hierarchy.

   The lower level would provide the energy by reducing its h_{eff} so that its energy is reduced and energy is liberated and taken by the higher level. This would induce the shortening of magnetic flux tubes at all levels. The cascade would proceed down to the level of MBs of proteins and also the U-shaped flux tubes connecting the protein to the other reactants would shorten and bring the reactants together. The reduction of the flux tube length should provide energy to overcome the potential wall, not only the energy going to the higher level of hierarchy.

It is not quite clear which option is realized. Motor actions involve transfer of metabolic energy from short to length scales giving rise to macroscopic coherent motion: time reversal would be natural from this point of view.

Methylation and acetylation

The figures of `https://cutt.ly/Qjgrko3` illustrate the effect of methylation and acetylation of DNA or of histone tail.

1. The nucleosomes [I13] surround a given gene but nucleosomes can roll along DNA downstream towards the gene to be transcribed and opens the DNA double strand. The modification of the histone tail can prevent or facilitate the opening of the double strand.

2. The portion of DNA between the nucleosome and gene corresponds to the promoter part of DNA initiating the gene expression. Proteins initiating the transcription bind to it or alternatively it can be transcribed to RNA.

The methylation [I13] and acetylation [I1] of the histone tail serves as the first example. The binding of the methyl, acetyl, or some other group to the histone tail has an indirect effect on the gene. Histone is positively charged. Since DNA is negatively charged, DNA and histone bind together.

The addition of a modifier can increase or reduce the charge of the histone and tighten or loosen the binding between histone and DNA. Methyl is positively charged and tightens the binding

and makes the opening of DNA necessary for transcription more difficult. Acetyl is negatively charged and loosens the binding so that the transcription becomes easier.

Consider next the methylation of a promoter region (`https://cutt.ly/3jj8ohZ`).

1. A promoter is a sequence of DNA to which proteins bind that initiate transcription of a single RNA from the DNA downstream of it. This RNA may encode a protein, or can have a function in and of itself, such as tRNA, mRNA, or rRNA. Promoter region has therefore two - it seems alternative - functions.

2. The methylation of cytosin occurs at CpG islands associated with the promoter region of gene. Promoter region is the region to which proteins initiating the transcription of gene bind. Methylation occurs also for the promoter regions of CpG-islands [I32].

3. How methylation silences the gene transcription? Methylation decreases the charge of DNA locally and loosens the binding to histone. This would favor the transcription of the promoter region instead of the transcription of the gene requriing the binding of RNA polymerase to the promoter region.

4. If methyl is always positively charged, the direct binding to DNA reduces DNA charge locally and reduces the interaction between histone and help opening of DNA in the promoter region: this would not facilitate the transcription of gene but transcription of non-translated RNA or protein. The binding would also prevent the binding of RNA polymerase to the promoter region. The start codon of the non-protein coding gene could be in the promoter region.

More facts about DNA methylation [I14] (`https://cutt.ly/pjj3G45`) are needed to develop a TGD based view about the situation.

1. DNA methylation reprogramming occurs during gameto-genesis and early embryogenesis. The methylation patterns are erased and regenerated. This requires that the memory about the methylation pattern is stored. In the TGD framework MB could serve as the temporary information storage.

2. DNA methylation occurs also in highly transcribed gene bodies and must be distinguished from the methylation of promoter regions. The methylation of gene bodies seems to relate to splicing and could prevent the transcription of intronic portions of the gene.

3. In general, the level of DNA methylation is very low. The level of methylation is however high in promoter regions. In particular, in CpG islands [I5] (`https://cutt.ly/sjj3STW`) accompanying the promoter regions of genes, especially those coding for housekeeping proteins.

4. Usually the methylation of C in CpG leads to a mutation replacing C with T. This could have led to CpG loss in DNA except in CpG islands, where some stabilization mechanism should prevent the mutations: presumably an energy barrier somehow caused by CpG is involved.

   Hypermethylation accompanies cancer and also aging [I66, I70] and could be seen in the TGD framework as reflecting the approach to epigenetic chaos basically due to the reduction of the scale of quantum coherence in turn caused by the reduction of the values of h_{eff}.

5. CpG loss is believed to be induced by transposable elements (TEs) attaching to DNA and hopping around it. TEs are methylated and lose CpG as C transforms to T.

6. So called housekeeping proteins [I12] are enzymes crucial for various functions including general gene expression, and the control of various housekeeping functions takes place via the control of the expression of housekeeping genes. Therefore CpG islands, which are stable against mutations and allow both methylation and demethylation are needed. Dynamical and differential methylation is also known to relate to memory recall in the case of hippocampus.

   For CpG islands $C \to T$ the mutations induced by methylation are prevented by some mechanism. The loss of CpG makes sense outside CpG islands since this stabilizes the genes against $C \to T$ mutations.

MB uses enzymes and ribozymes as a tool in the control of the basic biochemical processes. DNA methyltransferases [I15] catalyze methylation and MB would control the process by activation of this enzyme. In the case of demethylation the enzymes used are demethylases [I8].

The mechanism of demethylation can be taken as an example since the failure of demethylation might lead to hypermethylation of CpG islands known to accompany aging [I66, I33] and in TGD framework it could be due to the approach of the dark genome and proteome to thermal equilibrium.

1. Oxidative demethylation [I9] (`https://cutt.ly/Gjj2Ilz`) replaces CH_3 group with hydrogen. This requires the presence of a reactive oxygen species (ROS). ROS include superoxide O_2^-, hydrogen peroxide H_2O_2 and hydroxyl radical OH.(`https://cutt.ly/yjj2Ubv`).

   Superoxide is produced in aerobic metabolism via $O_2 + e^- \to O_2^-$. This in turn leads to reactions $2H^+ + 2O_2^- \to H_2O_2 + O_2$ followed by $H_2O_2 + e^- \to HO^- + OH$ and $2H^+ + 2e^- + H_2O_2 \to H_2O$.

2. Demethylation is catalyzed by demethylases in presence of O_2. N-methyl groups are oxidized with oxygen coming from ROS O_2 and CH_2O splits out so that the net reaction is $R_2N - CH_2 \to R_2N - H + CH_2O$.

   Enzymes known as alpha-ketoglutarate-dependent hydroxylases act as DNA demethylases. Also Cytochrome P450 [I6] (`https://cutt.ly/ujj2OuK`) catalyzes demethylation in histones and some forms of DNA (cytocine associated with CpG). "450" refers to "450 nm"", which is the wavelength at which cytochrome P450 has maximum absorption. The wavelength corresponds to blue light near UV range and the photon energy is 2.76 eV. CYPs is a very large class of enzymes catalyzing metabolic processes.

   What TGD view could be?

1. Suppose that MB controls bio-matter by expressing its moods coded by bio-harmonies in terms of dark photons 3N-plets (say) with the frequency patterns correlating with mood and affecting matter in mood dependent manner via a transformation to bio-photons.

2. 60 per cent of promoter regions of human genes contain CpG islands of length about 100-1000 codons and almost all housekeeping genes have CpG islands in their promoter regions. Why?

3. MB would induce both methylation and demethylation and other modification using various enzymes which they could activate by dark 3N-photons using as address the dark proton sequence associated with the enzyme. After activation the reaction would proceed by the proposed general mechanism of biocatalysis.

4. One can imagine several alternative courses of events after the activation. Even the question whether the energy transfer is from short to long length scales associated with MB or vice versa is not fully settled: this depends on the arrow of time assignable to this process.

   In the case of CYP450, one cannot avoid the temptation to ask whether a biophoton with 450 nm wavelength could be formed in a decay of 3N-dark photon to ordinary photon.

Methylation, aging, and memory

According to the abstract of [I33] (`https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3482848/`), the general trends, supported by an increasing body of both in vitro and in vivo work, are the establishment of global hypomethylation (non-CpG islands) and regions of hypermethylation (primarily CpG islands) with age. CpG islands are located in the promoter regions of genes, in particular those of housekeeping genes.

Hypomethylation outside CpG islands could be due to the spontaneous mutation $C \to T$ but also the failure of the control of the methylation by MB could be involved. Hypermetylation

of promoter regions implies that the promoter region transcribing RNA is transcribed instead of gene. This could be due to the failure of demethylation caused by the loss of the control.

In both cases the loss of control could have the same reason. The MBs of the genes coding for housekeeping genes and possibly also the MBs of the housekeeping enzymes approach thermal equilibrium with the ordinary bio-matter.

How methylation could relate to aging in TGD framework?

1. Methylation could become irreversible during aging and lead to hypermethylation if MB loses the control of demethylation. If enzymes are the control tools of MB, the reduced transcription of DNAs coding for demethylases would lead to a failure of the control. The approach of MBs of DNA and enzymes to thermal equilibrium with ordinary biomatter could be the basic reason for the failure.

2. Housekeeping proteins are an especially important class of proteins since they catalyze basic biological functions necessary for the transcription of genes - also the genes coding form them. Their promoter regions are also almost always CpG islands. Therefore one can say that the methylation of their promoter regions would be a natural cause of various problems with housekeeping activities caused by aging.

3. CYP450 catalyzes generation of ROS in turn catalyzing demethylation and a large number of metabolic processes crucial for the functioning of the organism. In particular, demethylation could become less effective with aging due to the reduced level of CYP450. CYP450 is a housekeeping protein and the promoter regions of genes coding for CYP450 would be methylated. Methylation slows down transcription of CYP450 and this in turn slows down demethylation. This positive feedback loop eventually leads to a kind of death spiral.

4. Differential methylation of the hippocampus is known to be crucial for the memory recall (here memories are understood as learned behaviors rather than episodal memories) [J153]. Differential methylation is not possible without demethylation. If methylation becomes irreversible the formation of recallable memories becomes more difficult. Short term memory recall as also memory recall in longer time scales indeed become less effective during aging.

3.10.2 How epigenetic information is inherited?

There is evidence for the inheritance of epigenetic information.

1. Epigenetic inheritance takes place in mitosis and sometimes also in meiosis. The methylation related epigenetic disorder increases with aging.

2. How could the epigenetic information be inherited in this picture? It could be represented by the geometry of MB - flux tube network - and at the genetic level by both control genes. Emotional aspects, something new, would have bio-harmony as a correlate, and bio-harmony is determined by cyclotron frequencies determined by the magnetic field strengths of the flux tubes. Not only cell but also MB replicates and the replication of MB induces replication at cell and DNA level.

   Both genetic and epigenetic information could be inherited in the replication if MB replicates geometrically like a particle in the decay $A \to A+A$. Usually particles are regarded as pointlike and Feynman diagram expresses this. The line A decays to two lines A+A. This makes sense also for 3-surfaces, in particular magnetic bodies, replacing the point like particles. That replication occurs at the fundamental physics is a new element in TGD based vision.

   At the level of causal diamonds (CDs) $A \to A+A$ would look like follows. The CD of A in the initial state and the CDS of A+A in the final state would intersect and contain the vertex region. Could the moods of A be inherited by A:s in A+A under some conditions - in other words, are cyclotron frequency spectra of flux tubes of A inherited?: this is true i the flux tubes would replicate as such.

   Some methylation patterns are inherited in meiosis but not all. If these patterns are determined by the bio-harmony, magnetic flux tubes are copied faithfully in some cases even in meiosis but not always.

Chapter 4

Self and Binding: Part I

4.1 Introduction

The conflict between the non-determinism of state function reduction and determinism of time evolution of Schrödinger equation is serious enough a problem to motivate the attempt to extend physics to a theory of consciousness by raising the observer from an outsider to a key notion also at the level of physical theory by bringing in the notion of self. Further motivations come from the failure of the materialistic and reductionistic dogmas in attempts to understand consciousness in neuroscience context. There are reasons to doubt that standard quantum physics could be enough to achieve this goal and the new physics predicted by TGD is indeed central in the proposed theory.

4.1.1 Zero Energy Ontology

Zero Energy Ontology (ZEO) was forced by the interpretational problems created by the vacuum extremal property of Robertson-Walker cosmologies imbedded as 4-surfaces in $M^4 \times CP_2$ meaning that the density of inertial mass (but not gravitational mass) for these cosmologies was vanishing meaning a conflict with Equivalence Principle. In ZEO physical states are replaced by pairs of positive and negative energy states assigned to the past *resp.* future boundaries of causal diamonds (CDs) defined as intersections of future and past directed light-cones ($\delta M^4_\pm \times CP_2$). The net values of all conserved quantum numbers of zero energy states vanish. Zero energy states are interpreted as pairs of initial and final states of a physical event such as particle scattering so that only events appear in the new ontology.

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

ZEO (ZEO) means that one must distinguish between M-matrix and U-matrix. M-matrix characterizes the time like entanglement between positive and negative energy parts of zero energy state and is measured in particle scattering experiments. M-matrix need not be unitary and can be identified as a "complex" square root of density matrix representable as a product of its real and positive square root and of unitary S-matrix so that thermodynamics becomes part of quantum theory with thermodynamical ensemble being replaced with a zero energy state. The unitary U-matrix describes quantum transitions between zero energy states and is therefore something genuinely new. It is natural to assign the statistical description of intentional action with U-matrix since quantum jump occurs between zero energy states.

Quantum measurement theory based on ZEO can be said to imply the notion of self and to explaining basic aspects of consciousness when one includes also the hierarchy of Planck constants characterizing hierarchy of quantum criticalities. At the embedding space-level CD is the correlate

of self whereas space-time sheets having their ends at the light-like boundaries of CD are the correlates at the level of 4-D space-time. The hierarchy of CDs within CDs corresponds to the hierarchy of selves. Zero energy ontology leads also an argument explaining why the arrow of subjective time induces an apparent arrow of geometric time as a result if intentional action and why the contents of sensory consciousness is restricted to such a narrow time interval (located near the future boundary of CD).

4.1.2   Hierarchy Of Planck Constants

The hierarchy of Planck constants corresponds to a hierarchy $h_{eff} = n \times h$ [K36, **?**, K73]. The original hypothesis was that it corresponds to a hierarchy of singular coverings of embedding space $M^4 \times CP_2$- or rather - given causal diamond (CD).

     The recent view is that there is a hierarchy of quantum criticalities such that the sub-algebra of super-symplectic algebra for which conformal weights are n-ples of those for the entire algebra acts as conformal gauge symmetries at given level. Due to the resulting non-determinism the space-time surfaces connecting 3-surfaces at the opposite boundaries of CD are gauge degenerate and there are n conformal equivalence classes analogous to sheets of Riemann surface of $z^{1/n}$. This view has far reaching consequences. The hierarchy of quantum criticalities has an interpretation as that for macroscopic quantum phases and the phase transitions increasing n to its multiple occur spontaneously and generate also negentropy if NMP is assumed. Hence evolution can be seen as a gradual reduction of criticality occurring unavoidably.

     An alternative formulation [K97, K70, K73, **?**] emerged in terms of gravitational Planck constant $h_{gr} = GMm/v_0$, where v_0 is characteristic velocity in the system consisting of two masses involved, introduced originally by Nottale [E1] h_{gr} would be associated with the flux tubes connecting the two masses. Later it became clear that the identification $h_{eff} = h_{gr}$ leads to considerable insights in biology: in particular bio-photons can be identified as ordinary photons resulting from dark cyclotron photons with a universal energy spectrum.

     The book metaphor inspired by the original view about hierarchy of Planck constants is however very useful. The value of the Planck constant characterizes partially given page and arbitrary large values of $\hbar$ are predicted so that macroscopic quantum phases are possible since the fundamental quantum scales scale like $\hbar$. All particles in the vertices of Feynman diagrams have the same value of Planck constant so that particles at different pages cannot have local interactions. Thus one can speak about relative darkness in the sense that only the interactions mediated by the exchange of particles and by classical fields are possible between different pages. Dark matter in this sense can be observed, say through the classical gravitational and electromagnetic interactions. It is in principle possible to photograph dark matter by the exchange of photons which leak to another page of book, reflect, and leak back. This leakage corresponds to $\hbar$ changing phase transition occurring at quantum criticality and living matter is expected carry out these phase transitions routinely in bio-control. This picture leads to no obvious contradictions with what is really known about dark matter and to my opinion the basic difficulty in understanding of dark matter (and living matter) is the blind belief in standard quantum theory.

4.1.3   P-Adic Physics As Physics Of Cognition

p-Adic mass calculations relying on p-adic length scale hypothesis led to an understanding of elementary particle masses using only super-conformal symmetries and p-adic thermodynamics. The need to fuse real physics and various p-adic physics to single coherent whole led to a generalization of the notion of number obtained by gluing together reals and p-adics together along common rationals and algebraics (see fig. `http://tgdtheory.fi/appfigures/book.jpg`, which is also in the appendix of this `http://tgdtheory.fi/appfigures/book.jpg`). The interpretation of p-adic space-time sheets is as correlates for cognition. p-Adic and real space-time sheets intersect along common rationals and algebraics and the subset of these points could be called intersection of realities.

     In fact, the intersection can be interpreted in more abstract sense at the level of WCW as surfaces for which parameters (WCW coordinates) are such that the interpretation both as real and p-adic surface is possible. In this way one avoids discretization at space-time level. It has turned out that string world sheets and partonic 2-surfaces with defining parameters in an extension of

rationals define naturally the intersection and strong form of holography allows the continuation of these 2-surfaces to space-time surfaces.

The outcome is a vision about hierarchy extensions of rational numbers defining an evolutionary hierarchy. So called ramified primes associated with the extension define preferred primes identifiable as p-adic primes and weak form NMP allows to understand p-adic length scale hypothesis and its generalization stating that primes near powers of primes are favored by NMP.

There exists an infinite hierarchy of number theoretical entropies making sense for rational or even algebraic entanglement probabilities. In this case the entanglement negentropy can be negative so that NMP favors the generation of negentropic entanglement, which need not be bound state entanglement in standard sense. Negentropic entanglement might serve as a correlate for emotions like love and experience of understanding. The reduction of ordinary entanglement entropy to random final state implies second law at the level of ensemble. The generation of NE as the outcome of the reduction is not totally random process: the prediction is that second law need not universal truth holding true in all scales. To avoid making wrong conclusions about NMP, one must keep in mind that entanglement entropy is two-particle property whereas thermodynamical entropy is single partcle property.

Quantum measurement theory allows only final states, which have density matrices which are projectors so that the rational entanglement probabilities $p = 1/n$ are identical in this case. If the prime p divides n, one obtains negative entanglement entropy and one can say that entanglement is negentropic. Negentropy is largest for the largest power of prime dividing n and one could define entanglement entropy as that associated with this prime.

4.1.4 NMP

One obtains standard quantum measurement theory by assuming that the density matrix of the sub-system is the universal observable. In state function reduction this observable is measured and the system goes to an eigenstate of it. It can however happen that the eigenvalues are degenerate and in this case one can ask whether the reduction leads only to an eigen space so that entanglement characterized by a n-dimensional projection operator remains.

If p divides n, one obtains negative entanglement entropy and one can say that entanglement is negentropic. Negentropy is largest for the largest power of prime dividing n.

Negentropy Maximization Principle (NMP) [K56] codes for the dynamics of standard state function reduction and states that the state function reduction process following U-process gives rise to maximal reduction of entanglement entropy - or equivalently - gain of entanglement negentropy- at each step. In the generic case this implies decomposition of the system to unique unentangled systems and the process repeats itself for these systems. The process stops when the resulting subsystem cannot be decomposed to a pair of free systems since energy conservation makes the reduction of entanglement kinematically impossible in the case of bound states.

The interpretation is that NMP favors generation of negentropic entanglement (NE). One can of course argue that the generation of this kind of entanglement is extremely improbable. The hierarchy of Planck constants involving quantum criticality could however provide the way to generate it.

TGD inspired theory of consciousness forces to challenge the hypothesis that NMP always forces the state function reduction to the sub-space defined by the projector with maximal dimension appearing in the decomposition of the density matrix. NMP would not allow the self to make choices, which are bad deeds in the sense that they do not increase maximally the negentropic resources of the Universe. We would live in the best possible Universe becoming better all the time. This is obviously too good to be true.

The weak form of NMP allows the choice leading to maximal negentropy gain but allows also those choices for which the reduction occurs to a sub-space of the space defined by projector. When this sub-space is 1-dimensional standard quantum measurement results and the self is isolated from the target of observations. Negentropic entanglement has interpretation as attention with positively colored contents of consciousness. Experience of love would be one attribute of this kind of state. Weak form of NMP would be like God allowing the sinner to choose between Good and Evil.

Weak form of NMP turns out to have surprisingly strong consequences. For instance, by choosing the sub-space to have dimension given by power of prime, the state function reduction can yield a larger negentropy gain than otherwise. Primes near powers of prime as dimensions of final

state projector are optimal from the point of view of evolution since they give a large negentropy gain and generate large p p-adicity, which means higher evolutionary level in number theoretical sense: this result is nothing but a generalization of p-adic length scale hypothesis.

NMP generalizes also so that it applies to hyper-finite factors of type II_1 and also in this case it is possible to define negentropic entanglement. In this case entanglement negentropy is positive because the projector for the sub-space as dimension smaller than one as the inverse of the index of inclusion. The interpretation is that the degrees of freedom below measurement resolution carry NE characterized by the projector to the sub-space.

4.1.5   The Notion Of Self

The quantum notion of self solved several key problems of TGD inspired theory of consciousness but the precise definition of self has remained a long standing problem and I have been even ready to identify self with quantum jump. Zero energy ontology allows what looks a final solution of the problem. Self indeed corresponds to a sequence of quantum jumps integrating to single unit, but these quantum jumps correspond to state function reductions to a fixed boundary of CD leaving the corresponding parts of zero energy states invariant. In positive energy ontology these repeated state function reductions would have no effect on the state but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and gives rise to self. The first quantum jump to the opposite boundary corresponds to the act of free will or wake-up of self.

p-Adic physics as correlate for cognition leads to the notion of negentropic entanglement possible in the intersection of real and p-adic worlds involves experience about expansion of consciousness. Consistency with standard quantum measurement theory forces negentropic entanglement to correspond to density matrix proportional to unit matrix. Unitary entanglement typical for quantum computing systems gives rise to unitary entanglement. A natural conjecture is that the integer n in $h_{eff} = n \times h$ corresponds to the dimension of the unit matrix associated with negentropic entanglement. Also a connection with quantum criticality made possible by non-determinism of Kähler action and extended conformal invariance emerges so that there is high conceptual coherence between the new concepts inspired by TGD.

The identification of the imbedding space correlate of self as causal diamond (CD) of the embedding space combined with the identification of space-time correlates as space-time sheets inside CD solved the problems concerning the relationship between geometric and subjective time.

Subjective memory is assumed to correspond to an average of conscious experiences of quantum jumps occurred after the last wake-up of self (the first one in the sequence of state function reduction at same boundary of CD). This leads to the identification of qualia as averages of the increments of quantum numbers and zero modes in the ensemble of quantum jumps defining self. Summation hypothesis states that self X experiences the experiences of its subselves as abstracted experiences, averages X_{ij} about sub-subselves X_{ij}. Subselves of un-entangled selves can entangle (this is due to the many-sheeted sub-system concept) and this allows fusion and sharing of mental images.

Quantum entanglement provides a mechanism leading to the formation of irreducible wholes at the level of mental images. Entanglement can be entropic bound state entanglement or negentropic entanglement, which need not involve binding energy. The latter is possible only in the intersection of real and p-adic worlds where life can be said to reside and quantum criticality of TGD Universe accompanied by the hierarchy of Planck constants is essential for it. Quantum entanglement is possible also in time direction in zero energy ontology. It is tempting to assign negatively colored emotions to the entropic entanglement and positive emotions to the negentropic one. In TGD framework the standard vision about brain based on reductionistic-holistic dichotomy must be replaced with a trinity in which negentropic entanglement corresponds to a mode of cognition, which does not allow linguistic expression and episodal memories, and various mental feats of synesthetes and idiot savants could be seen as a manifestation of negentropic entanglement. Also meditative consciousness would be negentropic.

Selves are called irreducible if they possess no subselves, otherwise reducible. Subselves correspond to mental images so that irreducible subselves possess no mental images and are in a state of pure self-awareness: it is not clear whether this kind of states are possible in practice. When the subselves of self fuse to single negentropic subself, a state of "one-ness" results in somewhat

different sense. This mode of consciousness can be identified as "whole-body" consciousness and differs from ordinary consciousness during which self has large number of mental images. These modes could naturally explain emotional/holistic and rational modes of mind. These two modes could make it possible to understand various dichotomies like brain/left brain, emotional/analytic, religous/rational, Eastern/Western,... One could understand linear cognitive processes like thinking and language as self cascades in which self decomposes into subselves, which in turn decompose into subselves, which ... and self hierarchy implies connection with computationalism.

The possibility of negentropic entanglement (NE) has profound implications. It leads to a vision about learning as a basic quantum process possible in the intersection of real and p-adic worlds and made possible because state function reduction ceases to be a random process for negentropically entangled zero energy states. Quite concrete ideas about the role of synaptic transmission and neural transmitters for consciousness emerge. Music experience provides an especially interesting application for the vision about consciousness and zero energy ontology together with number theoretical vision inspires several concrete interpretations. Synchronous firing of neurons-in particular at 40 Hz frequency- is an attractive correlate for the negentropic entanglement and synesthesia can be interpreted as a particular manifestations of negentropic entanglement.

In TGD framework it is not at all obvious that the highest levels of our personal self hierarchy should correspond to the size of the physical body. Various empirical facts, in particular the observations related to the special effects of excitations of geomagnetic fields and ELF em fields in EEG frequency range on brain, inspire the hypothesis that our selves correspond to topological field quanta of em fields associated with EEG frequencies and thus by Uncertainty Principle have size scale of Earth. This leads to a rather radical modification of the brain centered views about consciousness, and one can quite seriously consider the questions like what physical death means from the point of view of consciousness: it could be that electromagnetic part of self hierarchy could survive after the physical death as a "soul".

This chapter is devoted to the theoretical aspects related to the definition of self. In second chapter applications of the notion of self are discussed. The plan of this chapter is as follows.

1. In the first section the notion of self is defined and various aspects related to it are discussed. This includes discussion about the flow and arrow of time, qualia, quantum model for intelligent systems, emotional representation of Boolean logic, the origins of ethics and moral as NMP allows to understand them, and self referentiality. Also the general structure of conscious experience is considered: self has sub-selves experienced as mental images and sharing and fusion of mental images is possible in many-sheeted space-time. Various aspects of binding are discussed in terms of negentropic entanglement. The basic prediction is entire self hierarchy and also the aspects related to this hierarchy are discussed.

2. Second section is devoted to a critical question: is NE experienced directly or does it only define a model of self and is it necessary to have a mechanism allow to make the information in question conscious. Although the most elegant assumption is that sequence of repeated state function reductions makes NE conscious, the possibility that interaction free measurement might be needed to achieve this, is discussed.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L17].

4.2 Quantum Self

The section introduces the definition of self, discusses the role of entanglement in binding, introduces the basic assumptions about the structure of conscious experience of self and some of their consequences.

The necessary conceptual background includes ZEO, hierarchy of Planck constants, fusion of real physics and p-adic physics to single coherent whole - adelic physics, the notion notion of negentropic entanglement, and weak form of NMP. These building bricks are discussed in the introduction.

4.2.1   Quantum Jump As Moment Of Consciousness

If quantum jump occurs between two different time evolutions of Schrödinger equation (understood here in very metaphorical sense) rather than interfering with single deterministic Schrödinger evolution, the basic problem of quantum measurement theory finds a resolution. The interpretation of quantum jump as a moment of consciousness means that volition and conscious experience are outside space-time and state space and that quantum states and space-time surfaces are "zombies". Quantum jump would have actually a complex anatomy corresponding to unitary process U, state function reduction and state preparation at least.

Quantum jump has a complex anatomy since it must include state preparation, state function reduction, and also unitary process characterized by U-matrix.

It took quite a long time to realize that state repeated state function reductions which do not change state at all in standard quantum measurement theory are quite essential for the notion of self and that the first state function reduction at the opposite boundary of CD corresponds to the state function reduction assigned with quantum measurement.

In ZEO the repeated state function reduction leave the passive boundary and the parts of the zero energy states at the passive boundary invariant whereas the active boundary and parts of states at it change. In other worlds, one has state function in the moduli space charactering the position of the active boundary (discrete Lorentz boosts leaving passive boundary invariant and discrete translations in the proper time distance between the tips of CD). Each repeated state function reduction corresponds to a unitary process inducing de-localization in these degrees of freedom and localization so that fixed CD results.

4.2.2   Definition Of Self In ZEO

Intuitively self corresponds to a sequence of quantum jumps which somehow integrates to a larger unit much like many-particle bound state is formed from more elementary building blocks. It also seems natural to assume that self stays conscious as long as it can avoid bound state entanglement with the environment in which case the reduction of entanglement is energetically impossible. One could say that everything is conscious and consciousness can be only lost when the system forms bound state entanglement with environment. Second intuitive view is that self is a subsystem able to remain un-entangled with the environment. This view can be subjected to criticism.

The precise definition of self has remained a long standing problem and I have been even ready to identify self with quantum jump. ZEO allows the most feasible candidate for the solution of the problem found hitherto.

In ZEO self indeed corresponds to a sequence of quantum jumps integrating to single unit, but these quantum jumps correspond state function reductions to a fixed boundary of CD leaving the corresponding parts of zero energy states invariant. In positive energy ontology these repeated state function reductions would have no effect on the state but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and also to self. One can also identify the age of self as the increase of the distance between the tips of CD. The first quantum jump to the opposite boundary corresponds to the act of free will or death of self and re-incarnation of self at the opposite boundary of CD.

The part of zero energy state at the fixed boundary is stable so that it indeed represents a system able to remain un-entangled. All entanglement associated with the passive boundary is either negentropic or bound state entanglement since state function reduction produced it destroys non-negentropic entanglement unless it is bound state entanglement.

Since number theoretic entropies are natural in the intersection of real and p-adic worlds, this suggests that life resides in this intersection identifiable in terms of string world sheets and partonic 2-surfaces. A natural assumption is that self experiences expansion of consciousness as it entangles negentropically. Quite generally, an infinite self hierarchy with the entire Universe at the top is predicted.

Self is assumed to experience sub-selves as mental images identifiable as "averages" of their mental images (sub-sub-selves of self). This implies the notion of ageing of mental images as being due to the growth of ensemble entropy as the ensemble consisting of quantum jumps (sub-sub-sub-selves) increases.

The hierarchy of Planck constants interpreted in terms of dark matter hierarchy predicts

a hierarchy of quantum jumps ad self such that the size of space-time region contributing to the contents of conscious experience scales like $\hbar$. Also the hierarchy of space-time sheets labeled by p-adic primes suggests the same. That sequence of sub-selves/sub-quantum jumps are experienced as separate mental images explains why we can distinguish between digits of phone number. The irreducible component of self (pure awareness) would correspond to the highest level in the "personal" hierarchy of quantum jumps and the sequence of lower level quantum jumps would be responsible for the experience of time flow. Entire life cycle would correspond to single quantum jump at the highest(?) level of the personal self hierarchy and pure awareness would prevail during sleep: this would make it possible to experience directly that I existed yesterday.

Dark matter hierarchy and p-adic length scale hierarchy would provide a quantitative formulation for the self hierarchy. To a given p-adic length scale one can assign a secondary p-adic time scale as the temporal distance between the tips of the causal diamond (pair of future and past directed light-cones in $H = M^4 \times CP_2$). For electron this time scale is.1 second, the fundamental biorhythm. For a given p-adic length scale dark matter hierarchy gives rise to additional time scales coming as $\hbar/\hbar_0$ multiples of this time scale.

4.2.3   Two Variants For The Notion Of Self

I have considered two basic notions of "self".

1. In the original variant of the theory "self" corresponds to a sequence of quantum jumps. "Self" would result through a binding of quantum jumps to single "string" in close analogy and actually in a concrete correspondence with the formation of bound states. Each quantum jump has a fractal structure: unitary process is followed by a sequence of state function reductions and preparations proceeding from long to short scales. Selves can have sub-selves and one has self hierarchy. The questionable assumption is that self remains conscious only as long as it is able to avoid entanglement with environment.

   Even slightest entanglement would destroy self unless on introduces the notion of finite measurement resolution applying also to entanglement. This notion is indeed central for entire quantum TGD also leads to the notion of sharing of mental images: selves unentangled in the given measurement resolution can experience shared mental images resulting as fusion of sub-selves by entanglement not visible in the resolution used.

   ZEO solves this problem. The sequence of quantum jumps defining self consist of only those for which state function reduction takes place on fixed boundary of CD! In ordinary quantum measurement theory these state function reductions would have no effect on state. Now however the wave function characterizing the position of the second boundary of CD disperses towards "geometric future" of the fixed boundary. Geometric time corresponds to the proper time distance between the tips of CD whose quantum average value increases. Self corresponds to this sequence of quantum jumps and indeed remains unentangled at the fixed boundary and also experiences flow of geometric time with definite arrow.

2. According to the later variant of theory, quantum jump has a fractal structure so that there are quantum jumps within quantum jumps: this hierarchy of quantum jumps within quantum jumps would correspond to the hierarchy of dark matters labeled by the values of Planck constant. Each fractal structure of this kind would have highest level (largest Planck constant) and this level would corresponds to the self. What might be called irreducible self would corresponds to a quantum jump without any sub-quantum jumps (no mental images). The quantum jump sequence for lower levels of dark matter hierarchy would create the experience of flow of subjective time.

   It would be nice to reduce the original notion of self hierarchy to the hierarchy defined by quantum jumps but there are some objections against this idea. Quantum jumps as moment of consciousness should indeed be a moment as we understand moment! One can argue that fractality is a purely geometric notion and since subjective experience does not reduce to the geometry it might be that the notion of fractal quantum jump does not make sense. It is also not quite clear whether the reasonable looking idea about the role of entanglement as destroyer of self can be kept in the fractal picture.

The first view about self, which I believe is nearer to the correct one, does not exclude the hierarchy of selves, and one should be also in this case able to construct a well-defined mathematical scheme allowing to understand what fractality of quantum jumps and selves at the level of space-time correlates could mean. The following argument represents such a proposal.

Let us start from the CD model as a lowest approximation for a model of zero energy states and for the space-time region defining the contents of sensory experience and allow wave function in the moduli space of CDs essential for the new view about arrow of time and self.

Let us make the following assumptions.

1. Assume the hierarchy of CDs within CDs in a sense to be specified more precisely below. CDs would represent the volumes of attention. Assume that the highest level in this hierarchy defines the quantum jump containing sequences of lower level quantum jumps in some sense to be specified. Assume that these quantum jumps integrate to single continuous stream of consciousness as long as the sub...-sub-self in question remains unentangled and that entangling means loss of consciousness or at least that it is not possible to remember anything about contents of consciousness during entangled state.

2. Assume that the contents of conscious experience come from the interior of the CD. A stronger condition would be that the contents come from the boundaries of the two light-cones involved since physical states are defined at these in the simplest picture. In this case one could identify the lower light-cone boundary as giving rise to memory.

3. The time span characterizing the contents of conscious experience associated with a given quantum jump would correspond to average temporal distance T between the tips of the CD in the wave function in space of CDs. The lifetime of self corresponds to the quantum average for the increase ΔT during the sequence of state function reductions to a fixed boundary of CD. A reasonable guess is that ΔT is of same order as T.

4. We know that the contents of sensory experience comes from a rather narrow time interval of duration about.1 seconds, which corresponds to the time scale T_{127} associated with electron. We also know that there is asymmetry between positive and negative energy parts of zero energy states both physically and at the level of conscious experience. This asymmetry must have some space-time correlate. The simplest correlate for the asymmetry between positive and negative energy states would be that the upper light-like boundaries in the structure formed by light-cones within light-cones intersect along light-like radial geodesic. No condition of this kind would be posed on lower light-cone boundaries. The scaling invariance of this condition makes it attractive mathematically and would mean that arbitrarily long time scales T_n can be present in the fractal hierarchy of light cones. At all levels of the hierarchy all contribution from upper boundary of the CD to the conscious experience would come from boundary of same past directed light-cone so that the conscious experience would be sharply localized in time in the manner as we know it to be. The new element would be that content of conscious experience would come from arbitrarily large region of Universe and seing Milky Way would mean direct sensory contact with it.

5. These assumptions relate the hierarchy of quantum jumps to p-adic hierarchy. One can also include also dark matter hierarchy into the picture. For dark matter hierarchy the time scale hierarchy $\{T_n\}$ is scaled by the factor $r = \hbar/\hbar_0$ which can be also rational number. For $r = 2^k$ the hierarchy of CDs generalizes without difficulty and there is a kind of resonance involved which might relate to the fact that the model of EEG favors the values of $k = 11n$, where $k = 11$ also corresponds in good approximation to proton-electron mass ratio. For more general values of $\hbar/\hbar_0$ the generalization is possible assuming that the position of the upper tip of CD is chosen in such a way that their positions are always the same whereas the position of the lower light-cone boundary would correspond to $\{rT_n\}$ for given value of Planck constant. Geometrically this picture generalizes the original idea about fractal hierarchy of quantum jumps so that it contains both p-adic hierarchy and hierarchy of Planck constants.

The contributions from lower the boundaries identifiable in terms of memories would correspond to different time scales and for a given value of time scale T the net contribution to conscious

experience would be much weaker than the sensory input in general. The asymmetry between geometric now and geometric past would be present for all contributions to conscious experience, not only sensory ones. What is nice that classically the contents of conscious experience would rather literally come from the boundary of the past directed light-cone along which the classical signals arrive (not however that this boundary disperses to future). Hence the mystic feeling about telepathic connection with a distant object at distance of billions of light years expressed by an astrophysicist, whose name I have unfortunately forgotten, would not be romantic self deception.

This framework explains also the sharp distinction between geometric future and past (not surprisingly since energy and time are dual): this distinction has also been a long standing problem of TGD inspired theory of consciousness. Precognition is not possible unless one assumes that communications and sharing of mental images between selves inside disjoint CDs is possible. Physically there seems to be no good reason to exclude the interaction between zero energy states associated with disjoint CDs (see **Fig. `http://tgdtheory.fi/appfigures/sharing.jpg`** or **Fig. ??** in the appendix of this book).

This scenario allows also to answers the questions related to a more precise definition of volume of attention. Causal diamond - or rather - the associated light-like boundaries containing positive and negative energy states define the primitive volume of attention. The obvious question whether the attention of a given self is doomed to be fixed to a fixed volume can be also answered. This is not the case. Selves can de-localize in the sense that there is a wave function associated with the position of the CD and quantum jumps changing this position are possible. Also many-particle states assignable to a union of several CDs are possible. Note that the identification of magnetic flux tubes as space-time correlates of directed attention in TGD inspired quantum biology makes sense if these flux tubes connect different CDs. The directedness of attention in this sense should be also understood: it could be induced from the ordering of p-adic primes and Planck constant: directed attention would be always from a longer to shorter scale.

4.2.4   Basic Consequences Of The Definition Of Self

Summation hypothesis, when combined with the mechanism for the formation of abstractions and mechanism of subjective memory, has rather nontrivial consequences.

Self, psychological time and its arrow

There are many difficult questions related to the relationship between subjective and geometric time. How the arrow of subjective time is mapped to the arrow of geometric time? How to understand the sharp distinction between geometric future and past at the level of conscious experience? What is the average interval of geometric time assignable to quantum jump and how it depends on the p-adic prime p characterizing system and on the value of Planck constant? Can one assign to quantum jumps space-time region about which the contents of conscious experience are, and how the temporal and spatial scales of this region depend on p and the value of Planck constant?

The emergence of ZEO and hierarchy of Planck constants provides to my opinion the most convincing partial answers to these questions found hitherto. the answers are not final however as the considerations of last section demonstrate.

1. Zero energy state is identifiable in positive energy ontology as a physical event, say elementary particle scattering such that positive and negative energy parts of the state correspond to the initial and final states of the event. The geometric correlate is a CD formed by a pair of future and past directed light-cones of M^4 and corresponds to a region of the embedding space rather than that of space-time.

2. The temporal distance T between the tips of the CD brings to physics a new time scale and simple argument predicts p-adic length scale hypothesis (favored primes p satisfy $p \simeq 2^k$, k prime), and that the minimal value of T for elementary particles corresponds to secondary p-adic time scale $T_{2,p} = \sqrt{p} T_p$. For nonstandard values of $\hbar$ T scales like $\hbar/\hbar_0$. In the case of zero energy state describing electron this time scale is.1 seconds and corresponds to the 10 Hz frequency defining the fundamental biorhythm, and the duration of moment of sensory experience.

3. The simplest explanation for the arrow of geometric time relies on the view about self as a sequence of repeated reductions at fixed boundary of CD. The sequence involves unitary evolution in the moduli space of the active boundary and is essentially dispersion. Each reduction means localization in the moduli space of CDs and by purely geometric argument the distance beween the tips of CD tends to increases. This distance defines the age of self and the arrow of phychological times means its average increase. In the first state function reduction to the opposite boundary of CD the arrow of geometric time changes but the distance between the tips increases also in this reduction.

4. There is a strong analogy with cosmic time and a natural proposal is that the quantum counterpart for cosmic time correspond to this kind of parameter for a very large CD. The relative positions of the of tips define part of the moduli space of CD and this space is discrete by number theoretical universality and correspond to a tessellations assignable to cosmic time constant hyperboloid having discrete algebraic subgroup of Lorentz group as isometry group. The hierarchy of tessellations is expected to relate to the hierarchy of algebraic extensions of rationals defining an evolutionary hierarchy. This would predict quantization of redshifts in cosmology.

Qualia

Since physical states are labeled by quantum numbers, various qualia correspond naturally to the increments of quantum numbers in quantum jump which leads to a general classification of qualia in terms of the fundamental symmetries [K39]. One can speak also about geometric qualia assignable to the increments of zero modes which correspond to the classical variables in ordinary quantum measurement theory and non-quantum fluctuating degrees of freedom which do not contribute to the metric of world of classical worlds (WCW) in TGD framework. Dark matter hierarchy suggests that also qualia form a hierarchy with larger values of Planck constant identifiable as more refined qualia. Rather amusingly, visual colors would correspond to increments of color quantum numbers assignable to quarks and gluons in standard model physics. The term "color", originally introduced as an algebraic joke, would directly relate to visual color.

NMP demands that self generates NE. One manner to achieve this is by performing a state function reduction to opposite boundary of CD meaning death and re-incarnation of self. The more pleasant option is to become an NE gatherer so that negentropic mental images are created: selves try to eat other selves to get negentropic sub-selves. This is nothing but metabolism with metabolites identifiable as negentropic carriers of quantum numbers. Fundamental qualia would correspond to quantum numbers for metabolites.

Quantum model for intelligent system

The concept of self provides justification for the assumptions behind the quantum model for intelligent systems [K22]. One can understand at very general level the mechanism for how universe forms abstractions about itself. Even the basic hierarchical structures of language could be identified in terms of Russian doll like structure formed by selves with phonemes possibly representing the lowest level selves in case of language. The possibility of NE possible in the intersection of real and p-adic worlds is perhaps the most important new element and makes possible the identification of quantum correlates of rules and abstractions. The intersection is number theoretically universal so that the number field assigned with it is some extension of rationals depending on the evolutionary level. NE in the intersection defines symbolic (real) and cognitive representations (p-adic) accompanying each other. Time-like negentropic entanglement between boundaries of CD in fermionic degrees of freedom is in principle also possible and would provide a natural representation for a Boolean rule $A \to B$ with paired instances of A and B represented by state pairs.

The close connection with the computationalistic approach to psychology and consciousness is obvious. The hierarchy of selves is analogous to a hierarchy of higher level computer languages. Note also the analogy with the hierarchy of the modules of a computer program. Selves could be interpreted as symbolic representations for the objects of external (and internal) world and cascades of selves generating selves inside selves provide a model for sensory experience and cognition. This model provides also a possible representation for logical implication sequences as temporally

ordered sequences generating sub-selves. NE between selves is a good candidate for representing how wholes are formed from parts consciously as also for the formation of associations. Abstraction process emerges naturally as a formation of quantum average selves about the sub-sub-selves of self. Zero energy ontology is ideal for construction of hierarchies as negentropically entangled states formed from zero energy states formed from....

NE and also quantum statistical determinism makes possible reliable thinking and sensory experiencing at the level of self and one could in principle model brain and sensory organs as ensembles of sub-sub-systems for which quantum measurement of certain observables occurs in quantum jump leading to the thought or sensory experience [K22]. For negentropic entanglement the outcome of the state function reduction is rather deterministic but U process can generate ensemble since one can obtain from a given negentropically entangled state new ones by permuting the entangled state pairs. This kind of transformation makes possible to realize quantum computations using negentropic qubits formed by entangled positive and negative energy parts of the state [K56]. Biological quantum computation could be rely on this kind of fuzzy qubits and the model of DNA as a topological quantum computer [K2] can be formulated in terms of negentropic qubits. What is especially nice is that temporal statistical averages become possible since mind-like space-time sheets can have also time-like distance: thus individual can learn form experience if temporal ensemble of cognitive space-time sheets is available.

Do positively colored emotions allow a representation of Boolean logic?

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

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

1. There should be a mapping of k-dimensional subspaces of n-dimensional space to the fermionic representation of Boolean algebra

2. Could one speak about a hierarchies of codes of cognition based on the assignment of different degrees of "feeling good" to the Boolean statements? If one assumes that the n:th bit is always 1, all independent statements except one correspond at least two non-vanishing bits and corresponds to negentropic entanglement. Only of statement (only last bit equal to 1) would correspond 1 bit and to state function reduction reducing the entanglement completely (brings in mind the fruit in the tree of Good and Bad Knowlege!).

3. A given hierarchy of breakings of super-symplectic symmetry corresponds to a hierarchy of integers $n_{i+1} = \prod_{k \leq i} m_k$. The codons of the first code would consist of sequences of m_1 bits. The codons of the second code consists of m_2 codons of the first code and so on. One would have a hierarchy in which codons of previous level become the letters of the code words at the next level of the hierarchy.

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

1. The hierarchy starting from $M_2 = 3$ contains the Mersenne primes $3, 7, 127, 2^{127} - 1$ and Hilbert conjectured that all these integers are primes. These numbers are almost dimensions of Boolean algebras with $n = 2, 3, 7, 127$ bits. The maximal Boolean sub-algebras have $m = n - 1 = 1, 2, 6, 126$ bits.

2. The observation that $m = 6$ gives 64 elements led to the proposal that it corresponds to a Boolean algebraic assignable to genetic code and that the sub-algebra represents maximal number of independent statements defining analogs of axioms. The remaining elements would correspond to negations of these statements. I also proposed that the Boolean algebra with $m = 126 = 6 \times 21$ bits (21 pieces consisting of 6 bits) corresponds to what I called memetic code obviously realizable as sequences of 21 DNA codons with stop codons included. Emotions and information are closely related and peptides are regarded as both information molecules and molecules of emotion.

3. This hierarchy of codes would have the additional property that the Boolean algebra at $n + 1$:th level can be regarded as the set of statements about statements of the previous level. One would have a hierarchy representing thoughts about thoughts about.... It should be emphasized that there is no need to assume that the Hilbert's conjecture is true.

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

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

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

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

How memories are represented and recalled?

Formation of memories and memory recall are key elements in the vision proposed by Hawkins [J83]. The question is what memories and memory recall are. If quantum jump is the fundamental process, it should automatically give rise to memories and memory recall.

1. Memories in given scale would naturally correspond to sequences of mental images defined by negentropically entangled sub-CDs of CD in given scale. According to earlier view the sequences of moments of consciousness bind to form higher level moments of consciousness, selves. Somewhat different view is that formation of selves means formation of sequence of

negentropically entangled sub-CDs stable against NMP and preserved in quantum jump and even increasing in size. Thus self would correspond to a property of state and consciousness would be associated with the replacement of state with a new one.

2. The hierarchical structure of memories would emerge naturally. Conscious memory recall would correspond to a generation of negentropic entanglement between the new mental images emerging in the state function reduction (recall that the sizes of CDs increase and new sub-CDs emerge) and already existing negentropically entangled mental images. Generation of negentropic entanglement would give rise to the experience of recognition of the new mental images.

3. The natural guess is that negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) is generated if the new sensory input is "consistent" with older mental images. The addition of new tensor factor would mean a more abstract representation so that the sequence of quantum jumps would mean accumulation of experience. Consistency with older mental images could mean that the mental images have same "name". The name could correspond to p-adic cognitive representation. The physical correlate could be a collection of resonance frequencies. The names would be same if the frequencies for older mental images and new one are same, so that resonant interactions becomes possible. The generation of negentropic entanglement would be like finding a radio station.

For this proposal memory recall and memory formation are actually more or less the same thing. Only the completely new memories claimed to be formed in hippocampus would not involve memory recall. The new memory would correspond to a new sub-CD or ensemble of sub-CDs representing the associated negentropically entangled mental images. Neuronal loop could make possible to build copies about the new memory and thinking about it would create copies of corresponding p-adic cognitive representations which in turn could be transformed via state function reduction to an opposite boundary of CD to actions. In TGD framework the 4-D hierarchy of memories could continue from hippocampus to the magnetic body: this would explain the correlation of EEG with memory and also with various other brain functions.

Self as a moral agent

There are many ways to interpret evolution in TGD Universe.

1. p-Adic evolution would mean a gradual increase of the infinite p-adic prime characterizing the entire universe implying the gradual increase of p-adic primes characterizing individual partonic 2-surfaces and therefore their size. Infinite primes at the n:th level of hierarchy defining the analogs of bound states of multiply second quantized arithmetic quantum field theory can be mapped to irreducible polynomials of n variables and for $n = 1$ they define irreducible extensions of rationals. Infinite integers in turn define polynomials giving rise to reducible extensions of rationals. Hence infinite primes having interpretation in terms of bound states define levels of the hierarchy of algebraic extensions defining evolutionary hierarchy.

2. The hierarchy of Planck constants suggests evolution as the gradual increase of the Planck constant characterizing p-adic space-time sheet (or partonic 2-surface for the minimal option). This evolution could be seen as a migration to the pages of the book like structure defined by the generalized embedding space and has therefore quite concrete geometric meaning. It implies longer time scales of long term memory and planned action and macroscopic quantum coherence in longer scales.

3. The vision about life as something in the intersection of real and p-adic words allows to see evolution information theoretically as the increase of number entanglement negentropy implying entanglement in increasing length scales. This option is consistent with the first one if the effective p-adic topology characterizes the real partonic 2-surfaces in the intersection of p-adic and real worlds. The singular coverings of CD s and CP_2 are characterized by an Abelian group Z_n permuting the sheets of the covering and corresponds naturally to powers

of the (quantum) phase $q = exp(i2\pi/n)$ allowing to define the notion of angle in p-adic context but only with a finite resolution since only finite number of angles are represented as phases for a given value of n. The increase of the integers n could be interpreted as the emergence of higher algebraic extensions of p-adic numbers in the intersection of the real and p-adic worlds. These observations suggest that all three views about evolution are closely related.

The third kind of evolution would mean also the evolution of spiritual consciousness if the proposed interpretation is correct. In each quantum jump U-process generates a superposition of states in which any sub-system can have both real and algebraic entanglement with the external world. If state function redution process involves also the choice of the type of entanglement it could be interpreted as a choice between good and evil. The hedonistic complete freedom resulting as the entanglement entropy is reduced to zero on one hand, and the algebraic bound state entanglement implying correlations with the external world and meaning giving up the maximal freedom on the other hand. The selfish option has the risk of leading to non-algebraic bound state entanglement implying a loss of consciousness: death as the prize of sin. The second option means expansion of consciousness - a fusion to the ocean of consciousness as described by spiritual practices.

In this framework one could therefore understand the physics correlates of ethics and moral. The ethics is simple: evolution of consciousness to higher levels is a good thing. Anything which tends to reduce consciousness represents violence and is a bad thing. Moral rules are related to the relationship between individual and society and presumably develop via self-organization process and are by no means unique. Moral rules however tend to optimize evolution. As blind normative rules they can however become a source of violence identified as any action which reduces the level of consciousness.

Weak form of NMP indeed allows the self to choose between good and evil since the reduction need not take place to the maximal dimension n_{max} defined by the projector in question but also to sub-spaces. This in fact allows to have larger negentropy gains as strong form of NMP: when n_{max} is product of primes it can happen that some smaller integer has larger power of prime as a factor so that negentropy gain is larger. The choice $n = 1$ means vanishing negentropy gain and implies isolation of self. Weak form of NMP makes also possible realization of Boolean algebra in terms of the lattice of sub-spaces of the n_{max}-dimensional space: only that $n = 0$ case is excluded so that one has $2^{n_{max}} - 1$ choices. In set theoretic representation of Boolean algebra this option corresponds to empty set.

There is an entire hierarchy of selves and every self has the selfish desire to survive and moral rules develop as a kind of compromise and evolve all the time. The need to satisfy the needs of NMP without dying (this in general means increase of negentropy) has led to the discovery of metabolism as the fundamental form of crime! Self can eat other selves and in this manner gain the NE of sub-selves and live longer. This has the positive outcome that self makes possible for its sub-selves (mental images) to evolve via repeated death and re-incarnations. Replication of magnetic bodies having concrete counterpart as splitting of 3-surfaces analogous to 3-particle vertex of Feynman diagram is another discovery making it possible for selves to replicate.

The newest progress in this evolution is brought by the cosmology of consciousness, which forces to extend the concept of society to four-dimensional society! The decisions of "me now" affect both my past and future and time like quantum entanglement makes possible conscious communication in time direction by sharing conscious experiences. One can therefore speak of genuinely four-dimensional society. Besides my next-door neighbors I had better to take into account also my nearest neighbors in past and future (the nearest ones being perhaps copies of me!). If I make wrong decisions those copies of me in future and past will suffer the most. Perhaps my personal hell and paradise are here and are created mostly by me.

Selves can make plans since they have 4-dimensional geometric memory (conscious experience contains information about a *four-dimensional* space-time region, rather than only time=constant snapshot, and gives rise to a "prophecy", a prediction for the future and past, which would be reliable if the world were completely classical). As a matter fact, it is p-adic space-time sheets which correspond to intentions and plans and act of volition transforms p-adic space-time sheet to a real one. Selves can make decisions and select between various classical macroscopic time developments. Selves are able to remember their choices since they have subjective memories about the previous quantum jumps. Thus selves are genuine moral agents.

Self-referentiality of consciousness and evolution

Quantum classical correspondence is the basic guiding principle of quantum TGD. Thanks to the failure of a complete determinism of classical dynamics, space-time surface can provide symbolic representations not only for quantum states (as maximal deterministic regions) but also for quantum jump sequences (sequences of quantum states) and thus for the contents of consciousness. These representations are regenerated in each quantum jump, and make possible the self referentiality of consciousness: self can be conscious of what it *was* conscious of. This allows to avoid infinite regress and replaced it with endless evolution.

Evolution in turn involves several aspects. The increase of the complexity of the algebraic extension of rationals in the intersection of reality and p-adicities and by strong form of holography identifiables as string world sheets and partonic 2-surfaces whose parameters (WCW coordinates essentially) are in the extension. The ramified primes in the extension define the preferred primes.

In strong form of holography p-adic continuations of 2-surfaces to preferred extrmals identifiable as imaginations would be easy due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K64]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes.

NMP leads to a generalizations of p-adic length scale hypothesis stating that primes near powers of prime are favoured. Generation of NE defining Akashic records is a one aspect of evolution. Increase of Planck constant $h_{eff} = n \times h$ and thus size scale of macroscopic quantum systems and CDs serving as correlates of selves is second aspect of evolution.

4.2.5   General Structure Of Conscious Experience

Combining summation hypothesis and the hypothesis about subjective memory one can understand quite a lot about the phenomenology of consciousness.

Summation hypothesis

Binding of selves by entanglement and summation hypothesis are the basic assumptions about the structure of contents of consciousness of self. Unentangled sub-system X possessing self behaves essentially as a separate sub-Universe with respect to NMP. This means that unentangled sub-systems X_i of X, in particular sub-selves, participate in each quantum jump. If one postulates that the conscious experiences of sub-systems X_i of unentangled sub-system X integrate with the self experience of X to form single experience, one obtains a filtered hierarchy of conscious experiences with increasingly richer contents. The integrated experience cannot a simple sum of individual experiences of sub-selves (we do not experience the conscious experiences of neurons separately). Rather, the experience of X is most naturally sum of abstractions about experiences of X_i. A natural hypothesis is that X forms kind of abstraction or average $\langle X_{ij} \rangle$ about the experiences of sub-selves X_{ij} of X_i representing what it is to be average X_{ij}, that is average over the mental images of X_i.

This kind of mechanism would explain why we do not experience the experiences of individual neurons, microtubules, DNA: s, etc... as a huge multitude of separate experiences and do note get drowned to useless information. Combining summation hypothesis with the hypothesis about subjective memory (described in previous section), one can understand self as an object having genuine extension in subjective time. In particular, it is possible to identify short term memory as a subjective memory. Also temporal average in geometric sense is possible since mind-like space-time sheets can have also time-like separation.

A challenge for the hypothesis of self and summation hypothesis is provided by split brain patients [J19]. It seems that in most serious cases either right or left half dominates the behavior of the split brain patient and communication between brain hemispheres is lacking. It is known that brain hemispheres learn to communicate indirectly. Is the hypothesis about summation of the right and left selves to form mental images of a higher self ireally consistent with the behaviour of split brain patients?

1. The dominance of either hemisphere is highly analogous to the dominance of a person over another one. The sudden changes of personality can be understood as result of different cognitive specializations of the two hemispheres. The lacking information transfer between hemispheres explains why right and left brain behave so differently (to the extend that they can have different future plans!). It is well known that in early childhood hemispheres behave as separate personalities and certain period in the learning of language seems to involve communication between brain hemispheres: left hemisphere comments what right hemisphere is doing. This kind of direct communication usually ceases, when the direct physical connection between brain hemispheres has developed.

2. One must of course ask what "dominance" really means. A possible definition is based on the notion of self hierarchy and magnetic body as intentional agent. Magnetic body could direct its attention in normal circumstances to either left hemisphere or right hemisphere or both if they are entangled (entropically or negentropically). The unattended hemisphere could be conscious but would not contribute to the conscious experience of the magnetic body representing us. Corpus callosum- the axon bundle connecting right and left hemisphere- would serve as a natural correlate for their entanglement, which should be negentropic in the normal situation. Quite generally, axons would serve as correlates for the entanglement so that also sensory receptors would be in this sense part of the brain. Note that this would make possible macroscopic quantum coherence between distance parts of body and brain and the regions of quantum coherence would be highly irregular.

3. The alternating hemisphere dominance characterizes also healthy persons and could provide magnetic body with three different views about world corresponding to hawks and doves and those between. Problems begin when either hemisphere dominates for too long time. For instance, for schizophrenics the time of dominance is longer than normally. For split brain patients the absence of physical connection between hemispheres makes impossible quantum entanglement binding the hemispheres together to form single coherent whole and the body of the patient is inhabited by two persons. The length of time-interval during which given hemisphere contributes to our conscious experience could be rather short. Interestingly, in the case of dolphins and some birds the second hemisphere sleeps. Is this for metabolic reasons or is the second hemisphere entangled with the collective consciousness of the dolphin horde? The theory of bicameral mind assumes that human consciousness before the evolution of language was dominated by another hemisphere entangled with collective level of consciousness. I have discussed a model of bicamerality in the earlier formulation of TGD inspired theory of consciousness in [K91, K92]. One can of course whether that dolphins could represent a modern example about bi-cameral consciousness.

Sharing and fusion of mental images

The standard dogma about consciousness is that it is completely private. It seems that this cannot be the case in TGD Universe. Von Neumann algebras known as hyper-finite factors of type II_1 (HFF) [K120, K36] provide the basic mathematical framework for quantum TGD and this suggests important modifications of the standard measurement theory besides those implied by the zero energy ontology predicting that all physical states have vanishing net quantum numbers and are creatable from vacuum. The notion of measurement resolution characterized in terms of Jones inclusions $\mathcal{N} \subset \mathcal{M}$ of HFFs implies that entanglement is defined always modulo some resolution characterized by infinite-dimensional sub-Clifford algebra $\mathcal{N}$ playing a role analogous to that of gauge algebra.

This modification has also important implications for consciousness. For ordinary quantum measurement theory separate selves are by definition unentangled and the same applies to their sub-selves so that they cannot entangle and thus fuse and shared mental images are impossible: consciousness would be completely private.

Space-time sheets as correlates for selves however suggests that space-time sheets topologically condensed at larger space-time sheets and serving as space-time correlates for mental images can be connected by flux tubes so that mental images could fuse and be shared.

HFFs allow to realize mathematically this intuitive picture. The entanglement in $\mathcal{N}$ degrees of freedom between selves corresponding to $\mathcal{M}$ is below the measurement resolution so that these

selves can be regarded as separate conscious entities. These selves can be said to be unentangled although their sub-selves corresponding to $\mathcal{N}$ (mental images at upper level) can entangle. Fusion and sharing of mental images becomes possible. For instance, in stereo vision right and left visual fields would fuse together. More generally, a pool of shared stereo mental images might be fundamental for evolution of social structures and development of social and moral rules and language (shared mental images make possible common meaning for symbols of language). A concrete realization for this would be in terms of hyper-genome making possible collective gene expression [K41, K51].

Self as a statistical ensemble, emotions, and qualia

The sequence of quantum jumps defining self defines also a sequence of completely unentangled quantum states resulting in the state reduction process governed by NMP. This set of states, which grows in size quantum jump by quantum jump, defines in a natural manner a statistical ensemble identifiable as the fundamental realization of the otherwise fictive notion of statistical ensemble fundamental in the formulation of statistical physics. As far as conscious experience is involved, it seems that it is the increments of quantum numbers and zero modes which are the relevant statistical variables.

This observation anchors the theory of conscious experience to statistical physics [K39]. For instance, the increments of zero modes resp. quantum numbers are responsible for geometric resp. non-geometric qualia. More precisely, the gradients with respect to subjective time for the zero modes and for the net quantum numbers associated with selves correspond to qualia. One can classify non-geometric qualia to kinesthetic qualia (sense of pressure and force and, more generally, gradient of any conserved (with respect to geometric time) quantity associated with self with respect to subjective time); and generalized chemical qualia (rates for the changes of numbers of particles with various quantum numbers). Various entropies associated with self and sub-selves in turn characterize the sharpness of the mental images, and one can relate concepts like attentiveness, alertness and the level of arousal to these variables.

Statistical aspect could be involved with sensory experiences also in the sense of ensemble averaging. For instance, various cones of retina are sensitive to different wavelength regions (red, green, blue) and their experiences must correspond to different colors. Therefore our color experience, which corresponds to average color, should be abstraction about experiences of a small group of retinal cells. Ensemble averaging could be present in case of sense such as temperature and pressure sense. Also temporal averaging with respect to *geometric* time would be made possible by mind-like space-time sheets and could be present.

The original proposal was that emotions some kind of qualia since also ordinary qualia have the characteristic black-white dichotomies. What is clear that emotions relate very closely to information. For instance, peptides are both informational molecules and molecules of emotion [J43]. This suggests that positive-negative dichotomy for emotions correlates directly with negentropic-entropic dichotomy for entanglement. For instance, the neurotransmitters producing positive (negative) emotions would generate negentropic (entropic) entanglement. The fate of the right amygdala would be a specialization to experience negative emotions by entangling mostly by bound state entanglement whereas left amygdala specialized to positive emotions would enjoy the negentropic entanglement.

In positive energy ontology it seems impossible to have quantum coherence in human time scales. The occurrence of 10^{39} quantum jumps per second probably means that at the lowest level of self hierarchy corresponding to time scale which is 10^4 Planck times statistical averaging thermalizes sub-selves completely so that mental images would contain no information. Decoherence is the physical counterpart of this process. In zero energy ontology the situation changes. The time scale assignable to CDassumed to be an octave of CP_2 time represents a completely new time scale which is macroscopic even for elementary particles. This time scale provides a simple estimate for the average increment of psychological time per quantum jump. For electron and quarks the time scales are.1 seconds and 1 millisecond and correspond to basic time scales of nervous system. The hierarchy of Planck constants allows to scale up these time scales and makes possible communication using photons with arbitrarily low wave lengths since large enough Planck constant implies that the energy of photon is above the thermal threshold. Negentropic entanglement makes possible the formation of completely new kind of macroscopic quantum systems. Time-

like entanglement makes possible fusion of quantum jumps to longer quantum jumps and thus macrotemporal quantum coherence.

The feed of metabolic energy could destroy entropic entanglement and feed negentropic entanglement as such: for a simple model see [**?**]. Interestingly, there is a well-documented disease in which the patient can live for decades in single frozen moment of consciousness. Is negentropic entanglement with abnormally large value of Planck constant in question? Or is entropic entanglement with abnormally large binding energy and therefore not possible to destroy by the feed of standard metabolic energy quanta in question?

Reducible and irreducible selves

Sub-selves correspond to mental images of self. Irreducible selves do not posses sub-selves and have thus no mental images. The interpretation of this kind of experience -if possible in practice- would be as a pure awareness without content. Whether this kind of states are really possible is not obvious since any space-time sheet contains smaller space-time sheets. When all sub-selves of self fuse (negentropically) together to yield a kind of stereo-consciousness (fusion of left and right visual fields gives rise to 3-D stereo vision), something exceptional results also. One might interpret this kind of state as whole-body consciousness, a state of oneness in very literal sense. Synchronous neuronal firing could be a signature of this kind of states at neuronal level. Reducible selves have several sub-selves experienced as mental images. One can model conscious processing as cascades leading to creation of sub-selves of sub-selves of...: selves are interpretable as symbolic representations of objects of sensory experience and a close parallelism with computationalism and connectivism emerges. In zero energy ontology negentropically entangled zero energy states form this kind of hierarchy.

4.2.6   Binding And Quantum Entanglement

How different components of conscious experiences, such as various sensory qualia and the active components of conscious experience involving thoughts, conscious selections and volition, integrate to single experience, is known as binding problem. In the original approach I distinguished between binding of conscious experiences and binding of conscious experiencers. Since mental images define experiences and are itself experiencers at a lower level of hierarchy, there seems however to be no need for this kind of distinction.

Negentropic entanglement as a mechanism of binding

Quantum entanglement provides a mechanism of binding of selves to larger selves. If the entanglement is negentropic, selves would experience an expansion of consciousness in the fusion. I have considered also the possibility of bound states entanglement and suggested that this leads to a loss of consciousness. Certainly bound state entanglement in the generic case cannot correspond to NE for which density matrix is projector. Whether conscious is lost in the formation of bound state entanglement and whether the higher level system is conscious remain open questions.

At the level of mental images (sub-selves) NE corresponds to the integration of parts to wholes. NE could create mental images representing rules as a collection of instances of rule as pairs of quantum states. Negentropically entangled Schrödinger cat would know that it is better to not open the bottle.

The successes of p-adic physics suggest that it should be possible to label also real selves/space-time sheets by p-adic primes. NMP and adelic view give strong support for this view. Algebraic extensions of rationals define a hierarchy and the parameters characterizing string world sheets and partonic 2-surfaces in the intersection of real and p-adic worlds belong to these algebraic extensions. By strong form of holography these surfaces carry the information about both space-time surfaces and quantum states and define cognitive representations. Boolean cognition (fermions) and cognitive representations reside in the intersection.

p-Adic primes would naturally correspond to so called ramified primes of extension. In strong form of holography p-adic continuations of 2-surfaces to preferred extrmals identifiable as imaginations would be easy due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector:

the interpretation would be that some space-time surfaces can be imagined but not realized [K64]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes.

NMP leads to a generalization of p-adic length scale hypothesis so that also primes powers of general prime rather than only $p = 2$ are allowe. Hence also real selves would form a p-adic hierarchy. Sensory experience corresponds to the space-time surfaces and to the classical correlates of quantum states. Both p-adic length scale hierarchy and its generalizations and the hierarchy of Planck constants reduce to the hierarchy of algebraic extensions of rationals.

The fusion of selves to a larger self by bound state entanglement means a formation of a bound state and the binding energy could be liberated as a usable energy. Thus quantum metabolism could accompany the negentropic binding of the mental images. In the case of NE the possibility that the binding energy is effectively negative would also make possible liberation of energy, and I have proposed that this might take place in ATP→ADP+P_i defining the fundamental step of metabolism in which the high energy phosphate bond is believed to liberate metabolic energy quantum [**?**]. High energy phosphate bond could correspond to a magnetic flux tube carrying NE. Jail and love are good metaphors for the two kinds of correlations represented by bound state entanglement and NE. The recent view is that metabolites are NE carriers and that NE is transferred to the used in metabolism. This applies to all forms of metabolism, not only energy metabolism.

Different components of sensory experience, even sensory qualia, naturally correspond to separate sub-selves, whose individual experiences are separate but combine to form various qualia in our experience. In TGD framework they could correspond to sensory pathways or parts of them and perhaps containing also primary sensory organs: this option looks at this moment the most convincing one. Quite generally, it seems that the reliability of the sensory experiences and the absence of experienced volition is guaranteed by the hypothesis about subjective memory.

In accordance with this, the experienced volition is most naturally related to the first state function at the opposite boundary of CD and means death and re-incarnation of corresponding self producing in typical case negentropy by NMP. Sensory perception in turn can be assigned to the sequence of state function reductions at fixed boundary of CD defining sensory mental images as sub-self.

For instance, synchronous neuronal firing could be understood as a consequence of almost simultaneous wake-up of neuronal sub-selves near criticality for phase transition changing the local topology of the space-time sheets associated with sub-self. 40 Hz neural synchrony to be discussed later has a nice interpretation in terms of the generation of NE.

If neurons have sub-selves, also subneuronal quantum jumps are possible and this could eventually make synchronous assembly and de-assembly of microtubules and even synchronously occurring biochemical reactions possible. Primary sensory experiences could occur in part of the sensory pathway containing also primary sensory organ and nerve pulse activity could be regarded as resulting from the creation or wake-up of sensory sub-self by quantum jump leading to state able to remain unentangled. It came as a surprise that in TGD universe our sensory representations (an entire hierarchy is involved) could be realized at the magnetic sensory canvas associated with the electromagnetic body accompanying the physical body and having size much larger than the physical body [K48].

A possible example of the bound state entanglement of sub-selves could be the binding of right and left visual fields to single visual field. The visual fields can sometimes fail to bind: this should result from the failure of the corresponding sub-selves to generate mutual entanglement with sufficient rate or at all (the connection between brain hemispheres is lacking).

Bio-feedback is a well-established phenomenon in which person receives feedback from the behaviour of, say, single neuron and learns to control voluntarily its behaviour. A possible mechanism of bio-feedback is based on quantum entanglement generated between the (sub)self of the person and the self of neuron. Socio-feedback at the level of entire society could be important mechanism making possible to establish moral and behavioural rules of the society: this socio-feedback is perhaps the basic function of sleep.

Binding geometrically

Quantum-classical correspondence suggests that the concept of binding should have a counterpart at the level of space-time geometry. The gluing of the space-time sheets by topological sum to larger space-time sheets creates nested hierarchical structures. This suggests that the summation of mental images to a collection of mental images experienced by a given self corresponds geometrically to the gluing of the material space-time sheets of sub-selves to the material space-time sheet of self by topological sum operation involving the formation of "wormhole contacts" (having physical identification as bosons and their super partners).

The binding of experiences (or experiencers) in turn would naturally correspond to the glueing of 3-surfaces together along their boundaries by join along boundaries bonds (topological sum for boundaries). Magnetic flux tubes is the more recent term meaning essentially same as join along boundaries bond. Magnetic flux tubes define a correlate for both kinds of entanglement.

The geometric counterpart of self defines a geometric representation for the subjective history of the self. For instance, larger mind-like space-time sheets at the higher level of the hierarchy could contain or generate holes making possible for smaller mind-like space-time sheets to form magnetic flux tubes. This mechanism would provide a concrete geometric realization for the communication between different levels of the hierarchy of selves. For instance, long term memories could become conscious through this kind of mechanism.

There are several arguments supporting the importance of flux tubes.

1. The dynamical realization of the self hierarchy as a master-slave hierarchy of various kinds of super conductors [K72, K71] relies on the identification of the magnetic flux tubes between the space-time sheets belonging to various levels of hierarchy as Josephson junctions. The "biofeedback" made possible by the magnetic flux tube makes it possible for the selves at higher levels of the hierarchy to experience what it is to be lower level self. In particular, our immediate sub-selves are represented by topological field quanta of ELF em fields associated with EEG frequencies and thus have size of order Earth's circumference by Uncertainty Principle, whereas sensory experiences involve in essential manner entanglement with sub..sub-selves with size scale of neuronal circuits.

2. Magnetic flux tubes are perhaps the most interesting magnetic flux tubes in the TGD based quantum model of biology. Wormhole magnetic flux tubes consisting of a pair of space-time sheets with opposite time orientations, carrying magnetic fluxes with opposite directions, and containing also dark matter with large value of Planck constant are especially interesting. They play a key role in TGD inspired view about bio-chemistry and in the model of DNA as topological quantum computer [K2].

Cognitive entanglement between real and p-adic variants of the partonic 2-surface should be probable only for preferred primes. The successful applications of p-adic physics give good reasons to believe that real partonic 2-surfaces and also space-time regions can be a labelled by p-adic primes characterizing their effective p-adic topology. This should make sense at least in the intersection of real and p-adic worlds. The most natural entanglement is between partonic 2-surface and its p-adic counterpart and has maximum for a unique prime. One expects that this negentropy is expressible solely in terms of rational and common algebraic points of real and p-adic surfaces and thus using only the data about real partonic surface. If this entanglement negentropy has a space-time correlate, one could expect that it is maximum for the same prime and that the geometry of the partonic 2-surface and perhaps also of corresponding light-like 3-surface and even of a 4-D space-time region reflects this p-adic topology. This prime could characterize the local p-adic topology to which the real region can be transformed easily (, that is criticality against this kind of transition). This easiness could be measured by the total number of rational and common algebraic points of the partonic 2-surface if the transition amplitude is expressible in terms of the information coming from the common points.

It has become clear that the effective p-adic topology most naturally manifests itself rather abstractly at the level of WCW and by strong form of holography for the parameters of string world sheets and partonic 2-surfaces belonging to an algebraic extension of rationals defining also the extension of p-adic numbers. It is of course quite possible that these parameters have interpretation in terms of space-time geometry and topology. Good example is provide by the

conformal moduli characterizing the conformal equivalence classes of partonic 2-surfaces and string world sheets. They have rather concrete geometric interpretation (say as positions for punctures). p-Adic variants of Teichmueller parameters indeed emerged first in p-adic mass calculations [K23]. What is nice is that these parameters are general coordinate invariants so that one avoids the problems with General Goordinate Invariance resulting if space-time coordinates are p-adicized and one wants to map real and p-adic space-time surfaces to each other.

Wholes and parts

The basic feature of higher level cognition is the formation of wholes from parts. NE between selves representing parts provides an attractive model for this process. NE is indeed highly suggestive in the case of cognition. One can wonder whether positive-negative dichotomy for emotions could reflect the negentropic-entropic dichotomy for entanglements. This would conform with the idea that the transformation of NE to bound state entanglement liberates metabolic energy and information and transforms nutrient to entropic waste. Therefore emotions would not reduce to special kind of qualia. The association of negatively colored emotions with bound state entanglement need not be the correct thing to do. Rather, the color of emotion tells how large negentropy gain is in state function reduction for sub-self. It it vanishes, the emotion is maximally negative.

Sub-selves represent symbolically the components of conscious experience, say letters of the word: in absence of NE between these "letter" selves the sum experience is set of letters whereas higher level experiences is about average letter. If sub-selves get entangled, there are no sub-self-experiences and sum-experience is about the word as is also the higher level experience. Understood word or written language could correspond to NE between the mental images representing letters. This entanglement could be also time like and by light-like 3-surfaces connecting a temporal sequence of CDs.

Entanglement might be also time-like in zero energy ontology and this could relate closely to the differences between right and left hemispheres. For right brain hemisphere time-like (and also space-like) NE could occur in longer time scales than for the left one as the saying right brain sings-left brain talks and the fact that spatial thinking is associated with the right hemisphere suggests.

This overall picture will be applied to the modelling of music experience later. The hypothesis will be also applied to explain paradoxical result of certain experiment testing right-left brain differences.

Entanglement and directed attention

Directed attention is one of the basic processes of consciousness occurring continually. Directed attention seems to involve free choice but focusing of attention could also occur spontaneously. One can approach the problem of identifying the physical correlates of directed attention from several angles.

1. The possibility to interpret self as a statistical ensemble suggests that the entropy of the mental image regarded as ensemble of sub-sub-selves of self measures its fuzziness. The negentropy of the mental image is maximal if sub-sub-selves are negentropically entangled to form a single coherent whole. Both attentiveness, alertness and level of arousal should relate very closely to the negentropy and thermal entropy of the mental image.

   Attention entangles it with the self attending it and creates negentropic system and in this manner prevents NMP to force the death of the mental image. Attention should bring in NE and this requires the feed of metabolites carrying NE.

   7 ± 2 rule of cognitive science suggests that the maximum number of our cognitive sub-selves, which can be awake simultaneously, is rather limited. The rule might be based on the metabolic limitations: sub-selves can have high energy NE content only in the presence of an external negentropy feed and metabolism must provide the needed negentropy feed. Note however that the needed metabolic energy might be extremely low. One could interpret the focused of attention as a wake-up of sub-self and keeping it in wake-up state and hence in short term memory. This could occur at the expense of the other sub-selves, which would be in wake-up state for only short times.

Negentropic fusion of mental images would be alternative strategy to keep them alive: note however that this requires state function reduction at opposite boundary of the CD involve with them so that the re-incarnated mental images would be fused.

2. One can imagine that sub-sub-self inside sub-self representing mental image (say "monitor screen" as average over subs-ub-selves representing the visual objects) somehow pops up one level higher in the self hierarchy so that it becomes mental image. Geometrically this could correspond to the re-gluing of the corresponding space-time sheet to the space-time sheet of self instead of that of sub-self. Negentropic entanglement could be in question.

3. Self is assumed to experience the sub-systems immediately below it in the hierarchy or perhaps to the entire collection of mental images. This might however not be what attention is basically. Rather, attention seems to select one particular mental image and put other mental images to background and feed NE to this mental image as its mental images. It seems possible to direct attention to lower levels of the self hierarchy than the one immediately below. For instance, I can direct my attention to the entire sentence, which I am writing here or to some word of this sentence or to individual letters of this word. The phenomenon of bio-feedback demonstrates that it is possible to learn to direct the attention to even single neuron. This suggests that selves are able to modify the hierarchy of selves by raising some sub...sub-self to the role of sub-self temporarily and thus experience the former sub...sub-self as a direct mental image.

4. The formation of the flux tubes between mind-like space-time sheets belonging to different levels of the self hierarchy provides a candidate for the geometric correlate of directed attention. A formation of flux tube connecting partonic 2-surface assignable to self with a partonic 2-surface assignable to sub-self would be in question. Both the directed character of attention and the selection of a particular mental image would have clear geometric correlates. The attention to an object of perceptive field would separate the corresponding mental image from the fusion of mental images. In the case of bound state entanglement this would require the feed of metabolic energy. In the case of negentropic fusion carrying energy it could liberate metabolic energy.

Anyone can do a simple but thought provoking experiment suggesting the presence of the macroscopic quantum entanglement at the level of brain and a change of the level of sub-self in the self hierarchy. Look at a mirror, direct your attention at your left eye, and redirect the gaze to the right eye. What you find that it is impossible to perceive the change in the direction of the eye gaze.

1. Consider first what probably happens when we perceive a moving object. A negentropic binding of the mental images of the visual field to single mental image implies that both the parts and the whole can be experienced so that the motion is perceived. If the direction of the gaze is stationary, the object moves relative to the background, and if the direction of the gaze follows the object the background moves with respect to the direction of gaze. In both cases the motion can be perceived.

2. If the eye follows its own rotating mirror image, neither of these options is realized if the environment to which the attention is directed is restricted to be the eye itself. The direction of the gaze should remain the same in order to perceive the change of the direction of the gaze but this is impossible.

3. The perceptive field however contains also other objects and one could argue that if the attention is directed also to these simultaneously, it should be possible to perceive the changing direction of gaze as they move relative to the changing direction of gaze. Does the very act of directing attention to the mirror image of eye separate it from the NE with the other mental images so that the conscious comparison with them is not possible anymore? Or is the visual mental image representing eye at a different level of hierarchy from the very beginning and cannot negentropically entangle with the other visual mental images? Eye cannot perceive itself! Not even in mirror.

4. This argument raises the question whether it is possible to perceive the the motion of object if the attention is permanently directed to it? Is it necessarily to direct the attention only temporarily to the object and whether the saccadic motion of eyes could relate to this? There are almost incredible sounding experiments demonstrating that the attention directed intensely to a fixed object makes it impossible to become aware what happens in environment.

Entanglement and altered states of consciousness

NE might provide the Royal Road to the understanding of altered states of consciousness. Entanglement can take place both at the level of self and sub-selves, In the latter case one can consider the possibility that self can choose in state function reduction whether the mental images are entangled entropically or negentropically. Weak form of NMP indeed predicts this.

For self the NE would be kind of moment of mercy by higher level self. Both space-like and time-like entanglement are possible and this can lead to transpersonal experiences and memories extending past the own life time. Also the increases of p-adic prime or Planck constant could be be involved with these experiences. Clearly, a wide repertoire of expanded states of consciousness is predicted. This picture conforms with the view that a certain kind of personal moral and intellectual evolution is a prerequisite for enlightenment experiences.

Examples of altered states of consciousness are transpersonal experiences and enlightenment experiences in which one identifies with some larger consciousness. For instance, prenatal experiences could result from a time-like NE of a sub-self with self having a temporal extension of order lifetime or longer and having kind of abstracted experience about the period of life before birth. Experiences like "sharing the sorrow of all mothers of dead soldiers" could involve the entanglement of sub-self with a collective mental image resulting in the entanglement with a collective mental images having quite concretely as mental images of mothers. If the notion of field body having size at least of order Earth size makes sense, this idea does not look so implausible anymore.

Direct eye contact as an example of quantum entanglement between experiencers?

Direct eye contact is fundamental in the communication between living creatures. The naïve intuitive picture of cartoon drawings about direct eye contact is is as rays connecting the eyes of persons involved. TGD suggests that this naïve picture actually represents fundamental mechanism for the temporal fusion of selves to form larger selves. What could happen is that magnetic flux tubes are formed between eyes, and, if the neural window hypothesis holds true, also between brains and eventually between sensory canvases.

MEs are optimal for this purpose. The coherent photons associated with them would be the required macroscopic quantum phase associated with the entire higher level self. Thus it is perhaps not accident that extended states of consciousness are so often described as experiences about radiance of light. A weaker hypothesis is that eye contact involves only the formation of magnetic flux tubes along which classical communication based on propagation of classical signals occurs. Also for this option MEs are optimal candidates for magnetic flux tubes.

The reader has possibly noticed that these arguments open up the possibility that our visual field in some sense corresponds to the actual visual field rather than only its cognitive representation provide by the visual pathways. The photons arriving along MEs connecting our brain with the objects of the perceptive field could provide the join along boundaries bonds extending our sensory self to contain part of the external world. Our visual field would still be determined by the light entering to our eyes so that no contradictions with well established empirical facts about vision are encountered. This kind of extension of visual self could however provide completely new ways for brain to compute the distances to the objects of the perceptive field since the basic information would not be mere two-dimensional picture in retina. The most plausible option seems to be however the one in which ultimate sensory representations are realized outside brain at the sensory canvas provided by the magnetic flux tube structures which can be even of the order of Earth size. This option is discussed in [K83].

Semitrance mechanism

The notion of semitrance allows to understand how higher level selves can communicate to and control and coordinate the behaviour of lower levels selves. If individual contains at least part

of time at least single sub-self, this sub-self can entangle with higher level self and in this trance state can communicate with the self and possible sub-selves and transmit commands, advices or messages. Communication is here quite generally understood as a generation of mental images, waking-up of sub-selves, these sub-selves could be p-adic sub-selves of real selves in accordance with the idea that communication is part of cognition. The wake-up process initiates self-organization leading to a final state pattern representing the message. Final state pattern depends only weakly on the stimulus serving as message: this is as it should be.

The NE of the right or left brain hemisphere (or some part of it, perhaps the linguistic regions with respect to which human brain has highest asymmetry) with a collective self could be the basic mechanism making it possible to communicate the commands of the collective self to left and/or right hemisphere as "hallucinations". This leads to a TGD variant of the vision of Jaynes about bicamerals and schizophrenics as persons who differ from the average modern man in that they are able to receive commands and advice from collective levels of consciousness as hallucinations [J85]. The notion of semitrance leads to very general views about how various societies (cells as societies of proteins, organisms as societies of cells, societies of various animals) develop and allows also to understand various altered states of consciousness [K91, K92].

The semitrance mechanism involves the generation of NE and liberation of metabolic energy if the liberation of metabolic energy always accompanies transfer of NE to the receiver. This non-metabolic energy might have something to do with the miraculous architectural feats of the ancient bicameral cultures (consider only pyramides) and the unusual physical strength of schizophrenics discussed in [J85].

Entanglement and sleep

What happens for our self during sleep? One can imagine several alternative answers to the question.

1. We really lose consciousness during sleep. This means that our self entangles negentropically with some other self. One can however ask why NE should not be possible and whether it could be the reason for healing effects of sleep. ZEO implies that the self representing our wake-up consciousness dies and re-incarnates at opposite boundary of CD. An interesting question is whether we can remember anything about this period of consciousness and whether memories about dreams are this kind of memories.

2. Long term memory representations are not constructed during sleep so that we do not remember anything about sleep time consciousness except when we wake up from REM sleep: note that in this case the memories fade rapidly in accordance with the idea that long term memories are not constructed. Synchronous hippocampal theta is indeed absent during sleep and synchronous firing would be a natural candidate for both the communications of mental images to magnetic body and for the generation of memory representations as negentropic fusions of mental images. If these memory representations are nor formed there is nothing to remember.

3. We are able to remember what happened during sleep only if we are asleep. Perhaps synchronous theta and delta oscillations are involved with the construction of negentropic memory representations experienced only during sleep just as theta synchrony is essential for memories about daytime experiences. The mirror mechanism of long term memories might allow this kind of possibility. These memory representations would be incomprehensible from the point of day-time consciousness. The strange mental images experienced just at the verge of falling asleep or waking up, which have meaning before transition but lose it during the transition, might reflect this.

Irrespective of whether the entanglement is bound state entanglement or NE, an important function of sleep could be the formation of larger collective selves. During sleep our selves could entangle to form a kind of a stereo consciousness representing human condition. This process could involve either phase transition changing local topology or a formation of magnetic flux tubes with much larger space-time sheets characterized by the same local topology. This mechanism could make possible subconscious communication between the members of society and also establish

conscience and moral. The topological field quanta associated with photons generated by EEG during sleep have frequency smaller than 7 Hz [K41]. This suggests that the higher level selves in question correspond to these topological field quanta and thus have a wake-up time of order .5 seconds during delta wave sleep. Mental images would not disappear but would become more abstract during sleep.

4.2.7 Self Hierarchy

The basic outcome of the definition of self is the prediction that infinite hierarchy of selves exists. This prediction clearly distinguishes TGD from brain centered theories of consciousness.

Infinite hierarchy of selves with God at the top

A rather dramatic prediction is a Russian doll like hierarchy of conscious experiencers having the entire Universe, God, at the top. The necessary localization in zero modes making the Universe of conscious experience classical together with the proposed concept of self allows to understand both active and passive aspects of consciousness and a general classification of various types of conscious experiences becomes possible. Summation hypothesis, sharing of mental images and "enlightenment" by the generation of negentropic entanglement hypothesis provide a general framework for interpreting various transpersonal experiences and altered states of consciousness as resulting from entanglement with larger units of consciousness.

Self, evolution and, self-organization

Quantum jumps between quantum histories make also possible genuine quantum self-organization. The concept of self-organization gets quite new additional meaning in TGD framework. Self-organization means also evolution of self-hierarchies. Self-organization by quantum jumps can be regarded as a hopping in the zero modes characterizing the macroscopic aspects of the space-time surface. Each self is a dissipative system which ends up to some asymptotic self-organization pattern in the presence of the external energy feed (and even without it). Dissipation is the ultimate Darwinian selector picking up the winning selves as favored self organization patterns. Since sub-selves correspond to mental images, the immediate implication is that also memes are subject to similar selection. For instance, the formation of long term memories and habits could be understood as a formation of surviving sub-selves.

The time evolution by quantum jumps has many facets. One of them relates to effective p-adic topology and is expected to be of speciall importance if live resides in the intersection of real and p-adic worlds. Simple arguments leads to the conclusion that evolution for a given space-time sheet must correspond to a sequence of p-adic primes increasing in a statistical sense. This means that the concept of nearness defining the effective topology becomes gradually more refined, the complexity of the universe increases, and the maximal information contents of the conscious experience increase in the long run (like $p \times log(p)$ or at least as $log(p)$ as a function of p-adic prime characterizing the system). This is nothing but evolution. NMP, which states that entanglement negentropy gain maximal for allowed quantum jumps, enhances this tendency.

The TGD based realization of the quantum criticality, besides making macroscopic quantum systems possible, in a well-defined sense maximizes the intelligence and complexity of the universe [K22]. In biosystems a concrete realization of quantum criticality is in terms of magnetic flux tube structures and electret type space-time sheets representing solutions of field equations dual to each other and having opposite signs of Kähler action density.

TGD universe is quantum spin glass and this adds additional aspect to the self-organization process. For instance, the energy landscape of the spin glass is fractal like structure containing valleys inside valleys and provides an ideal dynamical memory mechanism. Spin glass degeneracy also provides a mechanism increasing the lifetimes of the bound states formed by join along boundaries/flux tube condensates and thus could allow macrotemporally quantum coherent states able to perform quantum computation like activities. The impossibility of macrotemporal quantum coherence is indeed the main objection against quantum theories of consciousness.

This looks nice but one can ask whether the framework of standard quantum theory is all that is needed to formulate quantum TGD and the notion of quantum criticality. The original motivations for introducing the hierarchy of Planck constants and the generalization of the embedding

space to a book like structure having as pages the almost copies of the embedding space were purely physical. Now it seems that this generalization is required by a need to have a proper formulation of quantum criticality of TGD Universe. The hierarchy of Planck constants leads to a whole bundle of ideas about quantum biology and evolution of consciousness and also to a detailed model for how living matter can perform topological quantum computation like activities [K9, K2, **?**, K5].

State function reduction reducing entanglement is a random process unlike that producing negentropic entanglement and implies quantum de-coherence. Therefore the unentangled sub-selves of self define a statistical ensemble in a natural manner and dissipation is naturally related to the ageing of self since the statistical ensemble in question grows quantum jump by quantum jump. The averaging over quantum jumps means that the contents of consciousness of self thermalize with mental images becoming more and more fuzzy.

Haken's classical theory of self-organization applies almost as such if only entropic entanglement is considered since time development by quantum jumps means hopping around the space of zero modes characterizing the size and shape and induced Kähler fields associated with the space-time surface $X^4(X^3)$. Negentropic entanglement of mental images changes however the situation in time scale which could be the time scale assignable to the CDs associated with the entangled selves.

Self-organization involves Darwinian selection performed by dissipation inside each self. Dissipation selects also surviving sub-selves having interpretation as mental images. Hence the selection of memes is also in question.

Subjective ageing results from dissipation and is the price paid for having autonomous self separated from environment. Very concretely, the mental image of self represented by sub-self gets more and more entropic during ageing. One can also formulate questions about what happens in death in terms of physical concepts. Does only the bodily sub-self (mental image about body) cease to exist in the physical death so that only the field body consisting of magnetic flux tube structures and massless extremals (MEs, topological counterparts of light rays) remains? Can one identify the field body as the counterpart of what is called soul? Could the field body get interested of some new biological body and use it as sensory and motor organ (re-incarnation)? Is entanglement with some larger self generated after death (and during sleep)?

Space-time as a 4-dimensional living being

The new concept of the psychological time means a dramatic generalization of the standard view about subjective existence. mind-like space-time sheets are distributed everywhere around material space-time sheets of infinite time duration and all of them can participate in a given quantum jump. Therefore one can say that the entire space-time is a conscious, living being. Civilizations of the geometric past and future exist simultaneously with us. We are members of a four-dimensional society in the sense that our actions affect the life of selves of both geometric past and future since each quantum jump performed by us changes the macroscopic space-time in both past and future.

Everyday experience suggest that the geometric past is relatively rigid. Although changes in a given time scale can occur below some length scale, changes in larger scales are probably rare. Sensory representations could however change and this could explain the instability of long term memories. Turning point decisions are probably not possible for the me of my geometric past: otherwise dramatic quantum jump changing completely my personal identity would occur.

The notion of the four-dimensional body (both material and field bodies) becomes natural and only the concentration of consciousness to the psychological now during the physical life creates the illusion that the reality corresponds to the time=constant snapshot of the time evolution. Near death experiences indeed support the view that life is experienced as a temporal whole when the dominating contribution from the sensory input and motor actions is absent. 4-dimensional body is not static but changes quantum jump by quantum jump which suggests that life is like a four-dimensional sculpture which is gradually refined. We in our youth now experience in slightly more deeper manner and live in a society having slightly higher level of moral. Note that the newest view about arrow of time means that the creation of this 4-D sculpture can be also seen as classical time evolution in the first approximation.

4.3 Self And Model 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.

The original proposal was that self is conscious entity.

1. Self corresponds to a subsystem able to remain un-entangled under the sequential informational "time evolutions" U. Exactly vanishing entanglement is practically impossible in ordinary quantum mechanics and it might be that "vanishing entanglement" in the condition for self-property should be replaced with "subcritical entanglement". If space-time decomposes into p-adic and real regions, and if entanglement between regions representing physics in different number fields vanishes, space-time indeed decomposes into selves in a natural manner. Causal diamonds would form natural embedding space correlates for selves and their hierarchy would correspond to self hierarchy.

2. The intuitive idea inspired by the formation of bound states of particles from particles was that self corresponds somehow to an integration of quantum jumps to single coherent whole. Later I gave up this idea since it was difficult to understand how the integration could take place.

3. The next suggestion was that quantum jumps as such correspond to selves. It was however difficult to assign to selves identified in this manner a definite geometric time duration. It is an empirical fact that this kind duration can be assigned to mental images (identified as subselves).

4. Concerning the notion of self the notion of negentropic entanglement (NE) (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) is central. NMP implies that Universe is like a library with new books emerging continually at its shelves. It turned out that NE - "Akashic records" must be experienced directly and defines what might be called permanent self - self as understood in the framework of meditation practices.

    The original wrong idea was that so called interaction free measurement could give information about NE at the same time leaving it invariant. It turned out that interaction free measurement does not allow to read the "Akashic records" but makes possible to read memories relying on bit representations (not qubits). These representations could give rise to self model and often referred to as ego in meditative practices.

5. The approach which seems the most convincing relies on the following observation. In ordinary positive energy ontology repeated state function reductions leave the state invariant. In ZEO this is not the case. There is wave function in moduli space of causal diamonds (CDs) and all sizes of CD characterized by the proper time distance between the tips of CD and all Lorentz boosts of CD are allowed. State function reduction localizes this wave function so that the other boundary of CD is at fixed light-cone boundary but other remains delocalized.

    The sequences of ordinary state function reductions leaving state unchanged are replaced with sequences for which the part of the zero energy state associated with a fixed boundary of CD remains unchanged in state function reduction whereas the state at the other end of CD changes. This is something new and explains the arrow of time and its flow and self could be understood as a sequence of quantum jumps at fixed boundary of CD (with the average location of second boundary shifted towards geometric future like in dispersion). Amusingly, this is in accordance with the original proposal except that state function reductions take place on same boundary of CD as long as self exists. For this option NE is directly experienced and at the passive boundary of CD gives rise to the unchanging part of self. There is no need to read the Akashic records by any mechanism.

    This view is extremely attractive since it implies that the act of free will interpreted as genuine state function reduction must mean reversal for the direction of geometric time at some level of hierarchy of selves. The proposal has indeed been that sensory perception and motor action are time reversals of each other and that motor action involves sending of negative energy signals to the geometric past.

4.3.1   NE And Self

NE 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 NE 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 NE is necessary for mental images (having sub-CDs as correlates) to mental images representing spatial patterns. NE 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.

If one accepts the identification of self as a sequence of state function reductions to a fixed boundary of CD then the identification of NE at the passive boundary of CD as a building brick of self is natural. One must distinguish from self the self model (one might speak of ego) which would rely on memory representations at the active boundary of CD.

By definition NE tends to be preserved in quantum jumps also at the active boundary of CD so that it represents information as approximate invariant: this conforms with the idea of invariant representation and quite generally with the idea that invariants represent the useful information. Self as opposed to self model be determined by NE at the passive boundary of CD.

Self model would be based on the properties of state at the active boundary of CD: also here NE is possible but is not absolutely stable. If the notion of interaction free measurement makes sense also in TGD based quantum measurement theory, the models of self and external world can be defined in terms of representations (sensory -, memory -, cognitive -) and their time reversals and correspond to the reflective level of consciousness as opposed to the phenomenal consciousness to which sensory qualia contribute mostly. Self representations are not exact invariants although there seems to be no end for experience of consciousness: sleep in this framework can be interpreted as a period about which there are no memories accessible in wake-up state. If the contribution of the magnetic body dominates during sleep, this can be understood.

The picture about repeated state function reductions suggest the following view about self. The passive part of zero energy state is not changed during its life cycle and negentropic entanglement associated with it is preserved. Self at given level of hierarchy is in wake up state during period of fixed direction of geometric time. 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.

4.3.2   Is Interaction Free Measurement Needed To Deduce Information About Self Model?

The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of sub-self corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus change, how it is possible to carry conscious information about quantum state? The following proposal for non-destructive reading of memories and future plans allows to resolve this problem.

The objection is that the repeated state function reductions make the NE at the passive boundary of CD a part of the conscious experience defining the static background representing the experiencer as the background whereas the contribution to the experience from the changing active boundary of CD would define the figure.

This interpretation seems reasonable and actually the only possible one in the recent formulation of the theory. One can however consider the possibility that interaction free quantum measurement could allow to "read" memory representations realized in terms of bits. These representations would define self model localizable to the changing boundary of CD as opposed to the permanent self.

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. This information would be obtained as sequences of bits and might be correspond to declarative, verbal memories rather than direct sensory experiences.

1. The bomb testing problem of Elitzur and Vaidman gives a nice concrete description of what happens in interaction free measurement [B1] for an illustration of the system considered (see `http://tinyurl.com/kx2jsyu`).

    The challenge is to find whether the bomb is dud or not. Bomb explodes if it receives photon with given energy. The simplest test would explode all bombs. Interaction free measurement allows to make test by destroying only small number of bombs and at idealized limit no bombs are destroyed.

    The system involves four lenses arranged in square and two detectors C and D at the upper right corner of the square. In the first lense at the lower left corner the incoming photon beam splits to reflected and transmitted beams: the path travelled by transmitted beam contains the bomb.

    (a) The bomb absorbs photon with a probability which tells the fraction of photon beam going to the path at which bomb is (is transmitted through the lense). The other possibility is that this measurement process creates a state in which photon travels along the other path (is reflected). This photon goes through a lense and ends up to detector C or D through lense.

    (b) If the bomb is dud, the photon travels through both paths and interference at the lense leads the photon to detector D. If C detects photon we know that the bomb was not a dud without exploding it. If D detects the photon, it was either dud or not and we can repeat the experiment as long as bomb explodes, or C detects photon and stop if the detector continues to be D (dud). This arrangement can be refined so that at the ideal limit no explosions take place and all.

2. The measurement of bomb property is interaction free experiment in the sense that state function reduction performed by absorber/bomb can eliminate the interaction in the sense that photon travels along the path not containing the bomb. One might say that state function reduction is an interaction which can eliminates the usual interaction with photon beam. State function reduction performed by bomb can change the history of photon so it travels along the path not containing the bomb.

 This picture is only metaphorical representation of something much more general.

1. Bomb could be of course replaced with any two-state system absorbing photons in one state but not in the other state, say atom. Now one would test in which state the atom is gaining one bit of information in the optimal situation. Two-state atom could thus represent bit and one could in principle read the bit sequence formed by atoms (say in row) by this method without any photon absorption so that the row of atoms would remain in the original state.

2. Two-state system could be replaced with N-state system. In this case the testing selects at first step one state as analogs of bomb intact and the remaining states as analogs of dud. If the answer was "dud" in the first step, the next step selects one preferred state from $N-1$ states and regards the remaining states as "dud". The process continues until the state of the system is measured.

3. In TGD framework the photon paths branching at lenses correspond to branching 3-surfaces analogous to branching strings in string model and photon wave splits to sum of waves travelling along the two paths.

Memory recall as an interaction free measurement

One can imagine several applications if the information to be read in interaction free manner can be interpreted as bit sequences represented as states of two-state system. Lasers in ground states and its excited state would be analogous many particle quantum system. In TGD framework the analog of laser consisting of two space-time sheets with different sizes and different zero point kinetic energies would be the analogous system.

For instance, a model of memory recall with memories realized as negentropically entangled states such that each state represents a bit can be considered. The model applies also to the reading of future plans (memories on reversed time direction).

1. Reading of a particular bit of memory means sending of negative energy photon signal to the past, which can be absorbed in the reading process. The problem is however that the memory representation is changed in this process since two state system returns to the ground state. This could be seen as analog of no-cloning theorem (the read thoughts define the clone). Interaction free measurement could help to overcome the problem partially. Memory would not be affected at all at the limit so that no-cloning theorem would be circumvented at this limit. Memory bit to be read would be mathematically analogous to bomb in the Elizur-Weizman bomb tester thought experiment in which one tries to determine whether bomb is active (bit 1) and can therefore explode or passive (bit 0) and cannot explode.

2. A possible problem is that the analogs of detectors C and D for a given qubit are in geometric past and one must be able to decide whether it was C or D that absorbed the negative energy photon! Direct conscious experience should tell whether the detector C or D fired: could this experience correspond to visual quale black/white and more generally to a pair of complementary colors?

3. ZEO means that zero energy states appear have both embedding space arrows of time and these arrows appear alternately during periods of repeated state functions having no effect at the other boundary of CD. This dichotomy would correspond to sensory representation-motor action dichotomy and would suggest that there is no fundamental difference between memory recall and future prediction by self model and they different only the direction of the signal.

4. Since photon absorption is the basic process, the conscious experience about the bit pattern could be visual sensation or even some other kind of sensory qualia induced by the absorption of photons. The model for the lipids of cell membrane as pixels of a sensory screen suggests that neuronal/cell membranes could serve defined digital self model at the length scale of neurons.

Some comments are in order.

1. To avoid misunderstandings it should be emphasized that TGD based view about memory is not the same as the standard view. In ZEO brain is four-dimensional and in principle memories can be negentropically entanglement memories in geometric past. It is possible to build copies of memories by memory recall, and learning would correspond to a generation of large enough number of copies of the memory mental image. Memory recall could be seen as a negative energy signal inducing the interaction free measurement of memory qubits. Dark photons with EEG frequencies (say in theta band characterizing hippocompus) but having energies of visible photons could be involved with the memory recall. Correlation between EEG and bio-photons supports this view.

2. If the systems taking the role of the detectors C and D in interaction free measurement are analogous to population reversed lasers, their return to the ground state could automatically generate virtual sensory input propagating to the sensory organs and allowing to check whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected however to be much shorter than that for a typical neuronal activity.

Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa.

Libet's experiments on passive aspects of consciousness [J70] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about.1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity. This mechanism could also explain generation of after images.

3. Photons can be replaced with phonons or quanta of any other wave motion with constant propagation velocity (no dispersion of signal) in a given reference frame. This suggests that imagination and internal speech correspond to the two reading mechanisms of memories.

One could also introduce self as a subsystem, which is only potentially conscious and here the notion of NE (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) suggests an approach based on interaction free measurement. NMP implies that Universe is like a library with new books emerging continually at its shelves. It turned out that negentropic entanglement - "Akashic records" must be experienced directly and would define what might be called permanent self. Interaction free measurement does not allow to read the "Akashic records" but makes possible to read memories relying on bit representations (not qubits). These representations could give rise to self model.

Chapter 5

Self and Binding: Part II

5.1 Introduction

The conflict between the non-determinism of state function reduction and determinism of time evolution of Schrödinger equation is serious enough a problem to motivate the attempt to extend physics to a theory of consciousness by raising the observer from an outsider to a key notion also at the level of physical theory by bringing in the notion of self. Further motivations come from the failure of the materialistic and reductionistic dogmas in attempts to understand consciousness in neuroscience context. There are reasons to doubt that standard quantum physics could be enough to achieve this goal and the new physics predicted by TGD is indeed central in the proposed theory.

5.1.1 Zero Energy Ontology

Zero Energy Ontology (ZEO) was forced by the interpretational problems created by the vacuum extremal property of Robertson-Walker cosmologies imbedded as 4-surfaces in $M^4 \times CP_2$ meaning that the density of inertial mass (but not gravitational mass) for these cosmologies was vanishing meaning a conflict with Equivalence Principle. In ZEO physical states are replaced by pairs of positive and negative energy states assigned to the past *resp.* future boundaries of causal diamonds (CDs) defined as intersections of future and past directed light-cones ($\delta M^4_\pm \times CP_2$). The net values of all conserved quantum numbers of zero energy states vanish. Zero energy states are interpreted as pairs of initial and final states of a physical event such as particle scattering so that only events appear in the new ontology.

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

ZEO (ZEO) means that one must distinguish between M-matrix and U-matrix. M-matrix characterizes the time like entanglement between positive and negative energy parts of zero energy state and is measured in particle scattering experiments. M-matrix need not be unitary and can be identified as a "complex" square root of density matrix representable as a product of its real and positive square root and of unitary S-matrix so that thermodynamics becomes part of quantum theory with thermodynamical ensemble being replaced with a zero energy state. The unitary U-matrix describes quantum transitions between zero energy states and is therefore something genuinely new. It is natural to assign the statistical description of intentional action with U-matrix since quantum jump occurs between zero energy states.

Quantum measurement theory based on ZEO can be said to imply the notion of self and to explaining basic aspects of consciousness when one includes also the hierarchy of Planck constants characterizing hierarchy of quantum criticalities. At the embedding space-level CD is the correlate

of self whereas space-time sheets having their ends at the light-like boundaries of CD are the correlates at the level of 4-D space-time. The hierarchy of CDs within CDs corresponds to the hierarchy of selves. Zero energy ontology leads also an argument explaining why the arrow of subjective time induces an apparent arrow of geometric time as a result if intentional action and why the contents of sensory consciousness is restricted to such a narrow time interval (located near the future boundary of CD).

5.1.2 Hierarchy Of Planck Constants

The hierarchy of Planck constants corresponds to a hierarchy $h_{eff} = n \times h$ [K36, **?**, K73]. The original hypothesis was that it corresponds to a hierarchy of singular coverings of embedding space $M^4 \times CP_2$- or rather - given causal diamond (CD).

The recent view is that there is a hierarchy of quantum criticalities such that the sub-algebra of super-symplectic algebra for which conformal weights are n-ples of those for the entire algebra acts as conformal gauge symmetries at given level. Due to the resulting non-determinism the space-time surfaces connecting 3-surfaces at the opposite boundaries of CD are gauge degenerate and there are n conformal equivalence classes analogous to sheets of Riemann surface of $z^{1/n}$. This view has far reaching consequences. The hierarchy of quantum criticalities has an interpretation as that for macroscopic quantum phases and the phase transitions increasing n to its multiple occur spontaneously and generate also negentropy if NMP is assumed. Hence evolution can be seen as a gradual reduction of criticality occurring unavoidably.

An alternative formulation [K97, K70, K73, **?**] emerged in terms of gravitational Planck constant $h_{gr} = GMm/v_0$, where v_0 is characteristic velocity in the system consisting of two masses involved, introduced originally by Nottale [E1] h_{gr} would be associated with the flux tubes connecting the two masses. Later it became clear that the identification $h_{eff} = h_{gr}$ leads to considerable insights in biology: in particular bio-photons can be identified as ordinary photons resulting from dark cyclotron photons with a universal energy spectrum.

The book metaphor inspired by the original view about hierarchy of Planck constants is however very useful. The value of the Planck constant characterizes partially given page and arbitrary large values of $\hbar$ are predicted so that macroscopic quantum phases are possible since the fundamental quantum scales scale like $\hbar$. All particles in the vertices of Feynman diagrams have the same value of Planck constant so that particles at different pages cannot have local interactions. Thus one can speak about relative darkness in the sense that only the interactions mediated by the exchange of particles and by classical fields are possible between different pages. Dark matter in this sense can be observed, say through the classical gravitational and electromagnetic interactions. It is in principle possible to photograph dark matter by the exchange of photons which leak to another page of book, reflect, and leak back. This leakage corresponds to $\hbar$ changing phase transition occurring at quantum criticality and living matter is expected carry out these phase transitions routinely in bio-control. This picture leads to no obvious contradictions with what is really known about dark matter and to my opinion the basic difficulty in understanding of dark matter (and living matter) is the blind belief in standard quantum theory.

5.1.3 P-Adic Physics As Physics Of Cognition

p-Adic mass calculations relying on p-adic length scale hypothesis led to an understanding of elementary particle masses using only super-conformal symmetries and p-adic thermodynamics. The need to fuse real physics and various p-adic physics to single coherent whole led to a generalization of the notion of number obtained by gluing together reals and p-adics together along common rationals and algebraics (see fig. `http://tgdtheory.fi/appfigures/book.jpg`, which is also in the appendix of this `http://tgdtheory.fi/appfigures/book.jpg`). The interpretation of p-adic space-time sheets is as correlates for cognition. p-Adic and real space-time sheets intersect along common rationals and algebraics and the subset of these points could be called intersection of realities.

In fact, the intersection can be interpreted in more abstract sense at the level of WCW as surfaces for which parameters (WCW coordinates) are such that the interpretation both as real and p-adic surface is possible. In this way one avoids discretization at space-time level. It has turned out that string world sheets and partonic 2-surfaces with defining parameters in an extension of

rationals define naturally the intersection and strong form of holography allows the continuation of these 2-surfaces to space-time surfaces.

The outcome is a vision about hierarchy extensions of rational numbers defining an evolutionary hierarchy. So called ramified primes associated with the extension define preferred primes identifiable as p-adic primes and weak form NMP allows to understand p-adic length scale hypothesis and its generalization stating that primes near powers of primes are favored by NMP.

There exists an infinite hierarchy of number theoretical entropies making sense for rational or even algebraic entanglement probabilities. In this case the entanglement negentropy can be negative so that NMP favors the generation of negentropic entanglement, which need not be bound state entanglement in standard sense. Negentropic entanglement might serve as a correlate for emotions like love and experience of understanding. The reduction of ordinary entanglement entropy to random final state implies second law at the level of ensemble. The generation of NE as the outcome of the reduction is not totally random process: the prediction is that second law need not universal truth holding true in all scales. To avoid making wrong conclusions about NMP, one must keep in mind that entanglement entropy is two-particle property whereas thermodynamical entropy is single partcle property.

Quantum measurement theory allows only final states, which have density matrices which are projectors so that the rational entanglement probabilities $p = 1/n$ are identical in this case. If the prime p divides n, one obtains negative entanglement entropy and one can say that entanglement is negentropic. Negentropy is largest for the largest power of prime dividing n and one could define entanglement entropy as that associated with this prime.

5.1.4   NMP

One obtains standard quantum measurement theory by assuming that the density matrix of the sub-system is the universal observable. In state function reduction this observable is measured and the system goes to an eigenstate of it. It can however happen that the eigenvalues are degenerate and in this case one can ask whether the reduction leads only to an eigen space so that entanglement characterized by a n-dimensional projection operator remains.

If p divides n, one obtains negative entanglement entropy and one can say that entanglement is negentropic. Negentropy is largest for the largest power of prime dividing n.

Negentropy Maximization Principle (NMP) [K56] codes for the dynamics of standard state function reduction and states that the state function reduction process following U-process gives rise to maximal reduction of entanglement entropy - or equivalently - gain of entanglement negentropy- at each step. In the generic case this implies decomposition of the system to unique unentangled systems and the process repeats itself for these systems. The process stops when the resulting subsystem cannot be decomposed to a pair of free systems since energy conservation makes the reduction of entanglement kinematically impossible in the case of bound states.

The interpretation is that NMP favors generation of negentropic entanglement (NE). One can of course argue that the generation of this kind of entanglement is extremely improbable. The hierarchy of Planck constants involving quantum criticality could however provide the way to generate it.

TGD inspired theory of consciousness forces to challenge the hypothesis that NMP always forces the state function reduction to the sub-space defined by the projector with maximal dimension appearing in the decomposition of the density matrix. NMP would not allow the self to make choices, which are bad deeds in the sense that they do not increase maximally the negentropic resources of the Universe. We would live in the best possible Universe becoming better all the time. This is obviously too good to be true.

The weak form of NMP allows the choice leading to maximal negentropy gain but allows also those choices for which the reduction occurs to a sub-space of the space defined by projector. When this sub-space is 1-dimensional standard quantum measurement results and the self is isolated from the target of observations. Negentropic entanglement has interpretation as attention with positively colored contents of consciousness. Experience of love would be one attribute of this kind of state. Weak form of NMP would be like God allowing the sinner to choose between Good and Evil.

Weak form of NMP turns out to have surprisingly strong consequences. For instance, by choosing the sub-space to have dimension given by power of prime, the state function reduction can yield a larger negentropy gain than otherwise. Primes near powers of prime as dimensions of final

state projector are optimal from the point of view of evolution since they give a large negentropy gain and generate large p p-adicity, which means higher evolutionary level in number theoretical sense: this result is nothing but a generalization of p-adic length scale hypothesis.

NMP generalizes also so that it applies to hyper-finite factors of type II_1 and also in this case it is possible to define negentropic entanglement. In this case entanglement negentropy is positive because the projector for the sub-space as dimension smaller than one as the inverse of the index of inclusion. The interpretation is that the degrees of freedom below measurement resolution carry NE characterized by the projector to the sub-space.

5.1.5   The Notion Of Self

The quantum notion of self solved several key problems of TGD inspired theory of consciousness but the precise definition of self has remained a long standing problem and I have been even ready to identify self with quantum jump. Zero energy ontology allows what looks a final solution of the problem. Self indeed corresponds to a sequence of quantum jumps integrating to single unit, but these quantum jumps correspond to state function reductions to a fixed boundary of CD leaving the corresponding parts of zero energy states invariant. In positive energy ontology these repeated state function reductions would have no effect on the state but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and gives rise to self. The first quantum jump to the opposite boundary corresponds to the act of free will or wake-up of self.

p-Adic physics as correlate for cognition leads to the notion of negentropic entanglement possible in the intersection of real and p-adic worlds involves experience about expansion of consciousness. Consistency with standard quantum measurement theory forces negentropic entanglement to correspond to density matrix proportional to unit matrix. Unitary entanglement typical for quantum computing systems gives rise to unitary entanglement. A natural conjecture is that the integer n in $h_{eff} = n \times h$ corresponds to the dimension of the unit matrix associated with negentropic entanglement. Also a connection with quantum criticality made possible by non-determinism of Kähler action and extended conformal invariance emerges so that there is high conceptual coherence between the new concepts inspired by TGD.

The identification of the imbedding space correlate of self as causal diamond (CD) of the embedding space combined with the identification of space-time correlates as space-time sheets inside CD solved the problems concerning the relationship between geometric and subjective time.

Subjective memory is assumed to correspond to an average of conscious experiences of quantum jumps occurred after the last wake-up of self (the first one in the sequence of state function reduction at same boundary of CD). This leads to the identification of qualia as averages of the increments of quantum numbers and zero modes in the ensemble of quantum jumps defining self. Summation hypothesis states that self X experiences the experiences of its subselves as abstracted experiences, averages X_{ij} about sub-subselves X_{ij}. Subselves of un-entangled selves can entangle (this is due to the many-sheeted sub-system concept) and this allows fusion and sharing of mental images.

Quantum entanglement provides a mechanism leading to the formation of irreducible wholes at the level of mental images. Entanglement can be entropic bound state entanglement or negentropic entanglement, which need not involve binding energy. The latter is possible only in the intersection of real and p-adic worlds where life can be said to reside. Quantum entanglement is possible also in time direction in zero energy ontology. It is tempting to assign negatively colored emotions to the entropic entanglement and positive emotions to the negentropic one. In TGD framework the standard vision about brain based on reductionistic-holistic dichotomy must be replaced with a trinity in which negentropic entanglement corresponds to a mode of cognition, which does not allow linguistic expression and episodal memories, and various mental feats of synesthetes and idiot savants could be seen as a manifestation of negentropic entanglement. Also meditative consciousness would be negentropic.

Selves are called irreducible if they possess no subselves, otherwise reducible. Subselves correspond to mental images so that irreducible subselves possess no mental images and are in a state of pure self-awareness: it is not clear whether this kind of states are possible in practice. When the subselves of self fuse to single negentropic subself, a state of "one-ness" results in somewhat different sense. This mode of consciousness can be identified as "whole-body" consciousness and

differs from ordinary consciousness during which self has large number of mental images. These modes could naturally explain emotional/holistic and rational modes of mind. These two modes could make it possible to understand various dichotomies like brain/left brain, emotional/analytic, religous/rational, Eastern/Western,... One could understand linear cognitive processes like thinking and language as self cascades in which self decomposes into subselves, which in turn decompose into subselves, which ... and self hierarchy implies connection with computationalism.

The possibility of negentropic entanglement has profound implications. It leads to a vision about learning as a basic quantum process possible in the intersection of real and p-adic worlds and made possible because state function reduction ceases to be a random process for negentropically entangled zero energy states. Quite concrete ideas about the role of synaptic transmission and neural transmitters for consciousness emerge. Music experience provides an especially interesting application for the vision about consciousness and zero energy ontology together with number theoretical vision inspires several concrete interpretations. Synchronous firing of neurons- in particular at 40 Hz frequency- is an attractive correlate for the negentropic entanglement and synesthesia can be interpreted as a particular manifestations of negentropic entanglement.

In TGD framework it is not at all obvious that the highest levels of our personal self hierarchy should correspond to the size of the physical body. Various empirical facts, in particular the observations related to the special effects of excitations of geomagnetic fields and ELF em fields in EEG frequency range on brain, inspire the hypothesis that our selves correspond to topological field quanta of em fields associated with EEG frequencies and thus by Uncertainty Principle have size scale of Earth. This leads to a rather radical modification of the brain centered views about consciousness, and one can quite seriously consider the questions like what physical death means from the point of view of consciousness: it could be that electromagnetic part of self hierarchy could survive after the physical death as a "soul".

This chapter is devoted to the theoretical aspects related to the definition of self. In second chapter applications of the notion of self are discussed. The plan of this chapter is as follows.

1. In the first section the notion of self is defined and various aspects related to it are discussed. This includes discussion about the flow and arrow of time, qualia, quantum model for intelligent systems, emotional representation of Boolean logic, the origins of ethics and moral as NMP allows to understand them, and self referentiality. Also the general structure of conscious experience is considered: self has sub-selves experienced as mental images and sharing and fusion of mental images is possible in many-sheeted space-time. Various aspects of binding are discussed in terms of negentropic entanglement. The basic prediction is entire self hierarchy and also the aspects related to this hierarchy are discussed.

2. Second section is devoted to a critical question: is NE experienced directly or does it only define a model of self and is it necessary to have a mechanism allow to make the information in question conscious. Although the most elegant assumption is that sequence of repeated state function reductions makes NE conscious, the possibility that interaction free measurement might be needed to achieve this, is discussed.

This is the second part of the chapter devoted to the notion of self and discusses various applications of TGD inspired notion of self.

1. Some applications at brain level are considered including the differences between left and right brain hemispheres and music experience.

2. Negentropic entanglement seems to be the key to the understanding of altered states of consciousness. What I call whole-body consciousness is discussed in this framework. Also EEG synchrony and synesthesia are analyzed in terms of negentropic entanglement.

3. Higher levels of biological self hierarchy are discussed. Here the notion of magnetic body is central.

4. An attempt to understand what happens in ageing and death is made.

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` [L17].

5.2 Some Applications At Brain Level

In this section the notion of self and related notions are applied to brain at general level. Due to the introduction of the notion of negentropic entanglement (NE) the representation differs from the earlier one decisively. The most recent progress (2015) in understanding of ZEO, NMP, the role of NE, hierarchy of Planck constants and its its correlation with hierarchy of quantum criticalities, and number theoretic universality realized in terms of adelic physics have not however been taken into account properly although I have made some comments here and there.

5.2.1 A Simple Model For Cognition

The hierarchy of selves and summation hypothesis allows to construct a very general model for cognitive processes including as a special case thinking, analysis of visual experience, and language. In nutshell: cognitive process could be regarded as cascade like process leading to a generation of selves followed by generation of sub-selves for these leading to.... Quantum jump becomes the building block of cognition and thought but is not sufficient alone. p-Adic space-time sheets as correlates of cognition provide geometric correlates for thoughts, intentions, plans, etc.. are a fundamental element of cognition. The longheld idea that the transformation of intention to action corresponds to p-adic-to-real transition has been given up: it is mathematically awkward and is not needed.

The intersection of real and p-adic worlds understood as partonic 2-surfaces and string world sheets allowing an interpretation in both real and p-adic sense and the intersections of real and p-adic partonic 2-surfaces consisting of rational and common algebraic points define the lowest level cognitive representations. NE is possible only in the intersection in accordance with with the vision that cognitive representations carry the information.

Quantum criticality of TGD and existence of selves

The model of cognition provides a new view to the role of quantum criticality of TGD. TGD Universe is like a system at a top of hill at a top of hill at.... More concretely, there is an infinite fractal hierarchy of sub-algebras of super-symplectic algebra isomorphic to the full algebra with conformal weights coming as n-ples of those for the full algebra [K36, ?, K73]. This kind of sub-algebra acts as conformal gauge symmetries at the level of criticality labelled by n. The phase transitions replacing n with its multiple occur spontaneously and one obtains infinite inclusion hierarchies with $n(i)$ dividing $n(i+1)$. These hierarchy would naturally have interpretation as inclusion hierarchies for hyper-finite factors of type II_1 [K120].

The value of Planck constant $h_{eff}/h = n$ would label these hierarchies and for large values of n one would have macroscopic quantum coherence. By NMP the first state function reduction to the opposite boundary of CD would in ZEO give rise to a phase transition increasing h_{eff} but meaning death of corresponding self and re-incarnation at opposite boundary. Selves would fight to get NE to satisfy the needs of NMP and in this manner to avoid this fatal first state function reduction. The fight for survival would allow sub-selves representing to die and born again generate NE and evolution would be the outcome. Weak form of NMP allows also reductions for which the NE is not maximal. This option is actually better concerning generation of NE.

TGD universe would be in a state of maximal alertness ready to generate cascades of selves representing cognitive acts. Our sensory and cognitive acts would be only part of those of the entire Universe proceeding from top to bottom as infinite trees with branches representing new selves and nodes representing moments of wake-ups for the selves. Or expressing it in the terminology of AI: we would be like subprograms of infinite program represented by entire universe. The presence of higher level selves means that cognitive acts can proceed from the level of even entire biosystem to the level of DNA. This encourages to interesting speculations: for instance, the ideas of Sheldrake about learning at the level of species and even biosphere might find justification [K87].

Number theoretical criticality is an important aspect of quantum criticality and is taken to mean that life and conscious intelligence reside in the intersection of real and p-adic worlds, where discrete cognitive representations. By strong form of holography the intersection would consist of string world sheets and partonic 2-surfaces characterized by parameters in some algebraic

extension of rationals defining a hierarchy. By conformal invariance the moduli spaces of conformal equivalence classes restricted to algebraic extension would define the intersections.

Quantum jump as cognitive process

The following scenario is a vision about what happens in cognition much before the recent progress in understanding ZEO, NMP, the notion of negentropic entanglement, and hierarchy of Planck constants labelling that of quantum criticalities and dark matter, and is therefore out-of-date at the level of details.

U process followed by a cascade of state function reductions will be identified as the basic cognitive act.

1. State function reduction can be characterized as a binary tree. At each step of the state function reduction cascade some sub-selves manage to remain unentangled, some sub-selves lose their consciousness by developing entropic bound state entanglement, or experience expansion of consciousness by entangling negentropically. A particular branch of the process stops if sub-self allows no decomposition to entropically entangled but otherwise free pieces. What is new is that the entanglement is also time-like and time-like entanglement turns out to be central for understanding of what happens in learning.

2. The binary tree of state function reduction has a natural ordering. This ordering need not have any correlate at the level of geometric time. At the level of subjective time and conscious experience the correlate for ordering could exist but if self experiences its sub-selves as averages of sub-sub-selves this cascade is experienced only partially by given sub-self. One can of course argue that self wakes up in each quantum jump separately and quantum jump sequence should be seen as a sequence of "awakenings" (I used this term earlier): this awakening is however something different from the emergence of mental image. Maybe time-like NE is which binds this sequence of "awakenings" to a continuous stream of consciousness that we experience.

3. The outcome of the state function reduction is random when it leads to un-entangled sub-self but statistical determinism implies reliability at the level of ensemble. For NE state function reduction is nearly deterministic process and in this case one can speak in reasonable approximation about an iteration of a unitary processes defined by the powers of U. This iterative process defines a self-organization process expected to be also behind learning.

4. One possible interpretation of the self cascade is as a representation for an abstraction process representing thoughts about thoughts about... Our poor ability to form statements about statements about... would correspond to the fact that self experiences only its sub-selves directly. Another interpretation is as analysis, in which initial experience gradually sharpens and gets more and more structured during the decomposition into sub-selves. Sub-selves could be thought as symbols of language or as logical statements or objects in picture: interpretation depends on what kind of cognitive process is in question. This process occurs in several time scales- even in the time scale defined by human life cycle. The modular structure of cognitive acts is also analogous to the modular structure of a computer program: starting of subprogram means the reduction of entanglement for the corresponding subsystem.

One can see this process also at the level of embedding space correlates.

1. Selves wake up and begin to perform quantum jumps. The embedding space counterpart for self is CD (causal diamond) characterized by time scale coming as powers of two and is scaling like the value of Planck constant. Subselves correspond to sub-CDs. Wake-up requires a feed of metabolic energy to destroy the bound state entanglement. Self could be also created from vacuum or disappear to it in a quantum jump generating a completely new CD or annihilating it.

2. Cognitive process proceeds in a cascade like manner starting from the root of tree formed by CDs and going downwards along the tree choosing at each node some branches. For instance, understanding of a sentence would correspond to waking up of large self A representing

sentence in its entirety, words its sub-selves B_i, phonemes to sub-selves C_{ij} of B_i, etc... waking-up in this order. Similarly, the act of decomposing the figure to objects and of objects to sub-objects would correspond to a temporal sequence generating selves within selves. NE would be crucial for experiencing both the whole and the parts simultaneously. Background would be the largest conscious self and objects would correspond to a sequence of selves. Selves C_{ij} and further sub-selves can be generated before generation of next C_{i+1}: this should occur in case linguistic mental image: generation of word self would be followed by the generation of syllables and phonemes and only after this would next word be generated. Time non-locality of self experience with respect to geometric and subjective time would be essential.

5.2.2 Cognition, Learning, And Ne At The Level Of Brain

NE is information carrier and learning is gaining information. Does this mean that learning takes place automatically in the intersection of real and p-adic worlds? Unitary U-matrix between zero energy states characterizes single step of quantum jump sequences and for negentropic states the state function reduction is not random process and in the first approximation U^N characterizes the outcome of N subsequent quantum jump so that learning process should be characterized by the iteration defined by the powers of U.

In neuroscience synaptic contacts are believed to be crucial for cognition, learning, and memory and it is interesting to try to relate this picture to the TGD based vision about conscious information and learning. How NE could be realized at the level of brain? Is it time-like, space-like, or both? Can one assign the generation of NE between neurons to the attachement of neurotransmitter to receptor? Can one relate the general quantum model of learning to the neuroscience based model of learning relying on the growth of brain cells, synaptic contacts, and synaptic plasticity?

The picture of the standard neuroscience about learning

It is good to summarize first the vision of standard neuroscience about the neural correlates of learning.

1. Basic notions

Synaptic transmission [J9, J22] is believed to be a key element of brain consciousness. Synaptic transmission takes place as synaptic vesicles carrying neural transmitter. Given neuron can release several transmitters. The transmitter molecules bind to the receptors at the postsynaptic cell membrane. Depending on whether this process leads to a de-polarization or hyper-polarization one speaks of excitatory or inhibitory receptors (activation potentials). Since most transmitters attach mostly to either kind of receptor, one speaks about excitatory and inhibitory transmitters although this terminology is misleading. Receptors can be classified to relatively simple ion channel receptors and more complex receptors involving second messenger proteins.

The belief is that the primary process does not involve communications with genome but if one accepts the DNA as topological quantum computer picture-in particular, on the existence of magnetic flux tubes connecting cell membrane and DNA nucleotides- the possibility that these communications are an essential element of process and that a new kind of gene expression at cell membrane level is involved. The communication to the DNA could take with light velocity if massless extremals are involved.

The synaptic strength characterizes the sensitivity of the postsynaptic neuron to the firing of the presynaptic neuron. It depends on the density of receptors and their activity as well as the total amount of neural transmitter transferred between neurons determined by the number of synaptic vesicles transmitted. This in turn depends on the size of the synaptic button. All these parameters are affected in learning understood as a change of synaptic strengths. It must be emphasized that learning in this sense should be seen as a neural correlate for conscious (or unconscious-to-us) learning and possibly of memory. What is essential that the response of the postsynaptic neuron changes. This picture relies on the technical assumption that learning reduces to the changes of synaptic strengths. This assumption is probably an over-idealization: much more probably happens.

2. Learning at brain level

Learning in the sense as it is defined above can take place at the level of both anatomy and physiology. Learning at the level of anatomy can mean growth of new synaptic connections and of even new neurons. For instance, the growth of new neurons in hippocampus is now understood to be essential prerequisite for learning. It is believed that the information from the connections of old neurons is transferred to those of cortical neurons. This can of course happen but in TGD framework this is not necessary since the new view about time allows to interpret memory as communications with the brain of the geometric past.

Learning at the level of physiology is known as synaptic plasticity [J20] and involves several mechanisms. Synaptic plasticity means that the sensitivity of the postsynaptic neuron to the signals from presynaptic neuron can change.

1. Sensitivity means essentially the probability for the firing as a response to the firing of presynaptic neuron and this is controlled by the sign and magnitude of the activation potential and the increase of the sensitivity means a generation of stronger de-polarization or weaker hyper-polarization. Postsynaptic neuron can become more or less sensitive to the presynaptic neuron whereas presynaptic neuron can send stronger signal by increasing the number of synaptic vesicles.

2. The change of the sensitivity of the postsynaptic neuron can take place several mechanisms [J20].

   (a) The first mechanism involves the modification of protein kinases whose function is to phosphorylate the receptor which means essentially providing it with metabolic energy. The effectiveness of the protein kinases is regulated. Second mechanism depends on second messenger neurotransmitters regulating gene transcription and regulates the levels of key proteins at synapses. Gene expression is affected in this mechanism and the effect is long-lasting.

   (b) Third mechanism affects the number of ion channels (ion transfer between cell interior and exterior is basically responsible for the activation potential) and is involved with long term potentiation (LTP [J13]) and - depression (LTD [J12]) believed to be central mechanisms of learning memory. LTP is believed to be of central importance in hippocampus. The change of the density of receptors is one manner to achieve LPT or LTD. For so so called AMPA receptors [J4] to which glutamate binds this mechanism is well-established. Also phosphorylation and de-phosphorylation of AMPA receptors and change in the probability of glutamate release is a decisive factor.

3. The notion of Hebbian learning [J10] applies to LTP. Hebbian rules summarizes the above picture as simple mathematical rules allowing computer modelling. When pre-synaptic and postsynaptic neurons fire simultaneously, synaptic connections are affected. Weak stimulations of several pathways add up. Also temporal summation takes place if the frequency of firing is high enough. Strong stimulation of one pathway affects also other pathways. More general formulation of the rules does not require the firing of the postsynaptic neuron. For anti-Hebbian learning de-sensitization takes place. Also non-Hebbian learning is believed to take place.

4. The change of the postsynaptic action potential need not be the only outcome of learning. If this were the case, the huge number of neural transmitters and receptors inducing different responses would not be needed. The change of the sensitivity is only one aspect of learning and as its relationship to conscious learning is unclear.

TGD based vision about cognition and learning

In the following a brief summary about TGD inspired view concerning cognition and learning in general and at brain level is given.

1. Basic ideas

The general ideas about cognition have been also discussed but is useful to summarize them again.

1. Sub-self interpreted as a mental image is key notion. Sub-selves wake-up, fall asleep, and fuse together losing consciousness or experiencing expansion of consciousness.

2. The cascade of state function reductions can be regarded as an analysis leading to a final state in which sub-selves are either entropically or negentropically entangled systems. The latter systems can be seen as negentropic mental images resulting as sub-selves fuse together. In the case that two sub-selves are involved, the resulting mental image can be regarded as an abstraction or rule such that the state pairs appearing in the superposition correspond to the instances of the rule. If one state pair dominates then association in classical sense is in question in good approximation.

3. NE can take place between systems which belong to same or different number fields and gives rise to various kinds of conscious experiences. At least in the case that the other system is p-adic, NE should be a correlate for the conscious experience of understanding.

4. Zero energy states for brain represent rules as pairs of positive energy (initial) and negative energy (final) states. M-matrix characterizes zero energy state and defines a rule representing "laws of physics" at the level of conscious experience. Different M-matrices are orthonormal with respect to each other and in ensemble all of them appear and each of them can be also regarded as representing one particular instance of a rule.

A new element is that unitary time evolution characterized by U-matrix forces the learning to occur in the sector of state space containing zero energy states for which positive and negative energy parts of the states are negentropically entangled. U-matrix and its powers characterize the learning process. When the states are negentropically entangled, state function reduction for M-matrix is not a random process but leads to a unique state maximizing negentropy and in a good approximation the restriction of U matrix to these states codes for the evolution of M-matrix. U^N restricted in this manner characterizes the M-matrix after N quantum jumps. Therefore learning is unavoidable in the case of negentropic states and U^N at the limit of large number of quantum jumps characterizes the learning. The value of N is of course limited by the size of CD assigned to the learning system. One can of course wonder whether the unitary period is following by a return to unentangled state via the liberation of metabolic energy associated with the NE.

The powers of U define an iterative map and iterative maps are the key element of self organization and also one of the main tools of generating fractals [K87]. Quantum classical correspondence therefore suggests that 4-D fractal self-organization patterns define the space-time correlates for learning.

2. General view about learning at the level of brain

M-matrix for brain codes its view about laws of physics. In diagonal form represents pairing of initial and final states as rules $A \rightarrow B$. For instance, in fermionic degrees of freedom these rules can be interpreted as Boolean rules. More generally, the interaction as quantum associations containing superposition of instances of the associations are in question. Huge quantum superposition of rules is possible since the number of neurons large and the information storage capacity of entanglement increases exponentially with the number of neurons.

U-matrix approximated as a matrix restricted to represent unitary evolution of negentropic zero energy states assignable to brain provides the first principle description for learning as the sequence of powers U^N. In the models of associative learning learning is reduced to a local process expressible in terms of changes of the synaptic contacts. This suggests that the basic building block of U matrix is synaptic transmission. This means an analogy with the basic braiding operation of the neighboring strands represented as R-matrix defining the unitry matrix for topological quantum computation [K2]. There is also an analogy with generalized Feynman diagrams. The incoming particles would be neurons. Synaptic transmission analogous to particle exchange between two neurons. U matrix can be regarded as a quantum superposition over all possible diagrams containing arbitrary number of synaptic transfers. Multiverse picture at neural level thus results as one might expect since macrotemporal and macroscopic quantum coherence is involved. If the

situation reduces in a reasonable approximation to a description in terms of synaptic transfers one can in principle describe synaptic plasticity, LTP, and LTD and other mechanisms to in terms of the basic building block of U associated with the synaptic transmission and mathematically analogous to Feynman propagator. The binding to the receptor could induce communications with genome and also the U-matrix assignable to topological quantum computations at the DNA level might be involved.

As such this picture provides only a first principle formulation for what conscious learning is and it requires a work to deduce predictions testing this vision or at least to gain understanding using this vision. A key aspect of NE is that it carries metabolic energy. This has been already proposed to provide a first principle explanation for the notion of the high energy phosphate bond crucial for the understanding of $ATP \rightarrow ADP + P_i$ process defining the key stop of metabolism [**?**].

Also space-like NE is possible for positive (negative) energy parts of the states. In particular, negentropic entanglement between presynaptic neuron and postsynaptic genome generated by the attachment of the transmitter to the receptor might make sense. There is temptation to assign to this connection a magnetic flux tube identified as a carrier of metabolic energy released in the process and inducing ionic currents leading to the processes affecting the synaptic strength as well as the states of neurons involved. The larger the metabolic energy release is, the more intense are the ionic currents involved and the stronger the modification is. This would provide a first principle explanation for why more effective phosphorylazation of the receptor as a correlate for learning. Of course, the explanation works even without the heavy conceptual machinery if one is ready to accept the somewhat nebulous notion of high energy phosphate bond.

5.2.3 Ne And The Role Of Neurotransmitters

Soon after starting to develop TGD inspired theory of consciousness, I somehow ended up to an email correspondence with Gene Johnson who insistently emailed me links to abstracts about neuroscience. I read the classic Bible about brain by Kandel *et al* [J94] and tried to make sense of it in my own conceptual framework. This was of course hopeless task since I had only the notions of quantum jump and self. The feeling that something very simple -about which I do not and perhaps cannot ever have a slightest clue- must be behind this incredible complexity made the situation really frustrating. The deeper meaning of EEG, nerve pulse neurotransmitters, hormones- actually of entire brain chemistry and also biochemistry- remained a total mystery.

Development of ideas

After the required number of years however some concrete ideas began to emerge.

1. The notion of magnetic body with fractal onion-like structure meant a decisive step of progress. Also the hierarchy of Planck constants and dark matter as controller of visible matter in living systems emerged. The function of EEG as communication and control tool of magnetic body using biological body as a motor instrument and sensory receptor looked very natural. This led also to a proposal that there is an entire hierarchy of EEGs and their variants. After several trials a vision about nerve pulses as concomitants of quantum level communications emerged as also a vision about DNA as topological quantum computer based on the flux tubes connecting DNA nucleotides with the lipid layers of cell membrane emerged and providing a function for the intronic portions of genome as carriers of quantum computer programs [K2].

2. Also a vision about the biochemical role of dark matter evolved. In particular, phase transitions reducing Planck constant for a magnetic flux tube would induce its contraction and force biomolecules near to each other. This would explain the miracles of DNA replication, translation, and transcription and quite generally the processes known as aggregation of proteins. The reconnection of magnetic flux tubes changing the topology of the biological Indra's net would be also a central mechanism.

3. The model of nerve pulse and the vision about living matter as a kind of dynamical Indra's net led to a first clear idea about the role of neural transmitters. Transmitters are classified to inhibitory or excitatory depending on whether they increase or reduce the magnitude of

the membrane potential. This property is however a property of the receptor rather than that of the transmitter. The same transmitter can have both excitatory and inhibitory receptors although often either receptor type dominates. The proposal was that neural transmitters are associated with the ends of the links of the 4-dimensional web connecting neurons to each other. Neurotransmitter attaches to the plug defined by the receptor connecting the communication wire from presynaptic neuron to the flux tube leading to the passive portion of postsynaptic DNA strand acting as sensory receptor. This would make possible rapid communications to DNA. The corresponding active portion of DNA strand could then respond by generating an activity at the level of cell membrane. This conforms with the general idea that proteins represent only one particular outcome of the gene expression. This left open the question whether the excitatory-inhibitory dichotomy could have some deeper meaning.

4. Also it became clear the emotions and information are closely related and that peptides acting both as neurotransmitters and hormones are crucial for emotions [J43]. I proposed that emotions are "entropic" qualia. Although I realized the importance of negentropic entanglement I did not have time or I was not able to realize how far reaching this notion actually is.

Is genome a fractal counterpart of brain?

Fractality replaces standard reductionism in TGD Universe. An old idea inspired by p-adic length scale hypothesis is that the binary structures associated with p-adic scales $L(k) \propto 2^{k/2}$ and $L(k+2)$ define a fractal hierarchy. Brain hemispheres would represent one example of this kind of pair, lipid layers of cell membrane second one, and DNA double strand third one. Just for fun one could assume that the structure and functions of brain hemispheres have fractal analogs at the level of DNA double strand and vice versa and look what kind of questions this inspires.

1. Could the identical structures of DNA strands correspond to the anatomical similarity of right and left brain and could the functional asymmetry of the strands correspond to the laterizalization of brain function? Could the genome act as the brain of cell? Could various brain areas have counterparts at the level of DNA? Could the hydrogen bonds between nucleotides serve as the counterpart of corpus callosum? Could the splitting of these bonds during transcription and replication correspond to what happens to a split brain patient?

2. Before continuing it must be made clear that the global identification of right-left dichotomy with holistic-reductionistic dichotomy is wrong. One can however consider its local variant with holism and reductionism assigned do the pairs of right and left brain areas. For instance, in contrast to the naïve rule the emotional right (left) brain (amygdala) would be reductionistic (holistic, negentropic) whereas the intellectual right (left) would be holistic (reductionistic, entropic). The practical reason to the division to the entropic and negentropic pieces could relate to the metabolism. The entropic regions could provide the binding energy as a usable energy to the positive energy NE. Good is not possible without Evil! There are no winners without losers!

Right brain is specialized in spatial thinking and left brain to verbal thinking and arithmetics: the geometry-algebra division of mathematics! Right brain is not so good in motor actions as left brain as any right-handed person knows. Right brain is however better in tactile sensing: right handed persons tend to use left hand for touching objects to get an idea about their shape. Also this can be understood in holistic-reductionistic picture.

3. Apart from reflex actions almost all activities of the body seem to be controlled to a high degree by brain. Could also the activities of cell be regarded as motor actions of the genome acting as the brain of cell receiving sensory input from the cell membrane? Could one identify the analogs of sensory areas receiving information from cell membrane, processing, and sending it to the association areas? Could the analogs associative areas be identified as intronic portions of DNA performing topological quantum computations and communicating the outcome to the higher motor areas at the intronic portions of the of the complementary strand, wherefrom they would be communicated to the primary motor areas identifiable as the regions of DNA expressing themselves either chemically (RNA and proteins), as activities

generated directly at the level of cell membrane, or electromagnetically? For instance, could neurotransmitter in the receptor generate the feed of sensory input to the genome inducing the change of the membrane potential as the counterpart of motor action. Could prokaryotes without introns be analogous to brain with only primary sensory and motor areas or to mere ladder-like nervous system?

One could argue that the analogy between DNA are brain fails because second DNA strand is completely passive whereas both brain hemispheres express themselves via motor actions. This is not the case! Both DNA strand has regions expressing themselves but the transcription takes place in opposite directions. Hence DNA strands have motor and sensory areas as also brain does, and the natural guess is that primary motor areas correspond to the areas expressing themselves in terms of RNA, proteins, and possibly also as actions at the level of cell membrane. Primary sensory areas would correspond to to regions complementary to the primary motor regions.

4. What right brain sings-left brain talks metaphor could mean in this picture? Pitch-rhythm dichotomy is more technical expression for this dichotomy. Function providing local data and its Fourier transform providing global data is more abstract representation for this dichotomy and Uncertainty Principle for momentum and position relates closely to these two representations of information. This dichotomy could reflect the presence of two different natural time scales and millisecond time scale for nerve pulses and.1 second time scale for moments of sensory experience are the natural candidates.

   If so, this dichotomy could directly reflect the different time scales assignable to u and d type quarks (1 millisecond) and to electron (100 ms) and reduce to the level of elementary particle physics. This dichotomy would also have fractally scaled up variants made possible by the hierarchy of Planck constants. The analog of Fourier transform would be the NE of sub-CDs (assignable to quarks) to single mental image inside electron's CD. The analog of function itself would be a collection of sub-CDs representing separate unentangled mental images assignable to individual nerve pulses in millisecond time scale. Also the topological quantum computations assigned to the intronic portions correspond to different time scales due and reflect quark-lepton dichotomy. The quarks in question could be the quarks assigned to the ends of flux tubes in the model of DNA as topological quantum computer.

5. This raises some questions. Could the gene expressions of the two strands somehow reflect this dichotomy? For instance, could the flux tube structures assignable to the amino-acid sequences correspond to the millisecond and 100 ms scales assignable to quarks and electron have the property that also the functioning of these proteins is characterized by these typical time scales? According to [I68] the time scales of protein folding vary from.1 s to 10^3 s. According to Wikipedia [I16] the typical time scale is 1 millisecond which suggests that the time scales correspond to two ranges beginning from ms and 100 ms respectively. There are also short proteins for which the folding takes place in microsecond time scales which might relate to the CD of proton.

What can one say about the function of neurotransmitters?

Can one say anything interesting about the function of neurotransmitters if one combines this highly speculative picture- which can be defended only by the belief on fractality as universal principle- with the idea that bound state and NE make possible the fusion of mental images.

1. Suppose that the fusion of neuronal mental images is required to build higher level mental images that we experience. Suppose that neuronal mental images involve DNA in an essential manner. Suppose that magnetic flux tubes serve as correlates for the entanglement so that the transmission of nerve pulse from pre-synaptic neuron to post-synaptic one creates a flux tube connection between neurons possibly extending to the genome of the post-synaptic neuron. The transmitter at the end of flux tube attached to the receptor acting as a plug would build this connection to some part of DNA specialized to receive particular kind of sensory data from a particular region of cell membrane with complementary strand activating as a response a motor function inducing gene expression at cell membrane level. Gene expression as build-up of proteins would not be necessary and is also too slow for neural activities.

2. Suppose that the entanglement between neurons generated in this process is always negentropic as the interpretation as the idea about neural correlate for a conscious association suggests. One could also ask whether the neurons could entangled entropically and whether the entropic-inhibitory association could make sense. This does not lead to anything interesting and entropic entanglement between neurons should be regarded as a pathological condition. Note that neuron-neuron entanglement would be naturally time-like and in this case only NE might be meaningful.

(a) To gain some perspective consider the activation of cell in general by some external perturbation from the resting state to the active state (here I have learned a lot from email correspondence with Vladimir Mateev) In the resting state the proteins inside cell are passive -or rather, forced to be passive- as one might expect on basis of the general vision about homeostasis. The unfolded proteins and unfolded portions of the folded proteins are connected by hydrogen bonds to ordered water so that the folding occurring otherwise spontaneously is prevented. One can say that the cellular winter prevails. The situation is however nearly critical and if external perturbation occurs cell liberates metabolic energy melting the ice and spring comes. Also the outer surfaces of globular proteins are hydrogen bonded and when the ordered water melts, spontaneous melting of the protein takes place leading to a partial unfolding.

The resulting folded proteins and partially unfolded globular proteins interact by forming aggregates and this activity would naturally involve $\hbar$ reducing phase transitions and flux tube reconnections. In TGD based model the mechanism of both folding and melting would be the liberation of metabolic energy destroying the hydrogen bonds and the energy for this comes from the ATP containing positive energy negentropic bond between O=s of phosphates.

(b) Similar situation could prevail at the cell membrane. One can imagine that cell membrane is like a particle at the bottom of a small potential well. At the other side there is a deep well representing the generation of nerve pulse and at the other side a high wall corresponding to hyper-polarization requiring energy. Both polarization and hyper-polarization are prevented by the freezing of protein activities needed to induce them. The flux tubes connecting the presynaptic neuron and receptor and possibly genome are always negentropic and their formation can as such serve as the signal leading to the partial melting of the ordered water making possible to generate action leading to either de-polarization or hyper-polarization. The signal could be just the additional metabolic energy making it possible for these transitions to occur.

(c) This picture does not require any communications from the receptor to the genome and in the simplest situation the resulting action could be seen as the analog of reflex action. These communications could of course be present and the negentropic entanglement could make it easier to induce de-polarization also now. Also the question whether excitatory-inhibitory dichotomy for the receptors has some deeper meaning apart from taking the neuron nearer to or farther from criticality for firing remains unanswered.

5.2.4 Differences Between Left And Right Brain Hemisphere

The differences between left and right brain hemisphere or lateralization of brain functions -as the more technical term states it - represent a challenge for any theory of consciousness. This difference is often stated by saying that right brain is holistic and left brain reductionistic - or more concretely - that left brain talks and right brain sings, left brain is linear and right brain parallel, or that left brain is algebraist while right brain is geometer. The assignment of the holism-reductionism to the hemispheres as whole is probably an exaggeration. For instance, right limbic brain is specialized to negative emotions and left limbic brain to positive emotions and it is not clear whether this has anything to do with holism or reductionism. It could however be that pairs of various left and right brain regions could be characterized in terms of this dichotomy or perhaps trinity in which reductionism, holism, and their fusion are possible but that a given region of given hemisphere can favor any of these options.

Holism, reductionism and their fusion, entanglement, and zero energy ontology

In TGD framework the basic mechanism responsible for reductionism-holism dichotomy would be the possibility of the mental images to fuse to larger mental images. Depending on the nature of entanglement the resulting mental images are either negentropic or entropic. Entropic entanglement represents a holism as the antipode of reductionism whereas NE seems to represent a fusion of holism and reductionism. It would be tempting to assign positive emotions to the NE and negative emotions to the entropic entanglement. Both limbic hemispheres could be holistic but negentropic-entropic dichotomy would distinguish between them.

For the purposes of survival it is good to have both all these three views about reality. In politics hawks, doves and compromize makers would be a counterpart for this phenomenon. This would favor lateralization in a more general sense that a brain region in given hemisphere favours unentangled emotionally neutral mental images, negentropically fused mental images with positive emotional coloring, or entropically fused mental images with negative emotional coloring. Also metabolism could favor formation of the unpleasant entropic mental images since this liberates energy which could be stored in metabolic entanglement as a metabolic energy. Interestingly, it has been proposed that the simultaneous presence of holism and reductionism could explain the amazing mental feats of idiot savants. The irony is that these persons are usually unable to describe their experiences using language, which brings in mind the reports of meditators telling that it is impossible to tell anything about englightment experience using language. Maybe language relates crucially both to the ability to decompose the mental images to smaller pieces and to form entropically entangled wholes of them.

I might be self-contradictory here. On one hand, I have proposed that the feats of idiot savants are possible because they do not conceptualize and in this manner replace reality with the names of the objects of the reality: something extremely economical if one counts bits. On the other hand, I am proposing that the formation of concepts corresponds to the NE. It seems that I should distinguish between two kinds of conceptualizations: the NE without language on one hand achieved in meditative practices and the combination of both entropically entangled and non-entangled representations making possible language but losing the insight of genius.

Zero energy ontology suggests a quantitative formulation of this vision based on the observation that the time scale of electron's CD corresponds to the .1 second time scale defining fundamental biorhythm whereas millisecond time scale defining the fundamental time scale of nerve pulse activity could relate closely to the time scale of CDs assignable to u and d quarks predicted to play a key role in quantum information processing in the model of DNA ast topological quantum computer. There are also shorter times scales, in particular the time scales assignable to proton which can be estimated to be of order 10^{-7} seconds. Also p-adically scaled up variants of these time scales are possible as well as zooming of these time scales at the pages of the Big Book defining generalized embedding space and partially labeled by the values of Planck constant. The first guess is that quark and lepton time scales are behind the reductionism-holism division. Holism would mean temporal binding of the mental images assignable to nerve pulse patterns and characterized by millisecond time scale to negentropic (or possibly entropic) sub-selves characterized by .1 second time scales. Quark like sub-CDs of electronic CDs would serve as embedding space correlates for these mental images.

Objection against simplistic view about lateralization

The hypothesis that right brain is more holistic than left brain can be tested and a considerable support for the hypothesis have been found. There is however a rather paradoxical experimental result challenging the hypothesis in its simplest form and suggesting that the roles of various processing levels of brain hemispheres in the specialization to geometric shapes and linguistic symbols can vary. In [J86] there is report about two experimental situations testing right-left differences.

1. Subject persons saw figure S consisting of smaller figure F: s. On basis of neural firing left brain seemed to recognize smaller F: s whereas right brain seemed to recognize the entire figure S: just as expected.

2. For control purposes figure S consisting of small F: s was replaced with a figure of anchor

consisting of small cups. What happened was that left brain recognized the anchor and right brain recognized the cups! Also firing patterns were essentially the same! It was conjectured that the smallness of cups -smaller than letter F: s- might have something to do with the unexpected result.

Apparently the replacement of letters with geometric shapes means that the roles of brain hemispheres changed. This suggests that the naïve vision about roles of hemispheres must be replaced with something more complex in which one has scale hierarchy of levels such that each level has its own specialization.

1. Suppose first that at the lowest level of the hierarchy the left hemisphere is better in recognizing letters than familiar shapes and right hemisphere better in recognizing familiar geometric shapes than letters.

2. The subject persons are asked to concentrate on either the entire figure or details which repeat themselves. This raises the question whether a single detail becomes actually the whole since the attention is directed to details. If this is the case, the first assumption would explain why right brain hemisphere fires as cup is recognized. Same applies to the left hemisphere in the case of letter F.

3. When the figure as a whole must be recognized, the recognizing hemisphere seems to be the one for which the recognition should be more difficult! The hierarchy of CDs allows to consider the possibility that there is a fractal hierarchy of levels corresponding to different size scales for the structures appearing in the figure. The very fact that subject person is conscious about the existence of smaller details means that smallest structures are mapped to the first level of the hierarchy so that in both cases the figure as a whole would be mapped to the second level of the hierarchy. If one takes the experimental result at a face value, letters should be more familiar to the right hemisphere and geometric shapes of everyday objects to the left hemisphere at the second level of the hierarchy.

4. That the roles of brain hemispheres in lateralization depend on the level of the hierarchy might have an explanation in terms of basic information processing involving communications between hemispheres. Maybe there is a mapping from the first level of hierarchy of a given hemisphere to the second level of hierarchy at the opposite hemisphere and so on. At higher levels of the hierarchy the hemispheres would perceive each others visual percepts. Right hemisphere at the n: th level would receive sensory signals from $n-1$: th level of left brain and vice versa. In this kind of situation the maximal effectiveness of the information processing would be achieved if these two ladders rather than hemispheres have similar specializations.

Some examples

This framework explains various aspects of holism-reductionism dichotomy when given pair of brain regions is considered but it is not meant to apply to brain hemispheres as a single pair.

1. Linear-parallel dichotomy suggests that in a given time scale left hemisphere corresponds to large number of un-entangled sub-selves whereas right hemisphere would correspond to a larger number of entangled sub-selves with entropic (at least in case of limbic brain) or NE. For instance, the unentangled sub-selves can correspond to letters of written text at left hemisphere. At right hemisphere they could correspond to objects of everyday life or even understood words of written text with mental images representing letters entangling negentropically in time direction to form a single mental image. Also much smaller details such as edges an lines of figure having no direct meaning are certainly involved.

   Left brain seems to be skilled in forming mental images about structures consisting of well defined components whereas right brain can grasp the general shape and size of the structure (note however the previous example in conflict with this belief). This could be understood if left brain represents structures linguistically as associative linear structures consisting of parts represented as sub-selves. Thus a structure could be realized as a reverberating neural circuit in which sub-selves representing parts of the structure keep each other awake.

2. Right hemisphere is also claimed to be less analytic. It might be that also this might hold true only for the right-left-right-.. information processing hierarchy when compared with left-right-left... hierarchy beginning from left brain hemisphere. Certainly the entanglement of mental images would explain this.

3. That left brain talks whereas right brain (almost) sings is more than a loose metaphor. It is known that people who have left brain injury and cannot talk can sometimes express themselves by singing. Linear-parallel dichotomy would suggest that left brain is specialized to subjecto-temporal sequences of parallel small-sized mental images of short duration (say words of speech): this would correspond rhythm and other temporally local aspects of music which dominate in speech. Right brain is specialized to large selves formed by the fusion of parallel sub-selves formed by, say, separate notes of music which can last long time and have no linguistic content. These mental images should carry conscious information about non-local aspect such as pitch of the sound. Although the notes of song are heard one in time, they would continue to live in right brain as parallel mental images and make possible to experience the melody as sad or joyful or to remember the key of the music piece.

4. The poor temporal and spatial resolution assigned to the right hemisphere can be seen as a price paid for the holism of entanglement. Again one must however remember that a scale hierarchy might be involved.

5. The claim that right brain is more emotional should be taken with a caution. It seems better to say that the right limbic brain is dominated by negative emotions and left limbic brain by positive ones. The interpretation would be in terms of entropic *resp.* negentropic entanglement: in this sense left brain would have higher emotional intelligence. On the other hand, right brain is claimed to have better skills in recognizing and expressing emotions. This is not in conflict with the fact that left brain hemisphere is the happier hemisphere. These skills could be understood as a more holistic expression of emotions and their perception, and might also relate to the ability of the right hemisphere to generate negentropic entanglement with other brains.

Dr. P. and twins who saw primeness

Oliver Sack's book "The man who mistook his wife for a hat" [J117] contains fascinating stories about those aspects of brain and consciousness which are more or less mysterious from the view point of neuroscience. There are two stories which relate very closely to reductionism-holism tension of conscious experiencing.

The first story is about Dr. P. who suffered visual agnosia and could not recognize concrete objects, say faces unless some nonvisual association was involved. He could however recognize abstract symbols or objects containing some symbolic details making possible the recognition (he recognized Einstein's face, which has indeed become a symbol of wisdom!). Sacks tells about how his patient tried to recognize glove. "A curved shaped containing five small bags" was his abstract analysis: he could not identify the glove as a glove unless he got it in his hand! He could however define glove as an abstract geometric shape allowing simple linguistic description. Dr. P. could identify abstract shapes and symbols like letters and geometric objects but could not recognize real world objects. Amazingly, Dr. P. used musical associations as a way to cope with the complexities of everyday life. He singed through all his everyday activities and lost control totally if this was for some reason not possible. He could also continue teaching of this music class. For instance, he could recognize his music students only when they moved by recognizing their "body music".

As discussed, reductionism-holism duality provides the deep reason for why we have two brain lobes. This allows to understand what might be possibly involved with Dr. P: s case. Dr. P: s right visual areas had been damaged and he could not recognize faces and concrete objects of the visual field. Left visual areas were in good condition and he could identify abstract objects. Other than visual areas were still in good condition in both hemispheres and he could perform recognition using musical associations, associations created by smells, etc... Sacks notices also a deep analogy with Dr. P.: s case and neuroscience. Expressing rather freely what Luria said, entire neuroscience up to seventies provided analytic description of left brain about left brain. It had indeed turned out very difficult to assign any easily identifiable cognitive dysfunctions with

localized right brain injuries and Luria's opinion was that this necessitated completely different approach which he called "romantic" (stories of right brain about both right and left brain!).

In fact, one can formulate new kind of Uncertainty Principle, perhaps it might be called Uncertainty Principle of cognition. Same mental image cannot be both holistic and reductionistic simultaneously. The combination of reductionistic and holistic descriptions (and all possible intermediate descriptions combining parts to "sub-wholes" in various ways) to single description is impossible even in principle! Science and Art as descriptions of the world are very much like mutually incompatible observables of Uncertainty Principle! The obvious reaction of the alert reader is that NE might allow to achieve both reductionism and holism simultaneously. Maybe this is the case but in this case there is no manner to communicate the mental using language if the proposed interpretation is correct.

Sacks tells also about twins, John and Michael, who had mysterious ability to "see" large numbers. For instance, matchbox was dropped from the table and its contents were spread along the floor. Both twins shouted immediately "111!". Then John mumbled "37", Michael repeated it and John said "37" third time. Obviously this was their cognitive representation for the decomposition 111=3x37 of number 111 to a product of primes!

How John and Michael did these numerical feats? The first thing to notice is that twins had intelligence quotient of about 60 and could not perform even simplest arithmetical operations. They did not even understand what the concepts of prime and decomposition into prime factors mean conceptually. They however experienced primes as especially interesting numbers and even played a game in which they invented new primes. One can safely assume that they did not consciously calculate the decomposition of number 111 to a product of primes. When asked how they were able to tell the number of matches, they told that they "saw" it. In fact, their eyes moved in strange manner always when they were performing numerical tasks and stopped when the solution was found. Also the decomposition of 111 to a product of 3 primes "37" seemed to occur completely spontaneously "in front of their eyes".

The mysterious ability of twins is not a mere curiosity but could provide a crucial clue to the problem of understanding of how numbers are realized as mental images. Indeed, also ordinary human beings are able to experience directly "N-ness", when the size of N is small. A sensory memory associating the visual mental image with the verbal representations of "N" could be in question. This association resembles synesthetic associations, which are also completely automatic.

Thus the problem transforms to a more general question "How integers are experienced directly?".

1. In TGD framework the answer to the question is obvious. Experiencing of "N-ness" means experiencing "N" separate objects as a single whole and corresponds quantum physically to the generation of NE between the cognitive representatives of individual objects. If the resulting mental image associates automatically with a linguistic expression for "N-ness", say $N = 5 \leftrightarrow five$, reportable recognition of "N-ness" occurs. 7 ± 2 law suggests that this entanglement and association usually occurs only for maximal number of objects not larger than $N = 7 \pm 2$. In case of a numerical genius this number seems to be drastically higher. The generation of this entanglement should be spontaneous self-organization process in either brain hemisphere and entangled objects could correspond to separate neuron groups or neurons.

2. The decomposition of integer $N = N_1 \times N_2$ to a product of integers must in this picture correspond to the spontaneous formation of identical "sub-wholes". This process must be a quantum self-organization process. It could favour the decomposition of $N = N_1 \times N_2$ objects to N_1 "sub-wholes" consisting of N_2 entangled basic objects or decomposition of N_2 sub-wholes consisting of N_1 basic objects or something else depending on factors of N. This kind of final states of self-organization are natural since they are very symmetrical consisting of a repetition of an identical basic unit. This kind of self-organization patterns are analogous to the lattice-like self-organization patterns of Benard flow.

3. NMP [K56] could be involved in the following manner. Suppose that the perception of the number of N objects generates in brain an ensemble consisting of N mental images, which entangle negentropically. If so, then the simplest expectation is that entanglement probabilities are proportional to $1/N$ and the number theoretical entanglement entropy is large

only for p-adic primes dividing N. The prime divisor of N giving rise to the largest number theoretic negentropy would determine the p-adicity involved and this could correspond to a perception about the decomposition of the visual representation of N to N/p pieces.

The model also explains the ability of twins to see whether a given number is prime or not. Primes are stable against decomposition into sub-wholes and are therefore "elementary particles of cognition". Hence primeness is a "visible" property: primes are numerical mental images stable against decay to a set of identical numerical mental images. Note that this dynamical process breaks the symmetry between the factors of integer. This clearly occurred in $111= 3\times37$ example. Twins did not "see" "3": they saw only some 37's and did not explicitly tell that there were precisely three 37: s!

In [K15] a more concrete model for how real space-time sheets could represent integers and their prime factorization by their effectively p-adic topology, is discussed.

5.2.5   Music And Consciousness

Music experience provides an interesting testing ground for several assumptions of quantum TGD and TGD inspired theory of consciousness. The notion of self is especially interesting in this respect.

Some aspects of music experience

It is good to list first some elementary characteristics of music experience that the model should be able to explain. Both rhythmic aspects and pitch of the sound are important. Rhythmic aspects correspond to time domain representation for the intensity of sound carrying local information about sound wave whereas pitch carries global information. The relationship between these two elements of music is like that of function and its Fourier transform. Harmony enters the game when several frequencies are present.

1. Rhythm

There are two basic types of views about rhythm, additive and divisive, and they correspond to the multiplication and sum as basic arithmetic operations.

1. In western music rhythm corresponds to a division of longer periods of time divided into smaller rhythmic units. Rhythm is basically a clock and rhythm is essentially a decomposition of integer to a product of integers defining the rhythmic unit and their number. Classical western music is relatively simple rhythmically (consider only the music of Bach). In the music of Chopin tempo rubato makes the duration of the basic rhythmic unit and of its basic structural elements dynamical but rhythms are still relatively simple although simultaneous 3/4 and 3/8+3/8 appears often. In jazz and various forms of popular music rhythms tend to be highly clocklike but are very complex.

2. In Indian music for instance, rhythms are additive and larger periods of time are constructed from smaller rhythmic unis added to the end of the previous unit. This division corresponds to addition rather than multiplication algebraically. Also intermediate forms can appear and do so often in folk music (say folk music of Greece, Balkan, and Spain). For instance, one can have the sum of 3/4+3/8+3/8 as a repeating rhythmic unit. In flamenco form known as Bulerias [J7] the basic rhythmic unit consists of 12 beats and the collective performance creates a very complex and emotionally catching rhythm, which is almost impossible to analyze to pieces. It is easy to believe the claim that artists often fall in trance during the flamenco sessions.

2. Pitch

Pitch can be identified as the fundamental frequency of note. Pure sine wave is aesthetically unpleasing and harmonics are always present and characterize the music instrument. Not only frequencies but also phase relationships between them are important. For instance, they distinguish between the phonemes of spoken language and in the case of singing this brings in an important

additional element not so important for non-electronic instrumental music. Furthermore, melody is never a mere sequence of precisely defined frequencies. For instance, slow modulations of the pitch reducing mathematically to a superposition of closely separated frequencies and glissandos have emotional affect.

The model of music experience should explain also the following aspects related to pitch understand as fundamental frequency.

1. Octaves of the fundamental are experienced as equivalent. The presence of higher harmonics is needed to make pure sinus wave a musical note. Higher harmonics determine the character of the pitch chracterizing the music instrument.

2. There exists a large number of different scales to which one assigns attributes like diatonic, minor, chromatic, whole tone, pentatonic, diminished... All these scales have quite specific emotional coloring and they characterize different music styles. The minimum frequency interval corresponds to a minimal scaling of the frequency and depends on music style. Western classical music uses semitone as the basic unit corresponding to the scaling $2^{1/12}$ in equally tempered scale but also microintervals are used and the only limitation comes the from ability to discriminate between different frequencies. The scales have special notes such as tonic, supertonic, mediant, subdominant, dominant, submediant, subtonic with special roles in harmony. For instance, listener is often able to remember the basic scales even if the tonic of the scale has suffered several modulations during the music piece. Deviations from basic scale have important emotional effects (say in the case of minor scale).

3. Ancient mathematicians believed that the presence of rational multiples of fundamental frequencies are essential for harmony. It is possible to construct the basic scales involving only rational multiples of the fundamental in terms of selected harmonics. For instance, Pythagorean construction uses only powers of 3/2 and octaves to construct the basic scale (C, G, D, A, E, H, ...). Although the pitch is distinguished only within a finite resolution and equally tempered 12-note scale uses only powers of $2^{1/12}$ of the fundamental, rational multiples of the fundamental might relate deeply to the basic physics of cognition and to the frequencies generated in brain as opposed to those used to produce the music.

4. The expectation of an engineer is that the transposition of the scale should not effect on the music experience and one could think that it could be done in a continuous manner. Many composers, for instances Sibelius, experienced different modes differently and as synesthetes assigned to them different visual associations. Many people are able to recognize the ratios of notes but there is also the much rare phenomenon of absolute ear meaning that subject person is able to tell the pitch of the note directly. A synesthesia like phenomenon is probably in question.

5. An interesting question the notion of absolute scale could make sense to some degree? The fundamental frequency of sound producing organs is 10 Hz and the region of audible frequencies begins at 20 Hz and consists of approximately 10 octaves. kHz frequency is the resonance frequency of head sized object and at this frequency the mechanism allowing to deduce the direction of sound source changes. The biological basis for this would be that 10 Hz and 1 kHz define fundamental biorhythms. The quantum physical basis for this could relate to the p-adic length scale hypothesis predicting that 10 Hz and 1280 Hz could correspond CDs of electron and quarks. To get a contact with concretia note that soprano C corresponds to 1046.50 Hz. Also the cyclotron frequencies assignable to various biologically important ions in endogenic magnetic fields could defined preferred scales. The A above middle C corresponds by convention to 440 Hz, which is integer multiple of 10 Hz but by pure convention and fifth octave of 8.175 Hz which is not too far from the lowest Schumann resonance. An interesting question is whether the transposition to a scale for which the fundamental is simple rational multiple of 10 Hz or lowest Schumann resonance might have some specific emotional effect.

3. Harmony and other collective aspects of music

Harmony relates closely to the interaction of different frequencies and is therefore one particular collective aspect of music experience.

In the terminology of physicists, harmony is a phenomenon of many particle physics with particles replaced notes of the scale and many-particle states with chords. Depending on the ratios of the frequencies certain chords are aesthetically pleasing and emotionally significant and there are also principles governing aesthetically pleasing chord progressions. Harmony might be seen as the vertical aspect of the music whereas melody would correspond to horizontal one. Dissonance is the opposite of harmony and tritonus was forbidden in the early western music but is nowadays used to create tension. Polyphony -say in Bach's music- and simple chords used to accompany singing represent two opposite views about harmony. Chopin's music has especially rich harmonies and emotional expressive power.

While listening music one typically selects some instrument as figure and the rest as a background. In romantic piano concertos the competition between the solist and orchestra about the attention of the listener creates the basic tension. In polyphonic music one must also select the tone progression to which attention is directed and it is difficult -perhaps even impossible- to simultaneously grasp the separte tone progressions. Same applies to other elements of music.

Zero energy ontology, hierarchy of Planck constants, and number theoretic physics

The number theoretic vision brings interesting new physics elements which might help to understand music experience.

1. The hierarchy of selves has as an embedding space correlate the hierarchy of CD is basic prediction. p-Adic length scale hypothesis suggests that quantization of size scales of CDs as octaves and the question is whether this relates directly to the preferred role of octaves in music experience. The time scales of CDs define preferred fundamental frequencies coming as octaves and the hierarchy of Planck constants defines scaled variants of these as rational or integer multiples (depending on generalization of the embedding space).

2. The question is whether these fundamental frequencies also define fundamental keys so that music experience would depend on absolute frequency scale. Even if CDs define fundamental keys, the frequency scale associated with sub-CD as experienced in the rest system of CD can be scaled continuously by performing a Lorentz boost for CD. Even glissando could be achieved for CD by performing to the sub-CD a Lorentz boost continuously and leaving the other tip of CD invariant. The boost would be the hyperbolic analog of an ordinary rotation and act like acceleration from rest to constant velocity inside sub-CD. If one takes this picture seriously also Lorentz boosts would be important part of the representation of music at the level of magnetic body (presumably using MEs). Quantum TGD proper suggests the quantization of these boosts.

3. Number theoretic vision predicts an infinite number of algebraic extensions of rationals inducing those of p-adic numbers -in particular those corresponding to roots of unity. In the p-adic context the proper representation of sine waves requires the introduction of these algebraic extensions and the prediction is that rational multiples of the fundamental frequencies assignable to p-adic length scales should have a special role from the point of view of cognition. In fact, the algebraic extensions are now the correlate for the evolution and define a hierarchy of adelic physics predicting the existence of preferred p-adic primes and when combined with NMP also a generalization of p-adic length scale hypothesis [K119].

   This might justify the belief that the notes of the scale should be expressible in the optimal situation as rational multiples of the fundamental note. The cognitive representation of the music in the intersection of real and p-adic worlds should map the physical frequencies or rather the sine waves at a discrete set of time values to their p-adic counterparts. One has to deal with phase factors defined by plane waves $exp(ift_n)$ at discrete set of points t_n such that the exponent equals to $exp(i2\pi m/N)$ and belongs to the algebraic extension. The harmonics of f obviously satisfy the same condition. The representation of pitch in terms of algebraic extensions of rationals requires that the corresponding partonic 2-surfaces correspond to complex enough algebraic extensions of rationals containing high enough roots of unity. The modulation of the pitch as superposition of two nearby rational frequencies could is possible without leaving this framework.

4. One can consider also different but not exclusive explanation for why scales define preferred collections of frequencies. Pythagorean scale involves rational multiples of fundamental obtained as powers of 3/2 and 2 so that the frequencies involved correspond to rationals of form $3^m 2^n$ for which only 3-adic and 2-adic norms differ from one. Small-p p-adicity associated with $p = 2$ and $p = 3$ could select the preferred frequencies.

Why octaves are experienced similarly?

The model should explain the basic features of music experience. There are many interesting questions related to this. One of the most important is why frequencies which are 2^k- multiples of the fundamental frequency, notes differing by octaves, are experienced as identical notes.

1. p-Adic length scale hypothesis, zero energy ontology, and octaves

Thus the phenomenon of octaves could relate to the p-adic length scale hypothesis, which implies that physically preferred p-adic primes correspond to primes near prime power powers of two. For instance, this implies that the massless extremals (MEs) associated with physically important p-adic primes have fundamental frequencies which are octaves of each other. Therefore a classical resonance via the formation of join along boundaries bonds/flux tubes becomes possible and real space-time sheets corresponding to preferred p-adic primes can form larger resonant structures. This universal resonance could explain why octaves are experienced similarly. The problem of this argument was that primary p-adic time scales would come as half octaves instead of octaves.

Octaves seem to have much deeper significance than I thought originally and seem to emerge at the level of fundamental formulation of quantum TGD rather than characterizing only a very special kind of sensory experience. In the recent formulation of quantum TGD using zero energy ontology [K25, K24] one uses zero energy states which have their positive and negative energy parts at the light-like boundaries of causal diamonds consisting of future and past directed light-cones.

Physics as a generalized number theory vision, in particular the assumption that real physics and various p-adic physics result as algebraic completions of rational physics, motivates the hypothesis that the temporal distance T between the tips of the causal diamond is quantized and corresponds to powers of 2 using time scale defined by CP_2 size as a basic unit. This assumption allows to deduce p-adic length scale hypothesis ($p \simeq 2^k$, k integer), and to identify T as a secondary p-adic time scale. For electron this time scale is .1 seconds and corresponds to the fundamental 10 Hz biorhythm. For non-standard values of Planck constant T is scaled by a factor $\hbar/\hbar_0$. Thus octaves become a key element of fundamental physics. One can say that causal diamonds as space-time correlates of self appear naturally as octaves. Also rational multiples of fundamental frequency emerge via the hierarchy of Planck constants: in principle all rational scalings of the basic hierarchy are allowed.

2. Is sensory experience 2-adic in some sense?

A stronger hypothesis for the phenomenon of octaves is that cognitive music selves are 2-adic or that real music selves can transform easily to 2-adic selves. One might even consider the possibility that the phenomenon is much more general. Music metaphor has indeed turned out to be of crucial importance for the theory of qualia. Thus music metaphor could reflect the underlying 2-adicity of the sensory experience (at some level of self hierarchy). Perhaps at least some aspects of our experience result from a mimicry of the lowest level of the p-adic self-hierarchy. Taking 2-adicity seriously, one is forced to ask for the possible consequences of 2-adicity. For instance, could it be that at the level of primary qualia the intensity of sensation as function of stimulus depends on the 2-adic norm of the 2-adic counterpart of the stimulus and is thus a piecewise constant function if sensory input?

An observation supporting this speculation is following. When over-learning occurs in tasks involving temporal discrimination, the intensity of sensation as a function of stimulus deviates from smooth logarithmic form in small scales by becoming piecewise continuous function [J80] such that the plateaus, where response remains constant are octaves of each other.

This observation suggests a generalization inspired by 2-adic version of music metaphor. Primary quale has a multiple of cyclotron frequency as its correlate and, being integer valued, is essentially 2-based logarithm of the 2-adic norm for the 2-adic counterpart of the intensity of the

sensory input. Hence the increase of intensity of the sensory input by octave correspond to a jump-wise replacement of the n: th harmonic by $n+1$: th one and should be seen in EEG. Our experience usually corresponds to the average over a large number of this kind of primary experiences so that underlying 2-adicity is smoothed out. In case of over-learning or neurons involved act unisono and the underlying 2-adicity is not masked anymore.

At the level of MEs this would mean generation of higher harmonic when the number of nerve pulses per unit of time achieves threshold value allowing the amplification of corresponding frequency by the mechanism discussed already earlier. This certainly would mean that cognition is an important part of music experience. The strongest assumption is that the real note selves are able to transform to 2-adic selves by a phase transition changing local topology from real to 2-adic. Note however that p-adic length scale hypothesis might be enough.

Does harmonic complexity reduce to 3-adicity?

An interesting question relates to the conditions guaranteeing that a chord is experienced as harmonious in the Pythagorean sense [J18]. Pythagorean tuning is based on the notion of perfect fifths identified as scalings by $3/2$ producing the sequence C, G, D, A, E, .. In this tuning major-C scale corresponds to ratios $C = 1/1, D = 9/8, E = 81/64, F = 4/3, G = 3/2, A = 27/16, B = 243/128, C = 2/1$. E_b and $F_\#$ correspond to ratios $2^5/3^3$ and $3^6/2^9$. All notes are expressible as powers of two and three. Since the multiplication of any note by a power of two does not affect the harmony it should be to drop the powers of two from the integers characterizing the notes in the ratio of three notes. For instance, C-E-G reduces $3 : 3^4 : 1$, $C - E_b - G$ to $3^4 : 1 : 3^3$, and tritonus $C - E_b - F_\#$ to $3^9 : 1 : 3^3$. The problem of Pythagorean tuning is that one cannot represent 2 as an exact integer power of $3/2$ and the scalings give infinite number of tones. If the construction starts from G_b then $F_\#$ and G_b correspond to frequencies, which are not quite identical in Pythagorean tuning. One could make compromize by introducing the geometric mean of $F_\#$ and G_b but this would bring in $\sqrt{3}$ and would force to leave the world of pure rationals. For string instruments and electronic instruments the Pythagorean tuning is practical but for instruments like piano the transposition of the scale is impossible.

One should be able to characterize a given chord harmonically by a function $F(a, b, c)$, which is symmetric under the permutations of the reduced pitches a, b and c obtained by dropping powers of two and is invariant under over all scaling of the reduce frequencies. The elementary symmetric functions $F(a, b, c) = [a^2(b + c) + b^2(a + c) + c^2(a + b)]/abc$ and $G(a, b, c) = [a^3 + b^3 + c^3]/abc$ are the simplest functions of this kind. Either of these functions or their product or ratio could be considered as a measure for the harmonic complexity. The value of the denominator abc equals to 3^n, $n = 3, 7, 12$ in the cases considered. The numerator has in all cases 3-adic norm equal to one for both F and G. This suggests that the 3-based logarithm of the 3-adic norm $1/|abc|_3 = |F|_3 = |G|_3$ having the values 3, 7, and 12 for C-major, C-minor, and tritonus could serve as the measure for the complexity. It is indeed smallest for major and largest for tritonus. 3-adic norm for the product $1/a_1 a_2 ... a_n$ of n notes of the chord defines a measure of complexity in more general case. A good guess is that the 3-adic norms of the elementary symmetric functions give rise to the same measure.

For the chords C-E-G, F-A-C, and G-H-D appearing as basic chords in C- major scale the values of the harmonic measure are 3, 2, and 8. This means that the basic chords are not harmonically equivalent in Pythagorean system whereas in equally tempered system they would be. One might think that this explains why the tonic is remembered. The anomalously low value for F-A-C relates to the fact that it is only tone for which the power of 3 is negative. Situation changes of F is identified as a minimal power of 3 giving F equivalent with Pythagorean F within the resolution of ear to pitch which is about $|\Delta f/f| = 4.3$ per cent. $F = 3^5/2^8$ gives $|\Delta f/f| = 4.8$ per cent. This F would give for F-A-C the harmonic measure 8 which equals to that for G. This looks more reasonable than the purely Pythagorean value. This definition would also allow to find a unique choice of powers of three for 12-chord system. For instance, $F_\#$ is favored over G_b since it corresponds to a positive power of 3.

The ability to express the notes of scale as powers of $3/2$ by projecting the outcome to the basic octave suggests strongly that 3-adicity is an key element of music experience. Years after writing the first version of this text, I received an interesting email from Jose Diez Faixat giving a link to his blog (`http://tinyurl.com/ycesc5mq`). The title of the article in the blog

is "Bye-bye Darwin" and tells something about his proposal. The sub-title "The Hidden rhythm of evolution" tells more. Darwinian view is that evolution is random and evolutionary pressures select the randomly produced mutations. Rhythm does not fit with this picture. Faixat published 1993 the first article about his observations in the journal World Futures Vol. 36, pp. 31-56, edited by Ervin Lazlo with the title "A hypothesis on the rhythm of becoming" [I49, I50].

Thus it seems that 3-adicity might be fundamental not only for music experience but for biology. This conforms also with the generalization of p-adic length scale hypothesis implied by the weak form of NMP [K119] that primes near powers of primes are favoured by NMP. p-Adic length scale hypothesis corresponds to $p = 2$ and Faixat's findings and music experience support $p = 3$.

The notion of self and music

The music experience allows also to test the ideas related to the notion of self.

1. Summation hypothesis states that self is a sum of abstracted experiences of sub-selves and thus representing kind of averages about the experiences of sub-sub-selves.

   (a) The conscious experience induced by music decomposes in a clear manner to basic elements identifiable as sub-selves. For instance, melody and more generally various tone progressions could define such sub-selves and the experiences of these sub-selves would sum up to music experience. In the same manner rhythmic patterns define their own sub-selves. Therefore it might make sense to speak about "frequency sub-selves" and "rhythm sub-selves".

   (b) At space-time level the magnetic body and massless extremals (MEs) are the natural candidate for the representation of "frequency sub-selves". One can say that MEs provide a universal music instrument at the level of magnetic body since they allow arbitrary superposition of collinear waves proceeding in the same direction which is non-dispersive (shape of the pulse is preserved) so that arbitrary harmonics are possible for a ME with fixed length. Maybe the temporal duration of sub-selves assignable to MEs is what distinguishes between these representations.

   (c) A collection of sub-selves associated with ME at precisely defined periodically appearing positions could define rhythm whereas frequency selves would correspond to MEs with relatively long temporal duration. Interpreting MEs in terms of communications to the magnetic body, one expects that the rhythm automatically generates short-lasting MEs communication the pulses defining the rhythm to the magnetic body whereas pitch corresponds to long lasting MEs.

   (d) This picture challenges the assumption that the mental images created during music experience are localized to brain. Rather, MEs and magnetic body would be the carriers of the mental images. Maybe one could say that nerve pulse patterns induce these MEs. In left hemisphere nerve pulse patterns induced by the beats of rhythm and having a total duration considerably below.1 second would send single ME to the magnetic body. In right hemisphere the pulse patterns would integrate to single ME having duration of the note.

2. The hypothesis that entanglement creates wholes from parts and that there are three cognitive modes corresponding to reductionistic and holistic cognition and their hybrid based on negentropic entanglement is of special interest in the context of music experience.

   (a) Even admitting the dangers of naïve right-left thinking it would seem natural to assign the rhythmic aspects of the music to the reductionistic regions of brain and various aspects related to pitch to the right brain hemisphere. At least in the latter case MEs are highly suggestive as a fundamental representation of music at the level of magnetic body. Perhaps music experience actually involves in a very essential manner also magnetic body. That "eastern" music favors additive instead of divisive rhythm could

be understood as higher right brain dominance. The extremely mechanical rhythms characterizing the popular music today, the lack of melodic aspects, and the use of the volume of music as the basic means to induce emotional effect, could in turn interpreted in terms of extreme left brain dominance.

(b) Music can have a strong emotional effects and this allows to test the hypothesis that the character of entanglement correlates with the emotional color. Maybe just the fact that these emotions are enjoyable irrespective of whether they are sad or joyful and have an undeniable healing effect can be interpreted in terms of the presence of the NE. For instance, the ability of good music to generate vibrations in spine could relate to this negentropic aspects. Music as purely intellectual experience could induce essentially an analysis of what was heard based on the use of holistic-reductionistic dichotomy. Chopin's music has especially strong healing effect. Tempo rubato might reflect the profound integration of rhythmic aspects, melodic, and harmonic to single organic whole both at the level of representation and music experience.

3. The model of subjective memory and the new view about time might be relevant for the understanding of how the basic key of the music piece can be remembered. If conscious experience for a given self is about the space-time region defined by corresponding CD, one could understand how Mozart was able to experience the entire composition as a single whole. If the music piece defines in the ideal case the fundamental CD inside which the sub-selves representing the elements of the music oiece reside, this CD could also define the fundamental "key" and would be more or less sensorily experienced and need not even to be remembered. This would explain why the return to the original key in classical is so important to relieve the tension created by modulations.

Harmony and self-organization

The phenomenon of harmony should be somehow related to quantum self-organization: perhaps the often used metaphor of harmonious co-existence could be turned around. Various notes correspond to sub-selves in the population of sub-selves and it might be that self-organization favours simultaneous conscious existence of sub-selves corresponding to subsets of frequencies defining basic chords. One could even consider some kind of co-operation between the frequency selves belonging to same basic chord.

The simplest model for the phenomenon of harmony relies on the identification of the chords as "chord selves" formed by entangled "note selves" consisting of negentropically entangled "frequency selves". The listener is self having as sub-selves (mental images) note selves and chord selves which correspond to the same level of the self hierarchy. The entanglement between note selves could occur even at the level of ear between the mind-like space-time sheets sensitive to various frequencies. Topologically it would correspond to the formation of magnetic flux tubes between corresponding partonic 2-surfaces. The ability of the "note selves" of the chord to have stable flux tube bonds between themselves should depend crucially on the fact that the frequencies of the notes of the basic chords have simple rational ratios so that the oscillations involved are commensurate and match together. Hence a resonance phenomenon ins spirit of classical physics involving rational ratios of frequencies would be in question. During listening the chord self continually decomposes into sub-selves when listener consciously concentrates attention to some notes in the chord.

The ability of the music to occasionally create thrills in spine could correspond to whole-body consciousness in unusually large length scale. Note the this scale could correspond also to the secondary time length scale assignable to CD. It presumably involves a resonant fusion of also other than note sub-selves to larger negentropic sub-selves by the formation of stable flux tubes identifiable as magnetic flux tubes. The ability of certain sounds ("Om") to promote the emergence of whole-body consciousness could be due to the ability to very effectively generate negentropic entanglement direction. Perhaps the frequency spectrum of "Om" contains resonant frequencies of several sub-selves and induces large sub-selves. Also the healing effect of music and sounds could rely on this mechanism.

Focusing attention to some instrument producing melody creates kind of figure-background relationship. This requires that entire instrument playing the melody is represented by "instrument

self". An interesting possibility is that various instruments give rise to their own ensembles of frequency-selves. Note that the model makes it easy to understand why experienced performance is not simply the sum of individual performances. Music experience is a complicated self-organization process in which parts compose to wholes by quantum entanglement and vice versa according to how the listener directs his/her attention.

A model for harmony and genetic code

I have constructed a model of music harmony predicting also genetic code correctly and actually even the fact that there is variant of code involving two additional amino-acids [K80]. The model relies on two observations. Icosahedron has 12 vertices - the number of notes in 12-note scale - and 20 faces (triangles), which is the number of amino-acids.

The obvious idea is that amino-acid sequences define sequences of 3-chords defined by the notes at the vertices of the face representing amino-acid. DNA would represent the notes as a sequence of chords and amino-acid would play these notes. As a matter of fact, it turns out that DNA can be seen as a representation of music wit a harmony defined by 64 3-chords corresponding to the DNA codons.

One ends up to the proposal that music harmonies are induced by non-self-intersecting embeddings of 12-note scale as a quint cycle at icosahedron with the edges of the curve connecting neighboring vertices. This kind of cycles are known as Hamiltonian cycles. The 3-chords defined by the triangular faces of the icosahedron assign a notion of harmony to a given Hamiltonian cycle.

The surprising finding is that the symmetries of the resulting Hamiltonian cycles correlate strongly with the structure of genetic code. The numbers of faces at orbits of given face correspond to the numbers of DNAs coding for corresponding amino-acid. One can identify 60 DNAs in terms of 3 Hamiltonian cycles with different symmetry (Z_n for $n = 2, 4, 6$).

60 DNAs are not quite enough, and one has also the problem that already Pythagoras encountered: the 12 quints give slightly more than 7 octaves. One can add an additional tetrahedron to get 64 DNAs. One can glue it to a preferred face of icosahedron to get 13th note differing slightly from one of the notes of the scale. One can also add the tetrahedron without gluing. This gives two genetic codes and 2 additional amino-acids.

The outcome is a geometric representation of both music and genetic code. There are actually 256 different harmonic representations of codes with 64 basic chords defining the particular harmony. The proposal is that DNA and amino-acid sequences correspond to chord sequences and that chord sequences define a fundamental representation of emotions as music. The music can also correspond to light: dark photon triplets with frequencies in range of - say - audible sounds. Bio-photons would result from the decay of these photon triplets. One can imagine that various biomolecules are named by chord sequences just like the characters in Wagner's operas correspond to themes. An interesting question is whether these dark photon triplets are negentropically entangled and can serve as analog of metabolic energy.

Music is a way to express and induce emotions. This suggests that DNA night have additional aspect corresponding to these 256 different options perhaps serving as correlates for moods. The additional aspect might relate to the magnetic body of DNA giving rise to the cyclotron frequencies from which the chords are built. The 3-chords defined by dark photons could serve as a fundamental correlate for emotions and might define fundamental control and communication mechanism based on resonance phenomenon.

5.3   Whole-Body Consciousness: Physical Evidence And Tests

Whole-body consciousness is one of the predictions of the proposed theory and anomalously low dissipation can be regarded as the most dramatic physical signature of whole-body consciousness. This prediction provides a manner to test the theory.

5.3.1   Dissipation And Consciousness

The state function reduction sequence is a binary process which at a given step splits a subsystem into a unique pair of un-entangled subsystems if the subsystem allows decomposition to free entropically entangled systems. The process is random and explains second law and dissipation as a

transformation of ordered energy to non-ordered energy. In standard view about self-organization the generation of structures requires a feed of ordered energy to compensate the dissipation.

In TGD framework the function of the metabolic energy feed would be more complex than this. Energy feed is necessary in order to avoid the formation of large sized entropically bound sub-selves. The fed energy need not be ordered. The rate of dissipation depends on how small the scale of the non-decomposable systems is. If negentropic entanglement binds mental images to larger ones, the rate of dissipation is expected to be low. Ordered metabolic energy can be also transformed to the energy carried by negentropic entanglement and liberated as the entanglement transforms to ordinary free or bound state entanglement.

The overall picture is also made more complex by the simultaneous presence of several length scales in which the state function reduction process proceeds so that it makes sense to speak about quantum parallel dissipation.

EEG waves and parallel information processing

Parallel information processing requires a large number of correlated units acting in parallel. If the units correspond to sub-selves which are bound state entangled, the whole system acts like a single neuron so that the information processing is very un-effective. If the system consists of unentangled sub-selves, the correlations are absent and the system is analogous to a statistical ensemble rather than a quantum parallel computer. If the entanglement is negentropic, one achieves parallel information processing since sub-selves are correlated but have not lost their degrees of freedom.

In synesthesia synchronous firing is observed and the cognitive and memory feats of synesthetes suggest that parallel information processing and negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) are involved. Therefore synchronous firing and its EEG counterpart define candidates for the physical correlates of the negentropic entanglement. TGD inspired model for EEG and nerve pulse predicts both propagating EEG waves associated with neural circuits and non-propagating EEG waves associated with entire regions of brain (say gap junction connected cell groups) [K84].

It would be natural to assign non-propagating EEG waves to synchronous firing of neurons forming a single coherent unit. However, if neurons form a bound state they act in unisono and the information processing is very uneffective. Hence both propagating and non-propagating EEG waves should be present during parallel information processing periods and add up coherently. Synchrony would mean that standing wave part of EEG is for neurons like the rhythm of music for a ballet group. Coherence of EEG, one form of "oneness", would be the correlate for presence of both reductionistic and holistic aspects of consciousness.

Evidence and tests for a reduced metabolism as concomitant of whole-body consciousness

Consider now possible evidence and tests for the reduced metabolism as a signature of whole-body consciousness.

1. In synesthesia different sensory modalities are associated with a regular manner just as thoughts are associated with speech. A dramatic signature of synesthesia is the lowering of the cortical metabolism by as much as about 18 per cent from the average (synesthete should become blind or paralyzed if standard wisdom would hold true!). This is what is expected if the neurons of left cortex get entangled. Also a large scale entanglement with parts of limbic brain, with sensory organs associated with coupled sensory modalities, and magnetic body is possible. The extended self in state of oneness does not dissipate significantly.

2. The metabolism of trained yogis provides a test for the hypothesis: measure some signatures for neuronal or cellular dissipation occurred during the meditative state and find whether the dissipation is reduced during meditation. The lowered dissipation rate could even lead to the lowering of the body temperature or the temperature of nearby region.

3. There are even anecdotal claims about the ability of the dead bodies of gurus to resist natural decay. I am not certainly trying to convince any sceptic and, still having very living personal

body, I have no personal opinions about the reality of the claimed phenomena. It would be however good to be open-minded.

4. There is (I believe well documented) phenomenon in which persons in trance are able to dance on burning charcoals without any disastrous consequences. Certainly there are standard science explanations for this. A possible nonstandard science explanation is that state of a whole-body consciousness is involved and no dissipation in cellular scale occurs. Since dissipation is not possible, the irreversible effects caused by the heat flow from burning charcoals are not possible and only reversible and curable effects can occur.

5. The reduction of the dissipation rate in some length scales should occur also during sleep, which is one example of this kind of state (obviously a reduction of metabolism occurs).

6. Also hypnosis might involve (possibly negentropic) quantum entanglement between some part of the brain of subject person and hypnotizer. This could reflect itself as correlations between EEGs of hypnotizer and subject person.

5.3.2 EEG Synchrony And Negentropic Entanglement

If one accepts the vision about life as something in the intersection of real and p-adic worlds 40 Hz EEG synchrony can be interpreted as a correlate for the generation of negentropic entanglement between cortical neurons. Before proposing this interpretation let us first describe the experimental findings of a finnish neuroscientist Antti Revonsuo [J28].

Findings

The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [J28]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. There could be also some time lapse between the unified percept and the report about it but probably this cannot explain the entire lapse. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [J123]. Note that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [K33].

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

Interpretation in terms of generation of negentropic entanglement

A fresh view about what really happens during 40 Hz synchrony came with the realization that negentropic entanglement is possible in the intersection of real and p-adic worlds. The generation of negentropic entanglement between two sub-selves means that the corresponding mental images are fused [K108, K56]. The process is experienced by the fusing sub-selves as an expansion of consciousness whereas consciousness is lost when when bound state entanglement is generated. Also the meditative states begin with enhanced 40 Hz activity and the interpretation would be same. Quite generally, the generation of negentropically entangled neuron groups could be a correlate for the emergence of a new idea or a new holistic pattern emerging from a chaos. Synchronous firing would be a natural correlate for the synergic state resulting in this manner. The paradoxical looking reduction of the oxidative metabolism associated with 40 Hz firing could be seen as a

signature of reduced dissipation when dissipating ensemble of neurons forms a single quantum coherent system.

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

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

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

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

5.3.3   Synesthesia

Synesthesia [J126] seems to give a direct experimental evidence for a reduced rate of metabolism in "negentropic" states of mind. Synesthesia provides an excellent counter argument against the idea that sensory organs are primary experiencers unless one is ready to believe that cross-modal associations involve macroscopic quantum systems formed by the primary sensory organs involved and parts of brain.

TGD based quantum model for EEG and nerve pulse suggest that synesthesia is a natural by-product of the negentropic states of mind involving enhanced EEG in large regions of brain. Coherent large amplitude EEG induces synchronous neural firing in memory circuit containing hippocampus and thalamus. This leads to a "leakage" or nerve pulse activity in lateral thalamic nuclei from inducing sensory pathway to the indced sensory pathway.

An interesting possibility is that the non-propagating EEG waves predicted by TGD [K84] and possibly explaining the ability of right brain hemisphere to process information in a parallel manner are involved in synesthesia. The left brain hemisphere of synesthetes would be in some aspects like the right one during synesthesia and right and left brain could act like single conscious unit during synestesia.

Does synesthesia involve left cortex whole-body consciousness?

The following aspects of synesthesia suggest that left cortex whole-body consciousness might be involved with it.

1. Synesthesia depends on left brain hemisphere only. A dramatic signature of synesthesia is the lowering of the metabolism in the left cortex by about even 18 per cent compared to the

baseline (synesthete should become blind or paralyzed if standard wisdom holds true!). This is accompanied by relatively enhanced limbic expression. Hippocampus, which is believed to be crucial for long term memories, is critical for the synesthetic experience.

2. Synesthesia is emotional: the experiences are accompanied by a sense of certainty ("this is it") feeling. This is in accordance with the observation that limbic brain expression is enhanced.

3. Holism is an important aspect of synesthesia. Synesthetes can precisely remember entire passages of text (which actually means that also reductionistic aspect is present), re-experience entire episodes of previous life, remember precise locations of various objects in a room. Synesthetic experiences are emotional. Synesthetes also tend to have "unusual experiences" like deja vu, clairvoyance and pre-cognitive dreams. This kind of personality constellation characterizes temporal-limbic epileptics.

4. Synesthetes have un-even cognitive skills. Dyslexia, dyscalculia in some degree, inability to transform words to digits, right-left confusion, etc.. Synesthetes are also non-right-handed.

A possible TGD based interpretation is that part of the left cortex is in whole-body consciousness in the sense that mental images have fused negentropically to very few larger mental images and there are very few unentangled sub-selves (mental images).

1. In this state left cortex does not dissipate as much as usually. Negentropic entanglement explains why the metabolism can be reduced during synesthesia below the level causing death under normal circumstances. The relative enhancement of metabolism in left limbic brain could relate to emotionality but does not favor negentropic entanglement in left limbic brain.

2. Also the cognitive impairments can be understood. The negentropic entanglement is both time-like and space-like so that these sub-selves have also a long duration. The resulting experience is holistic both in spatial and time direction with overall gestalt being more important than details. A good temporal resolution is essential for the mentioned cognitive skills and the explanation for cognitive dis-abilities is that entangled left cortex does not generate temporal sequences of sub-selves of short duration defining the mental clock readings or beacons. The mental images are extremely informative but the lack of linguistic expression based on the replacement of the percept with a collection of distinct objects mapped to linguistic symbols disfavors this mode of consciousness. Therefore linguistic cognition is favored by the practicalities of the everyday social life. The lack of asymmetry between brain hemispheres behind holism-reductionism dichotomy essential for language would naturally relate to non-right-handedness and the difficulty to distinguish between right and left. This inability would also conform with the view that some regions of right and left hemisphere are negentropically entangled.

3. The exceptional episodal memory achievements could be understood as a formation of large scale negentropic mental images which are stable so that long sequences of events of geometric past are re-experienced. In [K83] a model for long term episodal memories as questions sent to the geometric past inducing time-like entanglement with the self of the geometric past making possible episodal memory as a shared sensory experience is discussed. The question sent to the geometric past is coded to the light-like vacuum current associated with a stationary ME, usually in right brain but in left brain in case of synesthesia. The time like entanglement of the space-time sheets located in the geometric now and past (or future in case of clairvoyance) makes possible the episodal memory.

The proposed mechanism could also explain both the extraordinary memory feats of some autistic persons and their difficulties with the challenges of the everyday life. Dramatic example is a person able to draw from memory an area of London with size of several square kilometers as seen from air. The same person draws from memory a building having hundreds of windows and the number of windows comes out correctly although this same person is not able to count corretly the number of three objects. As in the case of synesthetes cognitive impairments could be necessary prerequisites of the extraordinary gifts. Although the person cannot count how many windows the mental image of the building has, he can draw them correctly just by drawing along the image he sees in full concreteness.

Basic observations

The following observations provide a valuable information making possible to construct a more detailed model of synesthesia.

1. Synesthesia is in-voluntary and usually uni-directional: for instance, auditory experience creates visual association but not vice versa. Cross-modal associations, just like ordinary associations, do not change in the course of time. It has not been possible to find any rule telling which kind of associations are possible. It seems that cross-associated experiences are however generic and simple so that one can speak of form invariants which are kind of primitive building blocks of perception: for instance, visual associations tend to be blobs, lines, spirals and lattice shapes.

2. Synesthesia is projected: synesthetes experience their secondary sensory experiences in the space in the immediate surroundings of the body, never at large distances as is in principle possible in the case of vision and hearing. For instance, visual associations are seen on screen near to eyes.

3. The reduction of the metabolism is concentrated in the cortical regions whereas relatively enhanced metabolism occurs in the limbic brain, in particular hippocampus. Seizure discharges in hippocampus induce synesthesia in non-synesthetes: associations are simple experiences and become more complicated if seizures spread to the temporal lobes. The exceptional activity of hippocampus correlates with the exceptional ability to have precise episodal memories.

4. According to [J126] it is very rare that taste or smell is a synesthetic response or trigger of it. In fact that author of the articles knows no case in which smell alone would be the inducing sensory modality. This could relate to the fact that olfactorion is exceptional sensory modality in the sense that there are two olfactory pathways: the first one projects directly to amygdala whereas second projects to cortex via thalamus as do also the sensory pathways associated with order sensory modalities [J94]. Furthermore, the olfactory pathway to the thalamus projects to the medial dorsal nuclei whereas other sensory pathways project to the lateral dorsal nuclei.

5. Synesthesia can also generate sensory-motor associations. For instance, visual input can generate well defined motor outputs and synesthete can express sensory experiences by dancing!

Memory coordination circuit and Papez circuits as brain circuits possibly involved with synesthesia

Hippocampus is believed to be crucial for the formation and experiencing of long term memories. This suggests that an enhanced activity in some neural circuits involving hippocampus in a form of increased EEG amplitudes (at theta frequencies) is essential for generating the sensory leakage between neural circuits and sensory pathways leading to synesthesia. For this kind of mechanism synesthetic mode need not be the only mode of experiencing: ordinary and synesthetic modes could also alternate. If synesthetic and non-synesthetic periods alternate, synesthesia cannot interfere radically with the real experience. This is clearly the safest option and perhaps favoured by natural selection. The ability to control theta wave amplitudes in hippocampus could make possible an artificial generation of synesthesia.

There are two important circuits going through hippocampus [J51]. The first circuit is memory coordination circuit having the following structure:

1. Lateral dorsal nucleus and anterior nuclear group of the thalamus

2. Cingulate cortex

3. Subiculum and the rest of the hippocampal formation with input via entorhinal cortex and output via the subiculum and fornix

4. Back to 1.

Fornix is known to be the circuit responsible for slow theta rhythm of about 3-7 Hz, which does not correspond to a conscious experience: thus memory coordination circuit is believed to be unconscious to us under normal circumstances [J51]. Temporal cortex contains a region which projects to hippocampus and receives input from all sensory modalities. Memory circuit is believed to somehow to provide a handle to the memory constellations believed to reside in the temporal lobes. That the EEG amplitude associated with the fornix would be exceptionally large during synesthesia is in accordance with the fact that that synesthetes tend to have personal constellation of limbic-temporal epileptics. Also the abnormal episodal memories (Nabokov is one of the best known synesthetes with miraculous memory) supports resonance in this circuit. Only memory circuit projects to the thalamic nuclei receiving both sensory and motor input. Hence also the occurrence of the motor synesthesia supports the view that the sensory leakage occurs in the thalamic nuclei contained by the memory circuit.

Papez circuit is second circuit containing hippocampus. Papez circuit has following structure:

1. Anterior nuclear group of the thalamus

2. Cingulate cortex

3. Hippocampal formation

4. Hypothalamus

5. Back to 1.

The enhanged activity of the Papez circuit induced by the hippocampus could correlate with the emotionality of the synesthetic experience.

The general picture about the sensory leakage

These observations and facts suggests the following general model for synesthesia.

1. Contrary to the original expectations, the hypothesis that the primary sensory qualia are associated with the sensory organs can be defended against various objections if one assumes that brain and sensory organs quantum entangle so that a fusion of sensory mental images with cognitive mental images occurs. The hypothesis explains elegantly the differences between imagination, dreaming, hallucinations, and ordinary sensory experience. Dreams and hallucinations would involve a back projection from brain to sensory organs giving rise to a "qualiafication" of the cognitive mental images represented by the nerve pulse patterns. In the case of synesthesia the back projection would assign to a sensory input from the inducing sensory modality an artificial sensory input in the induced sensory modality.

2. If the cross-modal communication between sensory organs occurs through thalamic nuclei common to the cross-associated sensory modalities, one can understand why smells alone are never the inducing sensory modalities. Lateral dorsal thalamic nuclei would be the sites of the sensory leakage. Furthermore, in the case of hearing, vision, and tactile senses it is easy to produce artificial sensory experience than in case of chemical senses (molecules attaching to the sensory receptors would be required).

3. The possibility of the sensory-motor synesthesia suggests that the back-projection involves artificial sensory input to the motor organs inducing a motor activity, which in TGD framework corresponds to a geometric time reversal of the sensory perception starting from the level of motor organs and proceeding in a time reversed direction. Only memory coordination circuit involves thalamic nuclei receiving both sensory and motor inputs. Memory coordination circuit involves lateral dorsal nuclei (all modalities except olfaction) but not medial dorsal nuclei (olfaction). This leads to the hypothesis that the exceptionally high activity of the memory coordination circuit induces a sensory leakage in the lateral dorsal nuclei of the thalamus belonging to the memory coordination circuit.

Synesthesia as a sensory leakage between thalamic nuclei common to the memory coordination circuit and primary sensory pathways

Synesthesia could be a byproduct of an abnormally large EEG amplitude in the memory coordination circuit and possibly also Papez circuit inducing a "leakage" of nerve pulses between sensory pathways in thalamus in turn giving rise to synesthetic crossmodal associations. That synesthetic associations are projected, is consistent with the sensory leakage hypothesis.

The resonant EEG amplitude associated with the thalamic nuclei of the resonating memory coordination circuit spreads out to the primary sensory or motor pathways in the physical vicinity of the resonating pathway and generates a sensory leakage and a back projection to the sensory organs of the induced modality thus inducing synesthesia. The structure of the synesthetic association is determined by the pattern of neurons activated and thus creating the virtual sensory input back-projected to the sensory organ of the induced sensory modality. One can imagine each neuron as a pixel of a sensory picture and the pattern of activated pixels determines the synesthetic association.

The model makes testable predictions.

1. The assumption that the sensory leakage occurs in the thalamus could be tested. One could study whether the crossmodal associations change, when the sensory input from right or left side of body is lacking. For instance, one could find what happens if audio-to-visual synesthete blocks left/right ear during audio-to-visual synesthesia.

2. The generation of artificial sensory experience by back-projection to the sensory organ of the induced sensory modality means that a permanent or an artificially induced temporal loss of the induced sensory modality (by a local anaesthesia of the axons of the sensory pathway) should lead to the loss of the synesthesia.

How to understand the memory feats of synesthetes and the reduced metabolism in the left hemisphere?

Negative energy MEs can be interpreted as classical signals sent to the geometric past, and they could be crucial for an active memory recall involving a question sent from the magnetic body to the brain of the geometric past as a negative energy ME. Also chemical signals- say very slow Ca^{++} wave inside brain- could be involved and could define the classical response to the negative energy signal.

1. Memories and time mirror mechanism

Time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig. ??** in the appendix of this book), which was first developed in the framework of positive energy ontology, is the simplest quantum mechanism of memory. Its recent formulation goes as follows.

1. The mechanism of episodal memory is assumed to involve only a sharing of mental images by negentropic time-like quantum entanglement. The notion of bound state entanglement in time direction need not make sense at all: the reason is that bound state energy is assigned with the entire system rather than sub-systems and for zero energy states total energy is always zero. Hence it seems better to assume that only negentropic entanglement and non-binding real entanglement in time direction is possible.

2. The basic question is what really distinguishes between verbal (declarative) and episodal memories. Is the difference between verbal and episodal memories related only to the temporal size scale of the negentropically entangled subsystems? In this case declarative memory would consist of a sequence of short lasting episodal memories with contents which are symbols rather than direct sensory perceptions with emotional content. Or can one interpret verbal memories as purely classical communications between geometric past and future? This would make sense if declarative memories result when an entropic entanglement between future and past selves is reduced to zero so that the communications would reduce to those between non-living systems. Episodal memories would be possible in the intersection of the real and p-adic worlds and declarative memories everywhere. This interpretation is consistent with the earlier vision.

One can model the memory recall as follows.

1. The view about memory recall is that a "question" realized as a negative energy ME is sent from magnetic body to the brain of the geometric past, it is reflected back as a positive energy signal, and returns back to the magnetic body. It is essential that the signal is between different CDs - say CD and its and sub-CD- rather than future and past boundaries of single CD.

2. One must be very careful with what negative energy signal really means. This signal would be generated in quantum jump and should connect the past boundary of CD to the future boundary of a CD in the geometric past- say for definiteness a sub-CD of CD itself if personal memory is in question. The condition that the positive energy of the past boundary of CD remains unchanged means that the energy flowing to the direction of future inside CD is increased as a recoil effect. The same applies in the case of sub-CD. This interaction could be seen as an interaction between two CDs implying an exchange of energy between the positive energy parts of the states.

3. The transfer of negative energy to the past can transform the positive energy part of the state of the geometric past to a bound state in the ordinary sense of the word. If positive energy negentropic entanglement is in question this need not happen although the energy of the state is reduced. Therefore negentropically entangled mental images are especially interesting from the point of view of episodal memories. The question and answer fuse to a single negentropically entangled mental image shared by the hemispheres of the geometric past and now. The negentropy of the past state is expected to reduced as its energy is reduced so that quite literally a flow of information to future is in question.

4. Duality between memory and recognition suggests itself. What is memory from the point of view of future CD could be precognition from the point of view of past CD.

The generation of negative energy MEs would involve a phase transition to a state in which the positive MEs propagating along axons with a subluminal effective phase velocity transform to negative energy MEs leaving the brain and are reflected back in time direction. Synchronous membrane oscillations could accompany negative energy MEs [K81]. If negative energy MEs are sent by the region of the left brain hemisphere, it gains some energy by pay now-let others pay mechanism.

2. Reduction of metabolism during synesthesia

Episodal memories could relate to the reduction of the metabolism by 18 per cent during synesthesia.

1. The original interpretation proposed before the formulation of zero energy ontology was that the generation of the negative energy MEs is forced by the starvation of the neurons induced by the over-activity of the neurons of the memory coordination circuit. The miraculous ability of synesthetes to remember episodally could be understood to result as a by-product of a neuronal emergency reaction. The starving cortical neurons of the left hemisphere would send negative energy MEs to the direction of the geometric past inducing entanglement bridges by the mirror mechanism with the brain of the geometric past in turn inducing episodal long term memories by the sharing of the mental images. The same mechanism might work also in the normal situation but involve a less dramatic artificial starvation.

2. The reduction of the metabolism could be also mostly due to the negentropic entanglement for the mental images in the left cortex "now" so that the episodal memories realized in the proposed manner would give only an additional reduction to metabolism.

3. Non-episodal memories

Also in the case of non-episodal memories the question to the geometric past could be communicated by the mirror mechanism using negative energy MEs but now time-like entanglement would be entropic free entanglement and would be reduced to zero in quantum jump so that the real answer would be communicated classically.

1. The classical signal could return to the magnetic body along reflected positive energy ME so that the question and answer could use the same cognitive code.

2. Second possibility is that signal returns back without leaving the brain. The classical signal sent by the left hemisphere of the geometric past to the left hemisphere of the future would propagate a finite distance L within brain in a time interval T defining the temporal span of the memory (say years) so that the ME would propagate with an effective phase velocity $v = L/T$. The velocities of Ca^{++} waves span an extremely wide spectrum and provide a natural candidate for the physiological excitations in question [J101].

3. Ca^{++} waves could be also be accompanied MEs with ultraslow phase velocities.

5.4 Self Hierarchy And The Notion Of Magnetic Body

TGD not only predicts infinite hierarchy of selves but also strongly suggests that "me" as an intentional agent should be identified as my field body, or perhaps better to say, my magnetic body having an astrophysical size. Magnetic body would also serve as an intentional agent and controlling biological body by time mirror mechanism. An entire hierarchy of magnetic bodies is predicted since the flux quanta of each body part define corresponding magnetic body. Also the magnetic body of Earth should define a conscious unit, kind of Magnetic Mother Gaia perhaps responsible for some third person aspects of our consciousness. The role of the magnetic body would be like that of a manual of an electronic instrument, that is it would provide a higher level representation for the body and its environment. Magnetic body would also serve as template for the formation of bio-structures. Magnetic body would share the mental images produced by brain as symbolic representations of the sensory input. Also time mirror mechanism of long term memories and Uncertainty Principle applied to EEG provide support for the notion. Some experimental findings supporting the notion of field body are Libet's findings, the role of Schumann resonance frequency for consciousness about time delays of consciousness, and the effects em radiation on brain and living matter at cyclotron frequencies.

This original version of this section was written much before the emergence of the zero energy ontology. A first principle justification for the notion of magnetic body is provided by zero energy ontology predicting that primary p-adic length scales are accompanied by secondary p-adic length scales (as well as time scales). For instance, in case of electron the secondary time scale is.1 seconds and correspond to a length scale of order Earth's circumference. It is natural to assign this time scale to the flux tubes of the magnetic body. This aspect will not be discussed explicitly in the sequel but should be kept in mind.

Am important question concerns about actual biological realization of the self hierarchy predicted to begin already at elementary particle level and continuing indefinitely. TGD indeed leads to rather concrete ideas about how this hierarchy is possibly realized.

5.4.1 Higher Level Selves In Biological Self Hierarchy

The basic inputs for the speculations about the higher levels of the biological self hierarchy are topological field quantization, the idea of memetic code and the observations about the effects of EFL em fields to brain suggesting that the higher levels correspond to em selves with sizes of order wavelength of photons generated by EEG currents having size of order of Earth and realized as topological field quanta. The general view about symbiosis of hierarchies of massless extremals (MEs) and superconducting magnetic flux tube structures with the ordinary matter at atomic space-time sheets provides strong constraints on the speculations. The general vision about sensory representations realized in terms of magnetic flux tube structures outside brain [K83] and having sizes of ELF wavelengths leads to rather concrete ideas about the self hierarchy and about our position in it.

5.4.2 Quantum Criticality

Quantum criticality is one of the basic guiding principles of Quantum TGD. What it means mathematically is however far from clear and one can imagine several meanings for it.

1. What is obvious is that quantum criticality implies quantization of Kähler coupling strength as a mathematical analog of critical temperature so that the theory becomes mathematically unique if only single critical temperature is possible. Physically this means the presence of long range fluctuations characteristic for criticality and perhaps assignable to the effective hierarchy of Planck constants having explanation in terms of effective covering spaces of the embedding space. This hierarchy follows from the vacuum degeneracy of Kähler action, which in turn implies 4-D spin-glass degeneracy. It is easy to interpret the degeneracy in terms of criticality.

2. At more technical level one would expect criticality to correspond to deformations of a given preferred extremal defining a vanishing second variation of Kähler Kähler function or Kähler action.

   (a) For Kähler function this criticality is analogous to thermodynamical criticality. The Hessian matrix defined by the second derivatives of free energy or potential function becomes degenerate at criticality as function of control variables which now would be naturally zero modes not contribution to Kähler metric of WCW but appearing as parameters in it. The bevavior variables correspond to quantum fluctuating degrees of freedom and according to catastrophe theory a big change can in quantum fluctuating degrees of freedom at criticality for zero modes. This would be control of quantum state by varying classical variables. Cusp catastrophe is standard example of this. One can imagine also a situation in which the roles of zero modes and behavior variables change and big jump in the values of zero modes is induced by small variation in behavior variables. This would mean quantum control of classical variables.

   (b) Zero modes controlling quantum fluctuating variables in Kähler function would correspond to vanishing of also second derivatives of potential function at extremum in certain directions so that the matrix defined by second derivatives does not have maximum rank. Entire hierarchy of criticalities is expected and a good finite-dimensional model is provided by the catastrophe theory of Thom [A21]. Cusp catastrophe (see `http://tinyurl.com/yddpfdgo`) [A1] is the simplest catastrophe one can think of, and here the folds of cusp where discontinuous jump occurs correspond to criticality with respect to one control variable and the tip to criticality with respect to both control variables.

3. Quantum criticality makes sense also for Kähler action.

   (a) Now one considers space-time surface connecting which 3-surfaces at the boundaries of CD. The non-determinism of Kähler action allows the possibility of having several space-time sheets connecting the ends of space-time surface but the conditions that classical charges are same for them reduces this number so that it could be finite. Quantum criticality in this sense implies non-determinism analogous to that of critical systems since preferred extremals can co-incide and suffer this kind of bifurcation in the interior of CD. This quantum criticality can be assigned to the hierarchy of Planck constants and the integer n in $h_{eff} = n \times h$ [K36] corresponds to the number of degenerate space-time sheets with same Kähler action and conserved classical charges.

   (b) Also now one expects a hierarchy of criticalitiesandsince criticality and conformal invariance are closely related, a natural conjecture is that the fractal hierarchy of sub-algebras of conformal algebra isomorphic to conformal algebra itself and having conformal weights coming as multiples of n corresponds to the hierarchy of Planck constants. This hierarchy would define a hierarchy of symmetry breakings in the sense that only the sub-algebra would act as gauge symmetries.

   (c) The assignment of this hierarchy with super-symplectic algebra having conformal structure with respect to the light-like radial coordinate of light-cone boundary looks very attractive. An interesting question is what is the role of the super-conformal algebra associated with the isometries of light-cone boundary $R_+ \times S^2$ which are conformal

transformations of sphere S^2 with a scaling of radial coordinate compensating the scaling induced by the conformal transformation. Does it act as dynamical or gauge symmetries?

Preferred extremals and criticality

Zero energy ontology (ZEO) was a great step of progress in the development of TGD. Now pairs of space-like 3-surfaces at the boundaries of causal diamond become the basic objects. It is important to notice that preferred extremal property itself in ZEO is un-necessary unless one requires Bohr orbit property: the reason is that for given pair of 3-surfaces at boundaries CD the space-time surface would be unique for deterministic dynamics. In the case of non-deterministic dynamics situation can change but this seems to relate to quantum criticality and hierarchy of Planck constants bringing in new degrees of freedom related to the non-determinism and to super-conformal symmetries acting as gauge symmetries.

Bohr orbit property would be space-time correlate for the correlations of the positive and negative energy states at the ends of CD and non-triviality of quantum dynamics so that preferred extremal property would be another name for Bohr orbit property. Therefore it seems reasonable to assume that the notion of preferred extremal indeed makes sense and is needed.

I have proposed several identifications for the preferred extremal property such as criticality of Kähler action, Hamilton-Jacobi structure space-time surface generalizing complex structure, quaternionic structure in tangent space.These characterizations might be equivalent.

2-D criticality suggests that conformal symmetries act as gauge symmetries for the deformations for which second variation of Kähler action vanishes and that there is finite number n of gauge equivalence classes which can be related to the hierarchy of Planck constants $h_{eff} = n \times h$. The space-time sheets connecting two 2-surfaces at the ends of causal diamond (CD) in zero energy ontology (ZEO) have same Kähler action and conserved charges. The n degrees of freedom would be discrete dynamical degreees of freedom and among other things could be responsible for the fractionization of charges.

Topological field quantization

Topological field quantization [K47] implies that various notions of quantum field theory have rather precise classical analogies. Topological field quantization provides the correspondence between the abstract Fock space description of elementary particles and the description of the elementary particles as concrete geometric objects detected in the laboratory. In standard quantum field theory this kind of correspondence is lacking since classical fields are regarded as a phenomenological concept only. Topological field quanta define regions of coherence for the classical fields and classical coherence is the prerequisite of the quantum coherence.

The energies and other classical charges of the topological field quanta are quantized if they correspond to preferred extremals meaning that the 3-surfaces at the boundaries of CD are correlated just like for Bohr orbits.

Feynman diagrams become classical space-time surfaces with lines thickened to 4-manifolds. For instance, "massless extremals" [K68] representing topologically quantized classical radiation fields are the classical counterparts of gravitinos and photons. Topologically quantized non-radiative nearby fields give rise to various geometric structures such as magnetic and electric flux tubes.

The virtual particles of quantum field theory have also classical counterparts. In particular, the virtual particles of quantum field theory can have negative energies: this is true also for the TGD counterparts of the virtual particles. The fundamental difference between TGD and GRT is that in TGD the sign of energy depends on the time orientation of the space-time sheet: this is due to the fact that in TGD energy current is vector field rather than part of tensor field. Therefore space-time sheets with negative energies are possible. This could have quite dramatic technological consequences: consider only the possibility of generating energy from vacuum and classical signalling backwards in time along negative energy space-time sheets [K11]. Also biosystems might have invented negative energy space-time sheets: in fact, so called "massless extremals" provide an ideal manner to generate coherent motions as recoil effects caused by the creation of negative energy massless extremals [K19]. An interesting possibility is that quantum entanglement has the formation of the flux tubes as its geometric correlate.

The hypothesis of topological self-referentiality stating that the topological field quanta of classical fields form a symbolic representation for the system's properties, provides a strong interpretative tool. For instance, bound state entanglement is represented by negative energy MEs and the generation of macroscopic bound states essential for the binding of the mental images is accompanied by the liberation of the binding energy as a usable energy. Hence the ability of the system to behave as a single coherent whole and non-local quantum metabolism are different sides of the same coin. The concept of field body (or electromagnetic body) consisting of the topological field quanta is also of central importance. Field body could be seen as a "manual" for the system providing a classical, topological representation for the quantum aspects of the material part of the system. The size of this field body is much larger than the material body of the system.

Topological field quanta (field bodies) could serve as templates for the formation of the biostructures. Thus topologically quantized classical electromagnetic fields could be equally important for the functioning of the living systems as the structures formed by the visible biomatter and the visible part of biosystem might represent only a tip of an ice berg.

Topologically quantized classical fields as templates for self hierarchy?

The web like structure formed by topological field quanta representing classical fields, in particular em fields, is reminiscent of structures formed by microtubules and collagens forming the connecting tissue of living systems. It has been already earlier suggested that magnetic flux tubes and other topological field quanta serve as templates for various biostructures in the sense that ordinary matter is topologically condensed on the flux tube like structures. This would mean that living systems would be only part of much larger web formed by Earth's classical em field forming one particular sub-self of Mother Gaia.

The thickness for the flux tubes of Earth's magnetic field is about $2/\sqrt{eB} \simeq 4 \times 10^{-6}$ meters for $B = .5 \times 10^{-4}$ Tesla. If magnetic flux tubes of Earth have direct geometric coupling with brain one could perhaps understand the miraculous ability of birds and bees to navigate using Earth's magnetic field. The proteins navigating along microtubules, cells navigating along collagen fibres and birds navigating along Earth's magnetic field lines would all be guided by higher level self! One could see also humans and the societies formed by them as continually self-organizing organs in the body of electromagnetic Mother Gaia. In this picture the so narrow wave cavity of radius 80 km between Earth's surface and ionosphere could be like brain of Earth, which is very sensitive to the conditions of ionosphere and biosphere and has "biofeedback" coupling with living systems. The effect of oscillatory phenomena (sound, radiations and magnetic fields) at frequencies Schumann resonances on brain to be discussed below supports also the direct interaction of our brain with Mother Gaia via Earth's electromagnetic field.

It is interesting to notice that the ratio of the thickness of solar corona (10^6 m) to the radius of Sun (5×10^8 m), the height of the wave cavity of Earth (80 km) to Earth radius (7×10^6 m), the ratio of the thickness of grey matter of cortex (1 mm) to the size of human brain lobe (10 cm) as well as the ratio of the thickness of cell membrane (10^{-8} m) to the radius of neuron (2.5×10^{-6}) have roughly the same value of order 10^{-2}. Thus it seems that cell membrane, cortex, electromagnetic cavity of Earth and solar corona might have similar role in the self hierarchy.

The web formed by topological field quanta of the classical em and fields continues to arbitrary long length scales. For instance, the flux tube structure of solar magnetic field provides an explanation for the anomalously high temperature of solar corona and a model for solar spot cycle [K97]. Perhaps also Sun is a conscious self forming part of "Indra's net" representing electromagnetic and other classical fields of cosmos. Since the four CP_2 coordinates are the primary dynamical variables, one must consider the possibility that topologically quantized classical gauge fields and classical gravitational field could form rather independent sub-selves.

Possible geometric correlates of entanglement?

The geometric correlate for the entanglement between sub-systems is the generation of flux tubes combining the corresponding 3-surfaces to single 3-surface: this is nothing but the direct touching of the 3-surfaces. Actually, all that is needed is the fusion of the space-time sheets of same local topology (real or p-adic) to single sheet. The entanglement generated in this manner can be

preserved even when direct geometrical contact between 3-surfaces is not present anymore. In TGD based model for brain these bonds are formed between parts of brain and sensory organs.

One can consider several models for flux tubes. Topological field quantization providing general description of classical gauge and gravitational fields in TGD framework implies that magnetic and electric flux tubes and "massless extremals" (MEs) are the basic building blocks of classical em fields. All these structures can serve as flux tubes.

MEs are especially interesting candidates for space-time correlates of time like entanglement between positive and negative energy parts of zero energy states. MEs are very general solutions of field equations of TGD and have properties making them ideal for realizing basic functions of biosystems.

1. MEs represent propagation of classical gauge fields with light velocity and can carry non-vanishing vacuum em currents and hence give rise to coherent photons. A tentative identification is as bio-photons of Popp [I37]. The hypothesis is that MEs make possible generation of quantum entanglement between brain and sensory organs. In this manner they provide a realization for neuronal window idea generalizing the idea about hologrammic brain [K22]. MEs could make possible both classical (quantum) communication by the propagation of classical fields (coherent photons) along them and neuron could literally have a window to external world via sensory organ.

2. In TGD framework space-time sheets with negative time orientation are possible and carry negative classical energies (in General Relativity this is not possible). The generation of negative energy MEs provides "buy now, pay later" type mechanism for energy production. Generation of negative energy ME is classical counterpart for the generation of virtual particle and it is to be expected that the subjective lifetime of negative energy MEs is finite number of quantum jumps. Thus organism must eventually "pay", that is to compensate for the dissipation of the energy gained by the generation of the ME by metabolism. Therefore metabolism is still needed. Even more, organism must be able to give guarantees that it can pay! The ability to provide these guarantees is perhaps one of the great achievements of the biological evolution.

3. MEs carry large momentum since all Fourier components of the gauge fields have parallel light-like momenta. Since classical 4-momentum is light-like, the amount 3-momentum per energy is maximal. Thus, if the system is able to generate ME by quantum jump, it gains automatically large recoil momentum. Hence MEs could provide the fundamental mechanism making possible the coherent macroscopic motion of living systems. Negative energy ME of this kind might be identifiable as a mind-like space-time sheet representing the geometric correlate for the conscious decision to move.

4. MEs represent dispersionless propagation of a pulse preserving its shape and are thus ideal for classical communication. If negative energy MEs are possible, one can imagine a mechanism of "real subjective time" communication between selves of either geometric past or future having arbitrarily large time-like distance. This idea is not conflict with standard classical causality at given space-time sheet. Needless to say, this kind of possibility would realize concretely the idea about four-dimensional society and revolutionize our view about universe: living beings separated by billions of light years could in principle have "real subjective time" chat.

5.4.3 Support For The Notion Magnetic Body

There exists both theoretical and empirical support for the notion of magnetic body.

Theoretical support

1. EEG and Uncertainty Principle

There are good reasons to expect that EEG is accompanied by radiation, which in TGD framework has topological light rays as space-time correlates. Typical EEG frequencies correspond to wavelengths $\lambda = c/f$ which for which natural length scale unit is Earth size. Thus Uncertainty

Principle suggests that structures of at least this size are involved with the self hierarchy associated with the brain.

2. p-Adic physics as physics of cognition

p-Adic physics as physics of cognition is a fundamental key idea of TGD inspired theory of consciousness. For long time I believed that p-adic-to-real transformations of space-time sheets realized as quantum jumps could serve as correlates for the transformation of intentions to actions allow deeper understanding of also psychological time as a front of p-adic-to-real transition propagating to the direction of the geometric future. It turned out that the mathematical realization of this idea might involve unsurmountable challenges and the natural vision is based on adeles: both reals and various p-adic number fields would be present and cognition would be present already at elementary particle level as also the p-adic mass calculations suggest.

Intentional behavior means that there is unpredictability in short time scales but predictability in long time scales because system can realize its long term plans and use its partially free will to cope with the changing challenges of the everyday life.

p-Adic topology differs radically from real topology in the sense that p-adically infinitesimal is infinite in real sense.

1. The rational values of real and p-adic embedding space coordinates correspond to the same points of the generalized embedding space (essentially union of real and p-adic embedding spaces for various values of p with rational points common to all number fields and also points, in particular points with algebraic number valued coordinates, shared by different number fields in a pair-wise manner identified).

2. The points, which are p-adically close to each other can have arbitrarily long real distance since the points x and $x + kp^n$, $k \in \{0, p-1\}$, become arbitrarily near to each other p-adically and arbitrarily far way in real sense as n increases for the p-adic topology characterized by prime p.

This means that intentionality and cognition are literally cosmic phenomena and present in all scales and evolution of cognition proceeds from long p-adic length scales to short ones in real sense (but from short to long scales in p-adic sense). The carving of a statue by starting from a rough sketch and adding details gradually is a good metaphor for what is involved. Development of any motor skill, say piano playing, is an excellent example of what happens.

Zero Energy Ontology (ZEO) leads to a rather precise view about volitional action. In ZEO self corresponds to a sequence of state function reductions occurring at fixed boundary of causal diamond (CD). Volitional action begins with the first state function reduction to the opposite boundary of CD involving "death" of corresponding self and re-incarnation at opposite boundary [**?**, K7]. Volition can be also seen as a transformation of intention to action. In the original vision this transformation was identified as p-adic-to-real phase transitions of space-time sheets taking place in quantum jumps. It has however turned out that this assumption creates more problems than it solves and that it is un-necessary if one accepts the adelic view meaning that the physics associated with all number fields form a coherent whole and p-adic physics is correlate for cognition. One can say that cognition is in the intersection of reality and various p-adicities defined by strong form of holography as string world sheets with the property that the parameters involved with their mathematical characterization are in algebraic extensions of rational numbers and can be thus algebraically continued to real and various p-adic number fields.

Negative energy topological light rays (MEs) provide an example of possible space-time correlates for intentional actions. Also wormhole magnetic fields consisting of pair of space-time sheets carrying magnetic fields of equal intensity and having opposite time orientations could be generated in intentional action.

In many-sheeted space-time (see **Fig. http://tgdtheory.fi/appfigures/manysheeted.jpg** or **Fig.** 9 in the appendix of this book) 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 transition increasing the p-adic length scale and thus the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and

possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the "dropping" option is discussed.

> *3. Time mirror mechanism of long term memories*

TGD based model of long term memory requires no storage of memories of past to the brain of the geometric now. The memories are in the geometric past as dynamical self organization patterns and subject to changes.

1. In the case of active memory recall the desire to remember is communicated to the geometric past by sharing and fusion of mental images made possible by entanglement. In the case of episodal memories also the memory recall would result in this manner. For non-episodal memories the memory would be communicated from the geometric past using classical communications.

2. In the case of episodal memories active precisely targeted memory recall might be difficult since the entanglement with a correct mental image seems to require good luck. In principle it is possible to select the distance T to the geometric past where the memory comes from by selecting the fundamental frequency of ME.

3. The most natural manner to realize the time mirror mechanism (see **Fig. `http://tgdtheory.fi/appfigures/timemirror.jpg`** or **Fig. ??** in the appendix of this book) is to regard magnetic body as the system communicating with the brain of the geometric past serving as mirror. The fundamental frequency $f = c/L$ of associated with a topological light ray of length L would naturally code for the time span of the long term memory as $T = L/c$ in the sense that only these memories would be communicated resonantly. Thus the distance from brain along magnetic flux tubes would code the time span of the memory. Long term memories with a span of order lifetime however require that the size of the magnetic body involved is measured in light decades.

Experimental support for the notion of magnetic body

The work of Blackman and other pioneers of bio-electromagnetism concerning the effects of ELF (extremely low frequency) em fields on brain [J53] discussed in [K33], provides dramatic support for this idea and also a concrete view about how brain manages to act as macroscopic quantum system. The currents generating EEG certainly create weak electromagnetic radiation fields which in TGD framework correspond to topological field quanta of size of Earth having natural coupling to the magnetic flux tubes.

The lowest Schumann frequency is roughly $c/2\pi R$, R radius of Earth, and equal to $\omega \simeq 8$ Hz. It is known that EEG frequencies are in the same frequency range as so called Schumann frequencies 8, 14, 21, ... Hz [F2] associated with the resonances of the electromagnetic fields in the 80 km thick wave cavity between Earth surface and ionosphere. The higher EEG frequencies seem to correlate with higher Schumann resonance frequencies: in particular, the frequencies 13 and 39 Hz which are also cyclotron resonance frequencies of Na_+, are very near to Schumann frequencies. Schumann frequencies vary in time and it has been found that also the variations of EEG frequencies correlate with this variation.

Magnetic perturbations near Schumann frequencies are known to have profound effects on human brain inducing altered states of consciousness and cortical instabilities such micro-seizures and epilepsies [J106]. The photons generated by Josephson currents associated with macroscopic ionic BE condensates have wavelengths of order Earth size and the topological field quanta representing classically the radiation field have size of Earth.

The explanation of the effects related to water memory [I29, I22] suggests that similar magnetic effects appear at much wider frequency range than ELF frequencies which would mean that the super-conducting magnetic flux tube circuitries form a fractal hierarchy. The findings challenging the notions of ionic pumps and channels [I40] provide additional strong support for the notion of many-sheeted space-time and hierarchy of super-conducting of magnetic flux tubes. The evidence for the fractal hierarchy of magnetic flux tubes is discussed in [K17, K18].

These observations support the view that our "physical" body is only a tip of an iceberg and formed by the topological condensation of the bio-matter around electromagnetic topological field quanta serving as templates for the bio-structures.

The findings of Libet [J70] about time delays associated with the passive aspects of conscious experience suggest that our sensor perceptions are a fraction of second old (.3-.5 seconds). This could be understood if the sensory percepts from brain are communicated to the magnetic body identiable as "us". This particular time scale would correspond to a layer of magnetic body which has 3-5 times the size scale of electron's CD which is about.78 times the circumference. A possible interpretation is in terms of dark electrons with a value of Planck constant which is 3-5 times the standard value. The corresponding EEG frequencies would vary in region.33-.2 Hz.

Cyclotron resonances as key to quantum consciousness

The estimate for the thickness of the magnetic flux tubes of Earth's magnetic field based on the quantization of the magnetic flux is about cell size. There is direct evidence for the hypothesis that ions in the magnetic field of.2 Gauss (Earth) magnetic field has nominal strength of $B_E = .5$ Gauss) form quantum states with the characteristic energies of order 10^{-14} eV and size of the orbit being of order $2/\sqrt{eB}$, that is cell size: in fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic field corresponds to the length scale $L(169) \simeq 5 \mu m$ rather precisely. This length scale is indeed the p-adic length scale which seems to correspond to our sensory consciousness and various macroscopic quantum phases seem to reside at $k = 169$ space-time sheets probably forming join along boundaries/flux tube condensates. The work of Blackman and other pioneers of bioelectromagnetism concerning the effects of ELF (extremely low frequency) em fields on brain [J53] provides dramatic support for this idea and also a concrete view about how brain manages to act as macroscopic quantum system.

The discovery of Blackman means that frequencies having special effect on biomatter correspond to cyclotron resonances for ions like Ca_{++}, Na_+, K_+ and Cl_- in magnetic field $B = 2B_E/5 = .2$ Gauss. The cyclotron frequency for Ca_{++} is 15 Hz whereas the remaining frequencies are in the range $7 - 13$ Hz (theta waves) at which also the most important Schumann resonances lie. The cyclotron frequency 5.5 Hz of iron is also a bio-active frequency and is the lower edge of theta region of EEG. Also lower frequencies resonant frequencies such as 2.4 (Iodium ion) are present. Even more remarkably, the pattern of data forces to conclude that the interaction occurs at quantum level. This conclusion is is dramatic conflict with the predictions of the standard quantum theory and with the standard view about space-time but consistent with the many-sheeted space-time concept of TGD.

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

$B = .2$ Gauss would corresponds to a flux tube radius $L = \sqrt{5/2} \times L(169) \simeq 1.58L(169)$, which does not correspond to any p-adic length scale as such. $k = 168 = 2^3 \times 3 \times 7$ with $n = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 25 \mu$m, size of a large neuron. However, $k = 169$ with flux $2h_5$ would be must more attractive option since it would give a direct connection with Earth's magnetic field. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux h_5. Note that $n = 5$ is the minimal value of n making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [K3].

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field in the direction of axon carrying $B = 2B_E/5 = .2$ Gauss, is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of Ca_{++} ion. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. This can be understood as resulting from parity conservation for the simplest transitions induced by that part of the interaction Hamiltonian which does not depend on the longitudinal coordinate of the axon. The reason is that odd and even values of n for harmonic oscillator states have opposite parities and the interaction hamiltonian describing the transition has odd parity. The simplest possibility is that these transitions occur in second via intermediate virtual intermediate state and correspond to second order in perturbation theory. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

These observations are consistent with the following interpretation. Ions with charge Z, spin S and mass m in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as multiples of

$$
\begin{aligned}
E &= (n + \frac{1}{2})\omega_c + \frac{S_z}{S}\omega_L ~, \\
\omega_c &= \frac{ZeB}{m} ~, \quad (\hbar = 1, c = 1) ~, \\
\omega_L &= \frac{gS\omega_c}{4} ~.
\end{aligned}
\tag{5.4.1}
$$

Here S and S_z denote total spin and its projection to the direction of the magnetic field. The contribution to energy coming from longitudinal motion has not been written explicitly. Here g is so called Lande factor which for free elementary fermions equals to $g = 2$. The experimental findings suggests strongly that external em field induces resonant transitions from between magnetic states. By the quantization of the magnetic flux, predicted by TGD also classically, the minimal size of the magnetic flux tube for the magnetic field of Earth is of order cell size. An attractive hypothesis is that the magnetic field in question is associated with axon and is parallel to it.

It must be emphasized that this vision is forced by hard experimental facts and is in dramatic contradiction with the standard physics view about brain. The wave functions of ions in magnetic field are confined in a region of size of order

$$
r_n \sim \sqrt{n/eB} ~,
$$

which is of the order of cell size for B=.2 Gauss: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the length scale $L(169) \simeq 4$ μm rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ (S denotes the area of the flux tube) and $Z = 2e$. $L(169)$ seems to correspond to our sensory consciousness and various macroscopic quantum phases seem to reside at $k = 169$ space-time sheets probably forming join along boundaries condensates.

The binding energies of ions in Earth's magnetic field are extremely small: of order 10^{-14} eV, which is ridiculously small energy when compared with the natural energy scale of one eV and corresponds to a temperature of order 10^{-10} Kelvin. According to standard quantum physics, Earth's magnetic field should have absolutely no detectable effects in hot, wetty and noisy environment provided by brain. Many-sheeted space-time concept provides the solution to the riddle. Ions are not on the molecular space-time sheets but have dropped to the cellular space-time sheet and it is indeed very cold, dry and silent here: an ideal place for the formation of macroscopic quantum phases. The energy scale implies the upper bound $T < 10^{-10}$ Kelvin for the temperature at cellular space-time sheets.

A further empirical input of crucial importance were the observations challenging the cherished notions of ionic pumps and channels [I40]. These findings lead to a concrete view about biosystems as three-levelled structures involving massless extremals (MEs), super conducting magnetic flux tube structures, and atomic space-time sheets containing the ordinary matter. MEs control the dynamics of the superconducting ions inside magnetic flux tube structures. Magnetic flux tubes in turn are in a many-sheeted ionic flow equilibrium with the atomic space-time sheets and thus control the ionic concentrations at these space-time sheets.

This general framework leads to a rather detailed model for the generation of nerve pulse and EEG; to a model of sensory representations based on the notion of sensory canvas realized in

terms of magnetic flux tube structures outside body with MEs serving as projectors of the cortical sensory representations to this sensory canvas; to a model of cognition including the realization of the memetic code in terms of cognitive antineutrinos and a physical mechanism translating nerve pulse sequences to the 126 bit long codewords of the memetic code; and finally, to a model for the quantum correlates of the sensory qualia and to what deserves to be called spectroscopy of consciousness.

Electromagnetic selves

Rather remarkably, the time scale of .1 seconds predicted by the model of the memetic code and defining in the zero energy ontology a fundamental time scale of electron as well as the time scales of the photons associated with the magnetic transition frequencies, in particular cyclotron frequencies, of ions correspond to the time scale of EEG. The currents generating EEG certainly create weak electromagnetic radiation fields which in TGD framework correspond to topological field quanta of size of Earth: the lowest Schumann frequency is roughly $c/2\pi R$, R radius of Earth, and equal to $\omega \simeq 8$ Hz. It is known that EEG frequencies are in the same frequency range as so called Schumann frequencies 8, 14, 21, ... Hz [F2] associated with the resonances of the electromagnetic fields in the 80 km thick wave cavity between Earth surface and ionosphere.

The higher EEG frequencies seem to correlate with higher Schumann resonance frequencies: in particular, , the frequencies 13 and 39 Hz which are also cyclotron resonance frequencies of Na_+, are very near to Schumann frequencies. Schumann frequencies vary in time and it has been found that also the variations of EEG frequencies correlate with this variation. Magnetic perturbations near Schumann frequencies are known to have profound effects on human brain inducing altered states of consciousness and cortical instabilities such microseizures and epilepsies [J106]. The photons generated by Josephson currents associated with macroscopic ionic BE condensates have wavelengths of order Earth size and the topological field quanta representing classically the radiation field have size of Earth.

These observations suggests the identification of the relevant selves in our self-hierarchy are electromagnetic selves having the size of Earth and correspond to EEG frequencies. What happens is that Josephson currents generate classical ELF em fields represented by topological field quanta of this size (by uncertainty principle alone) which in turn couple resonantly to ions. These observations raise the question whether our "physical" body is only a tip of an iceberg and formed by the topological condensation of the biomatter around electromagnetic topological field quanta serving as templates for the biostructures [K19]. There is also neuropsycological evidence for the importance of ELF fields. In particular, the work of Michael Persinger is especially important [J109, J107, J133] [K41].

One possible scenario inspired by these observations is following.

1. The magnetic transition frequencies for the superconducting ions at the flux quanta of magnetic field B=.2 Gauss correspond to personal sensory consciousness. The magnetic flux tubes emanating more or less vertically from brain and accompanied by massless extremals could act as projectors defining personal sensory representations at the magnetic sensory canvas formed by the flux tubes (or possibly shell like topological quanta) of Earth's magnetic field.

2. Schumann frequencies associated with the oscillations of the flux tubes of Earth's magnetic field would in turn correspond to transpersonal aspect of consciousness. Schumann resonances could indeed induce a synchrony of the vertical magnetic flux tube structures associated with separate brains and even entangle them during sleep. This view is supported by some observations. In hypnagogic states (states between wake and sleep) EEG is peaked near the lowest Schumann frequency 7.8 Hz. During these states it is possible to experience hallucinations and identification experiences (I have now and then fleeting but completely "real" experiences of being someone else). The so called sleeping spindles correspond to EEG patterns at 14 Hz which is the second Schumann frequency. A possible interpretation is that during sleep collective consciousness begins to dominate and brains form a highly synchronous whole. It would be interesting to test whether there are correlations between EEGs of different persons during sleep.

5.4.4 Some Functions Of Magnetic Body

The magnetic bodies associated with various body parts, including cellular and even molecular magnetic bodies, could have several functions besides defining a hierarchy of intentional agents (for this aspect see [**?**]).

Topologically quantized classical fields as templates for the formation of bio-structures?

Magnetic bodies could serve as templates of bio-structures. For instance, blood circulation and central nervous system could have magnetic circuitries as templates. The web like structure formed by topological field quanta representing classical fields, in particular em fields, is reminiscent of structures formed by micro-tubuli and collagens forming the connective tissue of living systems. It has been already earlier suggested that magnetic flux tubes and other topological field quanta serve as templates for various bio-structures in the sense that ordinary matter is topologically condensed on the flux tube like structures. This would mean that living systems would be only part of much larger web formed by Earth's classical em field forming one particular sub-self (mental image!) of Mother Gaia.

The thickness for the flux tubes of Earth's magnetic field is about $2/\sqrt{eB} \simeq 4 \times 10^{-6}$ meters. There is direct evidence for the hypothesis that ions in a magnetic field $B_{end} = 2B_E/5 = .2$ Gauss, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field, form quantum states with the characteristic energies of order 10^{-14} eV and size of the orbit being of order $2/\sqrt{eB}$, that is cell size. It must be emphasized that B_{end} is not equal to B_E as I erratically believed for a long time. The model for dark matter as macroscopic quantum phases with Planck constant equal to an integer multiple of the ordinary Planck constant [K36] leads to the working hypothesis that B_{end} corresponds to the dark counterpart of B_E [K33].

For $B_{end} = 2/5B_E = .2$ Gauss interpreted as a dark magnetic field with $\hbar = 5\hbar_0$ carrying 2 units of flux (the unit is $h_5 = 5h_0$) and corresponding also to the p-adic length scale $L(169)$, the radius is 25 μm, the size of a large neuron. This possibly relates to the fact that the effects of ELF em fields are observed for vertebrates (for details see [K33]).

The coupling of the neuronal layers of cortex and perhaps all cells with the flux tubes of Earth's magnetic field could make possible entanglement between brain and Mother Gaia. If magnetic flux tubes of the dark counterpart of B_E have direct geometric coupling with brain one could perhaps understand the miraculous ability of birds and bees to navigate using Earth's magnetic field. The proteins navigating along micro-tubuli, cells navigating along collagen fibres and birds navigating along Earth's magnetic field lines would all be guided by higher level selves.

One could see also humans and the societies formed by them as continually self-organizing organs in the body of electromagnetic Mother Gaia. In this picture the narrow wave cavity of radius 80 km between Earth's surface and ionosphere could be like brain of Earth, which is very sensitive to the conditions of ionosphere and biosphere and has "biofeedback" coupling with living systems. The effect of oscillatory phenomena (sound, radiations and magnetic fields) at frequencies Schumann resonances on brain to be discussed below supports also the direct interaction of our brain with Mother Gaia via Earth's electromagnetic field.

It is interesting to notice that the ratio of the thickness of solar corona (10^6 m) to the radius of Sun (5×10^8 m), the height of the wave cavity of Earth (80 km) to Earth radius (7×10^6 m), the ratio of the thickness of grey matter of cortex (1 mm)to the size of human brain lobe (10 cm) as well as the ratio of the thickness of the cell membrane (10^{-8} m) to the radius of neuron (2.5×10^{-6}) have roughly the same value of order 10^{-2}. Could this mean that cell membrane, cortex, electromagnetic cavity of Earth and solar corona might have similar role in the self hierarchy? The general ideas about self-organization indeed support this view: boundary regions are subject to the most intense external energy feed and thus self-organize most effectively.

The web formed by topological field quanta of the classical em and fields continues to arbitrary long length scales. For instance, the flux tube structure of solar magnetic field provides an explanation for the anomalously high temperature of solar corona and a model for solar spot cycle [K97]. Perhaps also Sun is a conscious self forming part of "Indra's net" representing electromagnetic and other classical fields of cosmos. Since the four CP_2 coordinates are the primary dynamical variables, one must consider the possibility that topologically quantized classical gauge fields and classical gravitational field could form rather independent sub-selves.

Dark magnetic fields and living matter

A considerable sharpening of the above discussed speculative picture came with the development of TGD inspired vision about dark matter as macroscopic quantum phases with quantized value of Planck constant having arbitrarily large values coming as integer multiples of the ordinary Planck constant [K36].

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [K33] .

1. The most general hypothesis is allowed by the proposed generalization of the notion of embedding space is that the values of $r = \hbar/\hbar_0$ come as rationals [K36]. A less general alternative is that the values r of come as integers: $r = n$, where n characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [K120]. In this case n would be a product of integers characterizing the number of sheets for singular coverings of CD and CP_2.

2. The values of n for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$.

The prediction is that also rational or at least integer multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \to h = rh_0$ in the transition scaling the Planck constant by r: one manner to achieve this is by scalings $L(k) \to rL(k)$ and $B \to B/r$.

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

An natural working hypothesis is that B_{end} defines the dark counterpart of the ordinary magnetosphere and that the relationship $B_{end} = 2B_E/5$ holds as a time average in the entire magnetosphere. The flux quanta of B_{end} would carry dark matter and would be responsible for the quantum control of the living matter.

Magnetic flux tubes and metabolism

Magnetic flux tubes could define super-conducting circuitry making possible a many-sheeted control of homeostasis: this aspect is discussed in [K46]. The hierarchy of magnetic flux tubes could also define many-sheeted lasers, and the dropping of particles to the larger space-time sheets would define a hierarchy of metabolic energy currencies as zero point kinetic energies liberated in the process. Process would also generate radiation at the harmonics of cyclotron frequencies at the larger space-time sheet. These frequencies could define a considerable part of EEG. Also fractally scaled up versions of EEG having similar band structure are predicted. The findings of Peter [I30, I31] are consistent with this prediction [K15]. The dropping of particles to larger space-time sheets for population inverted lasers would be also ideal for the realization of bio-control by time mirror mechanism and make possible remote metabolism and remote motor control.

Magnetic flux tubes as Nature's own bio-laboratory

Magnetic flux tubes could be ideal structures for the isolation and purification of various bio-molecules, and make also possible precise targeting of the reactants to reaction volumes defined by the nodes of the magnetic flux tube circuitry. Purification is made possible by the weight of the molecule if quantum-classical correspondence holds true in the sense that a magnetic flux tube carrying super-conducting bosons of mass m deforms so that it runs along a classical orbit of the particle with radius proportional to m. This would make sense for a many-sheeted magnetic field for which the fluxes associated with the magnetic flux tubes along which particles move return

along much larger space-time sheets and define the average magnetic field in which the particles move. This kind of Nature's own bio-laboratory might explain the miraculous selection of bio-molecules essential for the pre-biotic evolution. In accordance with the p-adic vision about the evolution of cognition, the evolution would have been proceeded from and guided by the magnetic flux tube structures of the Earth's magnetic field to the bio-chemical level [?].

5.4.5 The Magnetic Fields Associated With Body Parts And Higher-Levels Of Consciousness

The basic vision is that magnetic flux tubes containing ionic super-conductors, MEs carrying exotic representations of p-adic Super Virasoro algebra, and biological organisms live in a fractal symbiosis. MEs can induce cyclotron transitions amplified to quantum phase transitions inside magnetic flux tubes provided they have length above the wavelength defined by the cyclotron frequency. The exotic p-adic Super Virasoro representations with MEs have wavelength determined by the fundamental frequency which is of same order as the cyclotron frequency. The interaction of MEs and magnetic flux tubes by SQUID mechanism requires that magnetic flux of ME generates a current inside a circuit formed by magnetic flux tubes. Magnetic flux tubes to have arbitrary size scales below the size scale of ME.

Some body parts are carriers of static magnetic fields. The value of the static magnetic field associated with eye is slightly below 10^{-11} Tesla whereas the strength of Earth's magnetic field is about $.5 \times 10^{-4}$ Tesla. Also pineal gland ("third eye" also in a rather literal sense, see [K39]) contains magnetic material. Unfortunately I do know the value of the corresponding dipole strength: for a dipole having size of order micrometer the maximal dipole strength would be very roughly 10^{-9} times corresponding dipole strength for Earth's magnetic field which would mean field of order 10^{-13} T. Also head and entire body could act as static magnetic dipoles.

For purely sensory consciousness .1 seconds is the characteristic time scale and EEG is closely related with this form of consciousness. In case of B_e the magnetic cyclotron frequencies are in the range obtained by scaling the range of cyclotron frequencies in Earth's magnetic field by a factor about 2×10^{-7}. This means that the periods of the ionic cyclotron frequencies are roughly in the range 12 hours-1.6 years for ionic cyclotron frequencies corresponding to the range of frequencies $90 - 0.1$ Hz in Earth's magnetic field. These time scales are typical for the contents of higher level self consciousness involving self narrative. Notice however that these fields are perhaps not sufficiently weak for a self narrative in the time scale of several years.

The minimal thickness of the flux tubes for ULF selves associated with B_e would be roughly of the order of few millimeters, as one finds by scaling the radius for the flux tube of Earth's magnetic field which is about 5 microns.

Also bodily magnetic fields B_b could be involved. By scaling one obtains for the head's magnetic field an estimate $(mm/headsize)^2 B_e \sim 10^{-4} B_e$, which gives fT which is slightly above the thermal noise produced by body. The flux tube would have minimal thickness about 10 cm, the size scale of the head. The cyclotron frequency range would be scaled by a further factor of 10^4 factor meaning that the time scale range would be between 10 years and 10^4 years!

Higher levels of self hierarchy as levels of dark matter hierarchy

Higher levels of dark matter hierarchy provide neat quantitative view about self hierarchy and its evolution. The integer $n = 2^{k11}$, $k = 0, 1, 2, ...$ seem to define favored values of Planck constant in living matter. This means a hierarchy in which time and length scales are zoomed up by a factor of 2048 in the transition to the next level of hierarchy. This integer represents also fundamental constant in TGD Universe [K97].

For instance, EEG time scales corresponds to $k = 4$ level of hierarchy and a time scale of.1 seconds [K32], and EEG frequencies correspond at this level dark photon energies above the thermal threshold so that thermal noise is not a problem anymore. Various levels of dark matter hierarchy would naturally correspond to higher levels in hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in questions. $k = 7$ would correspond to a duration of moment of conscious of order human lifetime which suggests that $k = 7$ corresponds to the highest dark matter level relevant to our consciousness whereas higher levels would in general

correspond to transpersonal consciousness. $k = 5$ would correspond to time scale of short term memories measured in minutes and $k = 6$ to a time scale of memories measured in days.

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 [K51, 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.

Could the flux tubes of bodily magnetic fields correlate with more abstract levels of self consciousness?

The previous observations combined with the general speculative vision about Indra's web of consciousness stimulate several questions and ideas relating to the role of various magnetic fields associated with body.

1. Could it be that the ULF selves associated with the ionic super-conductors residing at the flux tubes of the bodily magnetic fields B_e and B_b (notice also the static magnetic fields of pineal gland and of other organs) belong to the self hierarchy and represent higher level selves contributing to our non-sensory consciousness under ordinary circumstances? This translates to the question whether the flux tubes of the corresponding topological quantized magnetic fields are closed in a relatively small volume as in case of an ideal dipole field or whether part of flux tubes have astrophysical lengths.

2. The above arguments do not pose restrictions on the strengths of the magnetic fields. In case of Earth's magnetic field the magnetic flux tubes have sizes of order of the wavelength associated with a typical cyclotron frequency. Could it be that the interacting MEs and magnetic flux tubes have sizes comparable to the wavelength defined by cyclotron frequency? If this is the case for B_e and B_b, the sizes of flux tubes would be astronomical with light day serving as lower bound. One could see the flux tubes of B_e and B_b as kind of umbilical cords connecting human bodies with magnetic structures of astronomical size and perhaps also with other organisms. Could one assign the more abstract levels of human consciousness and long term memories with the ULF selves associated with both the flux tubes of B_e and B_b and with MEs? In this view biological organisms would be like sensory-motor organs of this magnetic super organism.

3. Could one possibly test this hypothesis in case of B_e by studying the interaction of ULF em fields with frequencies above the time scale defined by day? Is the daily rhythm somehow relevant at the level of these em fields? For instance, could the natural 24 hour period certainly associated with ULF em fields of eye define the analog of alpha peak in EEG? Could the strength of the magnetic fields of eye be seen as a result of adaptation to the daily rhythm or is it dictated by the size of eye and flux quantization (there is roughly unit flux over an area of order millimeter squared)?

Objection

The bodily magnetic field change with time if the location orientation of the magnetic dipoles are fixed with body. Already the rotation of Earth induces periodic rotation of the magnetic flux tubes B_e and B_b. The volitional motion during wake-up period induces further effects.

There are several ways to circumvent this objection.

1. The most convincing manner to avoid the objection is that the flux tubes relevant for ULF consciousness have size at least of order of the wavelength defined by the cyclotron frequency and thus of the same order of magnitude as the size of the corresponding MEs. In this scale the rotating motion for the end of the magnetic flux tube of B_e or B_b would have absolutely

no significance and magnetic flux tubes would be somewhat like magnetic umbilic cords (like the tunnel involved with the NDE experiences connecting patient to the deceased relatives!).

2. If the magnetic flux tubes in question have sizes comparable or smaller than Earth size, the situation changes. Only in the very special case that the flux tubes rotate around Earth in the direction of equator, B_e and B_b could remain stationary and it makes sense to speak about stationary states.

3. One could also consider the possibility that magnetic flux quanta are layer like structures around Earth rather than rotating tubular structures, and have rotational symmetry with respect to the rotations around Earth axis so that it is body which is rotating with respect to these structures rather that these structures rotating with body. In this case it would make sense to assign cyclotron frequencies to the super-conducting ions in question since local magnetic states are certainly possible. In super-conductors of type I near critical temperature complicated layer like flux structures are indeed possible and in [K17, K18] it has been suggested that epithelial sheets formed by cell membrane inside cells correspond to this kind of flux structures.

The obvious question is how the rotation of Earth affects localized stationary states of the super-conducting ions inside co-rotating magnetic flux tubes with sizes smaller than Earth size. Does the description of the system in terms of cyclotron states make sense anymore? Quantum mechanically the ion in a stationary magnetic magnetic field is in radial degrees of freedom like a harmonic oscillator.

1. A simple analog system would be a harmonic oscillator rotating with an Earth and having an oscillation period which is longer than 12 hours. By separating center of mass degrees of freedom one finds that the particle in the rotating oscillator well feels besides the ordinary harmonic force a harmonic force $m\omega^2 \overline{r}_{cm}$ which means that the complete solution to the equations of motion is superposition of the harmonic oscillator motion plus a periodic oscillatory term with the frequency of the external force. The average motion is therefore just the rotating harmonic oscillator motion.

2. In quantum case one has harmonic oscillator coupled to an external harmonic force having a frequency much larger than the oscillator frequency. Time dependent perturbation theory allows transitions only between the states whose energy difference $n\omega_0$ equals to the forcing frequency and transitions thus possible only if one has $\omega = n\omega_0$. Thus no quantum jumps would occur in the generic case.

3. The guess motivated by these considerations is that the magnetic state in a rotating magnetic field is in a good approximation obtained by applying time dependent rotation to the ordinary magnetic state and that in the time scale defined by the cyclotron frequency the average effects to the state cancel also now. Thus effective adiabaticity holds true.

Further questions related to vision

One can make several interesting questions related to vision and the magnetic fields of eye.

1. What is the role of the rapid eye movements during REM sleep, in particular during dreams? Could it be that the communication of long term memories from ULF level is involved with dreams and that the rhythmic eye movements are essential for establishing this communication?

2. The motor control associated with eyes is decoupled from the motor control of the remaining body. Therefore persons who are totally paralyzed can still move their eyes and can even communicate in this manner. Could the special role of the eye-motorics relate to the remaining ability to stay in contact with ULF selves associated with eyes?

3. What is the interpretation of the rays of light characterizing the visual perception of intense light. Perhaps there is some natural explanation for this but since I do not know about it, I can entertain myself with the idea that these rays could directly correspond to MEs

representing rays of light and connecting me with the objects of the external world. The correspondence between sensory experience and reality would be amazingly simple, if this is true.

NDE experiences and magnetic consciousness

NDE experiences [J136, J129] involve vision in an essential manner. This suggests that the dominating component of NDE consciousness could correspond to ULF selves associated with B_e and or B_b and give rise to the typical bird's eye of view about own body involved with the OBE and NDE experiences. The cyclotron frequency time scale associated with B_b would indeed fit with the life review experienced in NDE experiences. Body would be seen by ULF selves in bird's eye of view through the magnetic flux tubes of B_e and B_b. There would be a strange resiprocity resembling to the resiprocity encountered in the techniques of radio communications where the antennae sending messages can also serve as receiving antennae. NDE experiences involve also meeting of the dead relatives. Magnetic flux tubes can connect patient also to other organisms. and it would not be too surprising if magnetic flux tubes starting from the body could serve as an umbilic cord connecting the patient with living relatives or magnetic structures representing deceased relatives.

NDE experiences involve also the experience of travelling through a tunnel. The tunnel is experienced also during epilepsy and migraine, during meditation and relaxed state of mind, and with certain drugs like LSD, philocybin and mescaline.

I have also personal "tunnel experiences" every-daily: when 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. The experience is not stable and tends to fade away all the time, and after few minutes I am not anymore able to achieve it. During my 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. I have pondered quite a many times about the possible interpretation of this background flow. The basic observation was that it resembles liquid flow to a very high extent. Liquid flows are usually incompressible in an excellent approximation and this means that the velocity field is divergence free. This is the basic property of also magnetic fields and means that magnetic flux through a circuit moving along magnetic flux lines is conserved. This has stimulated the obvious guess that the background flow indeed represents magnetic field. The question which I have not made is whether this magnetic field resides inside my brain or outside it. In light of the above considerations the most natural answer to the question is that the magnetic field visualized by the flow is precisely where it seems to be. The flow would represent nothing but the magnetic field associated with my own eyes or more probably head, or rather how the self associated with the flux tubes of this magnetic field experiences the world.

The thickness of the flux tubes of B_b would be roughly the size of the head and this fits with idea that the tunnel experience represents directly the magnetic flow without any scaling factors involved. The fractality of TGD Universe suggests that these magnetic fields contain flux tubes of stronger magnetic fields inside them, so that the tunnel experience would represent the flux tubes of these magnetic fields experienced as sub-selves by the ULF self contributing to my visual consciousness in this altered state of consciousness. Of course, it might well be that also during the ordinary consciousness the experiencer is this magnetic ULF self and that sensory input dominates the content of the conscious experience and creates the illusion about body as self. In the absence of a sensory input the contents of consciousness of a clinically dead person is determined by these magnetic field and bird's eye of view about body results.

What remains after the physical death could therefore be determined by the magnetic fields involved with body. Magnetic flux conservation allows configurations of the closed magnetic flux loops containing ionic super-conductors as the counterpart of soul continuing existence after death. Wormhole magnetic fields and p-adic variants of these magnetic fields would also make it possible to store information about the magnetic fields originally associated with body. The overall view suggesting itself that our bodies are like sensors and motor organs of a gigantic electromagnetic organisms of astrophysical size and represent its sub-selves (mental images). This interpretation

conforms with the fact that in EMDR method rhythmic eye movements induce experiences involving the meeting of deceased relatives [J30].

The experimental study of what happens to the magnetic fields associated with eyes, head and other body parts after the physical death would obviously provide interesting information in this respect, perhaps one can someday even develop refined methods of communication with the deceased.

What about magnetic fields of heart?

The magnetic fields associated with eyes are not the only bodily magnetic fields with peak intensities higher than the non-static magnetic fields generated by brain. Heart generates a periodically oscillating magnetic field B_h of order $.5 \times 10^{-10}$ Tesla which is almost ten times higher than the static magnetic field generated by eyes. I do not know whether B_h contains a static component and if so, what is its strength. In any case, the absence of the static component means that the possibly super-conducting ions inside flux tubes of heart's magnetic field are in a periodically oscillating dipole field (most probably with respect to the geometric time!).

Also here my "great experience", which has turned out to be an extremely valuable repertoire of altered states of consciousness, provides an illustrative example. During the second great experience which lasted only one night, I experienced what might be called "heart consciousness". In the beginning of the experience my whole consciousness was filled by the rhythmic "..aqua-aqua-aqua..". It took some time to recognize that this rhythm was the rhythm of my own heart. Involved was also the mystical experience about the fundamental importance of water for life (said jokingly, heart is an organ specialized to deal with liquid!) and the precognition of the notion of infinite primes. Could it be that the MEs associated with heart dominated the contents of my consciousness during this experience.

Chapter 6

Quantum Model for Sensory Representations

6.1 Introduction

This - as also the other chapters of "TGD Inspired Theory of Consciousness" - was written for the first time for more than a decade ago. The recent version is an outcome of an updating motivated by the progress taken place in quantum TGD proper during the period 2005-2010. Several new elements are involved. The improved understanding of the quantum TGD itself at the fundamental level; zero energy ontology including the notion of causal diamond (CD) defined as the intersection of future and past directed light-cones; the hierarchy of Planck constants requiring a generalization of the notion of imbedding space and involving the identification of dark matter as phases with non-standard values of Planck constant; and the progress in the understanding of p-adic physics-especially the realization that life could be seen as something residing in the intersection of real and p-adic worlds. The fact that number theoretic entanglement negentropy has a positive value in the intersection has profound implications for the TGD inspired theory of consciousness and quantum biology since the quantum measurement theory is modified profoundly.

6.1.1 Overall View About TGD Inspired Theory Of Consciousness

TGD inspired theory of consciousness allows to construct a general model of conscious experiences based on some very general principles.

1. The original view was that notion of quantum jump defines "microscopic" theory of consciousness whereas the notions of self and self hierarchy allow to understand "macroscopic" aspects of consciousness absolutely essential for brain consciousness. It however seems that zero energy ontology and the hierarchy of Planck constants allow to identify these notions by replacing the quantum jump as a fractal structure consisting of quantum jumps within quantum jumps. Despite this I will prefer to talk about these notions as separate ones in the sequel. The assumptions about how the contents of consciousness of self is determined allow to understand the basic structure of conscious experience at general level. One can understand intentionality and volition as closely related to the p-adic nondeterminism. Negentropic quantum entanglement is stable under state function reduction if governed by Negentropy Maximization Principle (NMP) so that state function reduction is not a random process anymore. The implications are obvious for understanding how conscious intelligence emerges. Theory leads to a very general model of sensory experience - including a vision about qualia - and the so called whole-body consciousness involving in an essential way negentropic entanglement explains the basic characteristics of altered states of consciousness.

2. The understanding of the relationship between subjective and geometric time has evolved via several proposals and leads to the notion of psychological time involving in an an essential way the new view about space-time. Symbolic representations at space-time level required by quantum classical correspondence are made possible by the classical nondeterminism of

Kähler action. All space-time sheet are assigned to CDs in zero energy ontology and correspond to mind-like space-time sheets in the earlier terminology. They serve as geometric correlate of selves. The notion of psychological time forces to view the entire many-sheeted space-time surface as a living system so that the standard notion of linear time is illusory and reflects the restricted information content of our conscious experience rather than fundamental 4-dimensional reality.

The paradigm of 4-dimensional brain provides a completely new understanding of the long term memory: no memory storage mechanisms are needed and one avoids the basic difficulties of neural net models. There are two kinds of memories: subjective and geometric. Also geometric memories come in two types: episodal and declarative. Time-like negentropic entanglement make possible episodal memories as a direct re-experiencing in the intersection of real and p-adic worlds, and state function reduction trivializing time-like entropic entanglement gives rise to declarative, verbal memories mediated by classical communications. Massless extremals (MEs) are proposed to serve as space-time correlates for both kinds of memories. The fact that the temporal duration of the light-like self associated with ME can be arbitrarily long, is very probably of significance. The hierarchy of Planck constants allows to overcome the objection due to the fact that the photons with the required extremely low frequencies are below the thermal threshold in living matter and therefore should not have any role for consciousness. Emotions might be understood as resulting from the comparison of geometric memories (the expectation) with the subjective memories (what really happened). The positive-negative coloring of the emotions could relate directly to whether the mental images corresponds to a system with negentropic or entropic entanglement.

3. An essential element is macro-temporal quantum coherence accompanying the formation of bound and negentropically entangled states. Already zero energy ontology assigns macroscopic time scales of coherence to elementary particles and the hierarchy of Planck constants and the stability of negentropic entanglement against state function reduction bring in additional elements. Quantum spin glass degeneracy lengthens the lifetimes of the resulting bound states.

4. Subjective time development by quantum jumps implies quantum self-organization which can be regarded as a sequence of quantum jumps between quantum histories. This evolution corresponds to a sequence of superposition of macroscopic space-time surfaces associated with the final state quantum histories assignable to the hierarchy of CDs. Quantum jumps imply dissipation at fundamental level. As in standard approach dissipation serves as a Darwinian selector of self-organization patterns, which can represent both genes and memes. Jumping from the bottom of a valley of the 4-D quantum spin glass energy landscape to the bottom of another valley by a temporary de-localization in zero modes explains phase transition like processes ranging from a change of protein conformation to the replacement of a habit routine by a new one. Further new elements to the standard view about self-organization are brought by zero energy ontology, negentropic entanglement, and hierarchy of Planck constants implying that second law does not hold true in the standard form anymore. An especially interesting prediction is that the CDs assignable to elementary particles correspond to macroscopic time scales. For instance, electron corresponds to the fundamental.1 second bio-rhythm.

The role of energy feed in self-organization becomes more complex in TGD framework. Learning becomes a fundamental process since state function reduction for negentropically entangled states is not random process anymore and in the first approximation the powers of unitary process define an iterative self-organization process. In this framework one can in principle understand how habits, skills and behavioral patterns are gradually learned. The possibility of the reversal of the arrow of the geometric time below p-adic time scale characterizing the system brings in time reversed dissipation identifiable as a healing. Bio-rhythms could quite generally correspond to dissipation-healing cycles. Motor action could be understood as geometric time reversal for the build-up of sensory representation in an appropriate time scale.

This process gives deep insight to a repertoire of widely different phenomena.

1. The formation of bound and negentropically entangled states implies subjecto-temporal fractality of consciousness meaning that the basic anatomy of quantum jump is replicated in various time scales, even that of human life cycle.

2. Both kinds of entanglements mean fusion of mental images. In entropic fusion sub-selves lose their consciousness whereas negentropic fusion accompanies the experience about expansion of consciousness. Depending on the character of entangling selves (real or p-adic for some p), one can assign to the negentropic entanglement some positively colored experience, say experience of understanding or experience of love. Telepathic sharing of mental images and remote mental interactions become possible. Sexual and spiritual experiences can be seen manifestations of the same basic process of fusion of selves and sex would be present even at the molecular level. For instance, information molecules and receptors entangling negentropically could be seen as having opposite molecular sexes with the binding of the information molecule to receptor giving rise to the experience of "oneness" and favoring co-operation instead of competition.

3. If the randomness of the outcome of the ordinary state function reduction means free choice, then self can choose to some degree whether sub-self ends up to a state in which it can decompose to sub-selves by state function reduction or becomes a entropic or negentropic sub-self stable against state function reduction. Maybe this choice could be seen as a choice between good and evil.

4. For negentropically bound states the powers of unitary process U define a sequence quantum computer type processes. More concretely, the combination of the notions of magnetic body and hierarchy of Planck constants leads to a model of DNA as topological quantum computer [K2]. Zero energy ontology and 4-dimensionality of the ensemble of computations assignable to sub-CDs mean deviations from the standard model for quantum computation.

5. The binding energy liberated in the formation of bound state entanglement is usable energy: this means quantum metabolism based on buy now-pay later mechanism. Negentropic entanglement in turn can carry positive energy and there is a large temptation to assume that metabolic energy is transferred in this way so that the somewhat nebulous notion of high energy phosphate bond would involve new physics.

The general vision about different types of conscious experiences and about qualia was discussed in [K54]. In this chapter a general model of personal sensory representations is considered: in [K39] a more detailed model for these representations is discussed. The so called magnetospheric sensory and memory representations possibly responsible for the third person aspect of consciousness are discussed in [K50].

6.1.2   The Quantum Hardware

The model involves the following basic notions and ideas about the quantal hardware of consciousness.

1. TGD universe is quantum spin glass and the plasticity of the brain is in accordance with a model of brain as point moving in an infinite-dimensional spin glass energy landscape. Inhibitory and excitatory nerve pulses induce motion in the energy landscape and justify the notion of frustration characterizing spin glass. The picture differs from ordinary neural net in that spin glass energy landscape has also time as one dimension in a well defined sense (this is due to the failure of the classical determinism in standard sense for the Kähler action defining the dynamics of the system). This allows a new view about what happens in learning.

2. The general model of sensory experience relies on the music metaphor. Axons are like strings of a music instrument. What this metaphor means is however not obvious. Frequency coding relates only the intensity of the sensory quale. Nerve pulses induce dropping of various ions to magnetic flux tubes in magnetic fields of $\simeq .2$ Gauss (Earth's magnetic field has nominal value .5 Gauss) and this generates EEG MEs at EEG frequencies serving as entanglers to the

sensory magnetic canvas, and the variation of these frequencies could code for the distance to the object of the perceptive field.

A stronger interpretation of the metaphor should be that sensory pathways are like strings of a musical instrument such that the sound produced by the string corresponds to a particular sensory modality and corresponding higher level cognitive representations associated with it. Primary sensory qualia can be associated with sensory receptors or primary sensory organ if brain and sensory organs are quantum entangled with each other. Nerve pulse patterns would build up what could be regarded as notes representing the music whereas the music (primary sensory qualia) is produced by the primary sensory organs. This leads to a generalization of the idea about brain as an associative, cognitive net.

3. The notion of self hierarchy is central for the model and allows to understand quantum correlates of the sensory qualia.

   (a) Self hierarchy is very much analogous to the hierarchy of subprograms of a computer program and defines a hierarchy of increasingly abstract experiences. Self hierarchy allows to understand computational aspects of brain although connectionistic picture realized as quantum association network seems to work at various levels of the hierarchy.

   (b) The empirical results [J53] about the effects of oscillating em fields on brain suggest that cyclotron frequencies, and more generally magnetic transition frequencies, of biologically important ions in magnetic field $B \simeq .2$ Gauss, which is by a factor $2/5$ weaker then the magnetic field of Earth, correspond to important oscillation frequencies of Josephson currents or some other perturbations acting on the system. Also the magnetic transition frequencies of electronic Cooper pairs seem to be important as perhaps also Z^0 magnetic transition frequencies of neutrino and various ions and atoms and even molecules. Classically cyclotron frequency for Josephson current corresponds to resonance.

   (c) The role of massless extremals (MEs) have become more and more central in TGD inspired theory of consciousness as I have gradually understood their properties. Very briefly, MEs are ideal for both classical and quantum communications, they give rise to quantum holograms both in quantum gravitational and "technological" sense. MEs make also possible the realization of long term memories as communications between future and past. The notion of conscious hologram makes these ideas very concrete.

   (d) The strange findings challenging the notions of ionic channels and pumps lead to the view about biosystem as a symbiosis of MEs, superconducting magnetic flux tube structures, and atomic space-time sheets. The latter two are in many-sheeted ionic flow equilibrium controlled by MEs and very elegant control mechanisms based on the classical em interaction between MEs and flux tubes inducing supra currents emerges.

   (e) Self hierarchy has as its geometric correlate the hierarchy of CDs the level of embedding space and the hierarchy of space-time sheets at space-time level. The fact that Josephson currents associated with ELF frequencies generate photons with wavelengths of size of Earth which by uncertainty principle correspond to topological field quanta with size of Earth. The only possible conclusion seems to be that our sub-selves correspond to (at least) these topological field quanta so that we are much more than our neurons.

   (f) It took years to arrive to the conclusion that also magnetic flux tube structures associated with various parts of brain could have same size as EEG MEs and serve as sensory canvas in the sense that the positions of objects of perceptive field are represented as sub-selves at the magnetic flux tubes of varying thickness woken-up by MEs generating magnetic transition frequencies. Obviously MEs and magnetic flux tubes associated with the sensory projectors must be very closely related (perhaps they are parallel to achieve Alfven wave resonance). Various attributes associated with the object of the perceptive field are associated with these magnetic sub-selves and brain, or rather entire central nervous system, can be seen as a collection of pre-existing features of perceptive

field which can be activated. Also long term memory recall can be understood in this framework as a communication between geometric now and geometric past made possible by MEs (which correspond to light-like selves) and magnetic flux tube structures associated with brain, both having astrophysical sizes.

6.1.3 Me As A Computer Sitting At Its Own Terminal?

It became as a surprise that the vision resulting from a long lasting thought experimentation is actually very much what the original, now twenty five year old, altered state of consciousness experience about myself as a computer sitting at its own terminal, when taken very literally in some aspects, actually suggests. This vision adds to the standard view about brain an additional layer responsible for the sensory representations and brings in the quantum level of control (possibly from magnetic body) so that nerve pulse patterns are only part of the control loop.

1. Magnetic flux tube structures serve as a sensory canvas analogous to the computer screen. The control commands realized by activating MEs, in which state they create coherent states of photons and possibly also other gauge bosons, generate magnetic quantum phase transitions, and induce supra currents, Josephson currents and Ohmic currents, provide a realization for the keyboard of this computer. Brain serves as central processing unit: the computations carried out are parallel computations and program modules are replaced by various self-organization patterns.

2. Motor actions and sensory representations differ in that they are time reversals of each other in a relevant p-adic time scale.

3. What imagined motor actions and sensory experience mean is not quite clear.

   (a) The first view is that for imagined motor actions and sensory experiences the first (rather than last as one might think!) step in the sequence of commands is simply not realized. For sensory experiences the first step means sensory input assuming that primary sensory qualia are at the level of sensory receptors. A real motor action proceeds like a geometric time reversal of the sensory input and starts from motor organs if it is real, and from some higher level if it is imagined. p-Adic-to-real phase transition is the basic step initiating neural activity leading to imagery.

   (b) A more quantal view about imagination is based on the notion zero energy states with time-like negentropic entanglement. In this case qubits and more general states are always fuzzy so that Schrödinger cat is never completely alive or completely dead. Suppose one takes a zero energy for which nothing happens and adds to it a little bit of state for which the imagined event happens. The higher the probability of the imagined event is, the nearer the imagined event is to a real event.

4. Cortex can be seen as a collection of pre-existing cognitive features which are activated when they appear in the perceptive field or form a part of motor action. The basic task of cortex is to identify these features from the sensory input, entangle them with sensory input, and project to the magnetic body.

5. The decomposition of the perceptive field into objects is one of the basic aspects of sensory experiencing and TGD provides a mechanism generating these objects as mind-like space-time sheets: the boundaries of these objects correspond to regions of strong Kähler electric field whose strength is assumed to correlate with the intensity of the neural input. It might be that even the objects of perceptive field or thoughts could be regarded as features. At the neuronal level one ends up to a model in which neurotransmitters at the ends of magnetic flux tubes attach to receptors at the ends of magnetic flux tubes connecting cell membrane and DNA and give in this way rise to a fusion of the pre- and post-synaptic mental images. In contrast to standard neuroscience view, gene level would be involved in an essential way in the information processing. U process could be described as a generalized Feynman diagram in which synaptic transmissions replace particle exchanges and for negentropically entangled states learning would correspond to a sequence of powers of U.

6. The computational activities associated with the construction of the sensory representations (say estimating distances and directions of the objects of perceptive field) and virtual sensory representations representing the goals of motor action are presumably realized as iterated processes in which virtual sensory inputs characterizing the expected experiences are compared with the real world sensory input. In a similar way the goal of the motor action is compared with the sensory representation resulting from effect of a virtual motor action on the representation of the recent state of world and body. This comparison does not necessarily require sensory representation at any level of the self hierarchy and could be based on comparison circuits defined by parallel supra currents in which the inputs which are sufficiently near to each other generate constructive interference giving rise to a large Josephson current. The fractal hierarchy of CDs coming as octaves of CD size and the hierarchy of Planck constants in principles makes possible zooming up and down possible so that simulations can be carried out in time scales smaller than that characterizing self.

7. The neural realization of long term memories has remained to a high extent a mystery and TGD suggests that the fundamental realization is not in fact neural. TGD allows the geometric memory storage in the geometric past, where the things happened and still happen. MEs suggest several candidates for the memory recall mechanisms and the quantum communication between geometric future and past is one of the most promising ones. Active memory recall might involve a question sent to the geometric past as a classical signal, perhaps MEs are involved at this stage. In the case of episodal memory the answer would involve the generation of time-like negentropic quantum entanglement: the recalled experience is shared by the experiencer now and in the geometric past. For declarative memories outside the intersection of real and p-adic worlds the communication of the memory would be classical.

8. The model of intentionality is mirror image of the model of long term memories obtained by real→ p-adic and geometric past→ geometric future replacements.

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` [L17].

6.2   General Ideas About Hardware Of Consciousness

In this section general ideas and metaphors about what quantum brain and quantum brain functioning might be, are summarized. These ideas have developed gradually during last decade and continue to do so. The recent view about brain conforms with the great sixteen years old vision about self as a computer sitting at its own terminal.

This vision, if taken completely seriously, means that the ultimate sensory representation conscious-to-us is outside the brain: that this is the case became clear quite recently (the geometric now when I am writing this is October, 2001). The title of this section is "General ideas about hardware of consciousness". rather than "General ideas about brain". The reason is that brain and body in TGD Universe form only a tiny part of a system involving hierarchy of MEs and magnetic flux tube structures having astrophysical sizes controlling the matter at the atomic space-time sheets defining brain and body in the usual sense of the world.

I defend this radical deviation from the standard wisdom by the fact that the world "consciousness" has ceased to be a taboo only during the last decade. It would be really astonishing if the materialistic view about consciousness as an illusion and brain as a computer would generalize to a general theory of consciousness just by adding one candle to the birthday cake of one century of brain science. Just like the creation of physics at the times of Kepler meant revolution in Earth centered world picture, also the creation of the general theory of consciousness is bound to mean thoroughgoing changes in the basic prejudices about human consciousness.

6.2.1   Brain As A Computer

Brain as a computer metaphor in sense of Turing machine has been one of the dominating metaphors about brain functioning. In TGD this metaphor makes sense as far as general func-

tional architecture of modern computer is considered. Programs must be however replaced by self-organization patterns.

Brain as a computer sitting at its own terminal

My personal great experience involved the realization that I am in some sense a computer sitting at its own terminal. It took more than one and half decades to realize what this self-referential idea having deep mystic coloring in it might mean in practice. Actually I realized the connection only after having ended up to this kind of view about brain by quite different routes.

To be precise, "computer" does not mean in the recent context the abstract Turing machine, but a real world personal computer. The concrete functional and geometric architecture seems to be mimicked by personal computers, not the detailed data processing. the deterministic computer programs are replaced by much more flexible self-organization patterns.

1. Brain corresponds to the central processing unit of this computer. The data in computer memory are typically represented at computer monitor which is outside the central unit, can have much larger size and be located arbitrary far away. In the case of brain this means that the ultimate, conscious-to-me sensory representations are realized outside brain at superconducting magnetic flux tube structures associated with various parts of brain. This view is inspired by very simple observation: when my eyes or my head move, I do not experience that the sensory image of external world moves although its physical representation in brain moves. As if I were an external observed looking the projection of sensory data on canvas inside brain so that the motion of canvas does not matter.

   The standard argument is that the fact that brain constructs sensory representations about the motion of eyes, head, and body, is enough to generate the experience that the world is not moving. At least in TGD framework it is extremely difficult to understand how the sensory image of the external world in motion would not give rise to the experience that the world is in motion. I see the failure to realize this point as one of the fatal consequences of computationalism decoupled from physics: the ability to calculate what really happens does not simply give rise to the experience what really happens in the world of physics.

2. In computer the representation of the data on monitor, printing of data, and even various control actions such as the control of a robot reduces to sending of files to various kinds of receivers: the data is just expressed in various ways. In case of brain this means that that the processes leading to sensory experience or motor action differ only in their last steps. If the last step is not present, imagined motor action or sensory experience is in question.

This picture leads to a very general view about sensory representations and motor actions. In this picture also "features" reduce to MEs and this might be too strong an assumption.

1. Brain can be regarded as a collection of standard feature records represented by MEs. These features represent basic features of objects of perceptive field and primitive elements of motor actions. The set of feature MEs is pre-existing and realization of the sensory image or motor action only activates a subset of these MEs. In principle the locations of feature MEs could be more or less random which means extreme flexibility and ability to adapt to new situations.

2. The basic frequency associated with a particular sensory ME codes for the distance of the object of the perceptive field and the direction of ME codes for its direction. Sensory MEs are naturally organized in radial bundles, files, representing various directions for the objects of perceptive field at given distance. Feature MEs with nearly the same frequency generate magnetic quantum phase transitions waking up magnetic self in the desired distance on the magnetic sensory canvas and thus assign to the object of the perceptive field various kinds of attributes. This means nothing but frequency binding and leads to what might be called spectroscopy of consciousness: EEG acts like a spectrogram allowing to deduce information about the functional state of brain.

3. Support for the view that sensory input and motor activities are very similar comes from motor synesthesia in which person can represent the sensory input by dancing it! More concretely, the realization of intention as motor action reduces to generation of MEs propagating

along axons and generating desired membrane oscillation and nerve pulse patterns. There might be however a crucial difference also: motor action could be a geometric time reversal for the construction of a sensory representation and start from a rough sketch in the geometric now and develop quantum jump by quantum jump to a detailed plan in the geometric past. Time reversed dissipation would polish a sketch to a precise plan. Motor action would start from the motor organs and proceed to the level of brain.

4. Brain can be said to contain a collection of passive sensory and motor features which it activates selectively. This brings in mind computer game containing large number of extremely simple files, for instance sound files producing *Aaaargh* 's and *Auuuch* 's. The activation of ME record could mean ME is color rotated by coherent state of WCW photons to electromagnetic ME which in turn generates coherent state of photons and WCW photons acting as a control command; activates magnetic quantum phase transitions; induces supra currents; or something else. Similar mechanism works even at the level of DNA where genes can be coded to various kinds of control commands by activating the associated MEs.

What this view implies that there is no need to worry about how brain realizes ultimate sensory representations inside brain as neural activities. What remains to be understood how brain develops into a collection of the standard features; how brain recognizes the standard features from the incoming sensory input; how brain evaluates the distances and orientations and other data related to the objects of the perceptive field; how brain decomposes the perceptive field into objects; and many other things not listed here.

1. Feature recognition might be based on comparison circuits based on supra current circuits. Expected features would be represented as standard patterns of supra currents. When the pattern of supra currents associated with the sensory input and running parallel to those of expected sensory input is sufficiently near to the expected one, a resonant generation of Josephson currents occurs and gives rise to a recognition of the feature.

2. The positions and other geometric data about the objects of perceptive field are presumably estimated by an iterative process in which the sensory input from the virtual world construct of the perceptive field is compared with the real sensory input which could be sustained in the sensory circuits. Cortico-thalamic communications might relate to this iteration. The comparison takes place by comparison circuits and when the two inputs resemble each other sufficiently, a sensory output at the magnetic canvas is generated. The consistency of these two representations should be gained gradually through learning and by the requirement of consistency between different sensory inputs. Similar comparisons are involved with the development of motor action to yield the final action giving rise to the desired goal.

Brain as a motor and sensory organ of higher level selves

Certainly the most dramatic deviation from the standard neuroscience implied by this view is the prediction of an entire hierarchy of MEs and magnetic selves using brain as a generalized sensory and motor organ. We correspond to only one level in this hierarchy making decisions and controlling the behavior of our body in certain time scale. For instance, long term goals and socially acceptable behavior could be seen as forced by selves at the higher levels of the hierarchy. Drives could perhaps seen as activities forced by lower level selves in the hierarchy (amygdala and other parts of paleobrain contra neocortex). What makes this so dramatic is that the sizes of our magnetic bodies could be astrophysical (here one must of course be very cautious: the realization of long term memories however encourages strongly this view). For instance, EEG ME and corresponding magnetic flux tube structures would both have sizes measured using Earth size as a unit.

A possible mechanism for the motor control from our own sensory canvas as well as from the sensory canvases of higher level selves is provided by MEs. The classical gauge fields entering to brain and body would represent very high level commands, and might be transformed to endogenous sounds by piezoelectric effect identifiable as internal speech (internal speech could also correspond to p-adic MEs). This is only one possibility. The construction of the model of nerve pulse and EEG leads to quite general model for the interaction of MEs as bridges between two

space-time sheets characterized by different p-adic primes, and inducing a flow of charge between the two space-time sheets, inducing in turn a flow of em charge, and in case of cell membrane a change of membrane potential leading to the triggering of the nerve pulse. The reduction of the effective phase velocity of ME to the conduction velocity of nerve pulse or of some other excitation involves the shift of entire ME to future occurring in each quantum jump. If the shift occurs in the direction of geometric past, a super-luminal effective phase velocity results. Both cases might be involved, and would correspond naturally to propagating and standing EEG waves and to the space-like and time-like soliton sequences predicted by the model for Josephson junctions.

Boolean mind and memetic code

The original proposal for the realization of Boolean mind was in terms of sequences cognitive neutrino pairs. These can be interpreted as wormhole contacts carrying neutrino and antineutrino at the light-like wormhole throats and would thus represent boson like entities. In the framework of the standard model the proposal looks of course completely non-sensical. TGD however predicts the existence of long range classical electro-weak fields, and one might imagine that inside neutrino-whose Compton length corresponds to length scale of cell- intermediate gauge bosons behave like massless fields. Although neutrinos could be important, the time scale of corresponding CD - about 10^4 years - suggests that cognitive neutrinos might be important in much longer time scale than the.1 second time scale assignable to the memetic code.

The recent view about TGD allows a much more general view. Zero energy ontology allows to interpret the fermionic parts of zero energy states as quantum superpositions of Boolean statements of form $a \rightarrow b$ with a and b represented in terms of positive and negative energy parts of the zero energy state. If one has negentropic entanglement this kind of state has interpretation as an abstraction - a "law of physics" - representing as a quantum superposition various instances of a more general law.

The simplest situation corresponds to a CD having only single positive energy fermion and negative energy fermion at its light-like boundaries. The fermion number or spin or isospin of the fermion could represent qubit. The hypothesis that memetic code corresponds to the next level of Combinatorial Hierarchy, when combined with p-adic length scale hypothesis, led to a prediction of order .1 seconds for the duration of the "wake-up" period of sub-self corresponding to the codeword of the memetic code. Since the CD assignable to electron has time scale.1 seconds and the CD assignable to u and d quarks has time scale $1/1.28$ milliseconds there is a temptation to proposed that the quark-like sub-CDs of electronic CD give to a realization of memetic code word as a sequence of 126 quark like sub-CDs. u and d quarks would be assigned to the magnetic flux tubes connecting DNA and the lipids of the cell membrane in the model of DNA as topological quantum computer. Clearly, beautiful connection between new elementary particle physics, genetic code, nerve pulse activity, DNA as topological quantum computer, logical thought, and the basic time scales of speech are suggestive.

This codeword consists of 126 bits represented by quarks such that the two possible magnetization directions correspond to the two values of Boolean statement. This implies that the duration of single bit should $1/1260$ seconds. The duration of the nerve pulse is slightly longer than this which might mean that the full memetic code is realized as membrane oscillations rather than nerve pulse patterns. Both hearing and vision have .1 second time scale as a fundamental time scale and sounds are indeed coded to membrane oscillations in ear.

One can consider also the realization of genetic code with six bits of the codon represented by various scaled up versions of quark CD coming as size powers of 2. In this case the ordering of the bits would come from the size of sub-CD whereas in previous example temporal ordering would define the ordering. It is not however clear whether the powers of two can be realized physically.

One can understand the number 126 as related to the total number of separately experienced frequencies in the interval $20 - 20.000$ Hz spanning 10 octaves. $10 \times 12 = 120$ is not far from 126: here 12 corresponds to 12 tones of basic music scale. Also speech has 10 Hz frequency as fundamental frequency. In visual primary cortex replicating triplets, 4-, 5- and 6-plets of spikes with highly regular intervals between spikes have been detected. The triplets are accompanied by ghost doublets. This would suggest a coding of some features of visual experience to reverberating mental images. The time scale for various patterns is.1 seconds. This could be seen as a support for the realization of some degenerate version of the memetic code as nerve pulse patterns.

The model for the memetic code encourages the following conclusions.

1. Membrane oscillation/nerve pulse patterns correspond to temporal sequences of magnetization directions for quarks representing yes/no Boolean statements.

2. The spin polarization of quarks is changed from the standard direction fixed by the spontaneous magnetization in the direction of axon by a ME moving parallel to axon, and inducing membrane oscillation or even a nerve pulse. Nerve pulses could correspond to a degenerate memetic code resulting by frequency coding for which the number of distinguishable code words is 64, and would thus naturally correspond to the reduction of the memetic code to the genetic code.

A very precise correspondence with the basic structures of the genetic code results. mRNA $\rightarrow$ protein translation corresponds to the translation of temporal sequences o magnetization directions to conscious cognitive experiences. Under very natural constraints the mapping to cognitive experiences is not one-to-one and the predicted degeneracy (2^{126} sequences correspond to $(2^{126} - 1)/63$ cognitive experiences) can be understood.

One might think that the full memetic code is an evolutionary newcomer and involved only with the logical thought: this would explain the completely exceptional characteristics of human brain. The full memetic code could be realized for certain regions of brain only. These regions certainly include auditory pathways responsible for the comprehension of speech [K41, K80, K81, K84].

6.2.2   Brain, MEs, And Quantum Holograms

MEs represent a communication link in the control hierarchy formed by the magnetic body having onion like structure consisting of superconducting magnetic flux tube structures and flux sheets carrying dark matter, and space-time sheets carrying visible matter, and would be thus involved with the fundamental control operations. EEG MEs and they fractal variants could mediate classical signals and act as time-like entanglers assigning mental images to the points of the magnetic body with distance to the magnetic body being coded by the length of ME and the direction of the point by the direction of ME. Of course, also the deformations of magnetic flux tubes could mediate classical signals as counterparts of Alfven waves, and magnetic flux tubes are natural space-like entanglers - the model of DNA as topological quantum computer as an example about this function.

A possible vision about how MEs act as communication links between magnetic body and biological body

One can imagine large number of options for how the MEs are concretely involved with biology and I have done so. The recent view about TGD inspired biology allows to consider a highly unique model for how MEs could perform their role as a communication link.

1. The most plausible one is that MEs associate with the communications between biological body and magnetic body are generated by genome acting as a kind of relay station. For this option MEs attached to the flux tube going through the passive DNA strand would mediate sensory data from the cellular environment to the magnetic body. The sensory data from environment would arrive through magnetic flux tubes connecting biomolecules and lipids of cell membrane to the passive DNA strand analogous to sensory areas of cortex.

2. Magnetic body could induce nerve pulse activity as one particular form of gene expression by ME attached to the flux sheet going through the active DNA strand. Rapid signalling along flux tubes connecting DNA nucleotides and lipids would make this gene expression much faster than the ordinary one. Also nerve pulse activity would be communicated to the magnetic body from the lipid layers of neuron membrane via genome and magnetic body could generate it It is of course possible that also reflex like nerve pulse activity which does not involve magnetic body is present. From the time scale of the nerve pulse the size scale of the layer of the magnetic body involved with nerve pulse activity must correspond to quark CDs and would be about 10^{-5} meters. This fits nicely with the vision about DNA as topological quantum computer.

3. EEG MEs could be automatically generated as an outcome of nerve pulse activity, when ions drop to the flux quanta of magnetic field $B \simeq .2$ Gauss (Earth's magnetic field has nominal value .5 Gauss), and entangle mental images with the points of the sensory magnetic canvas.

This vision is of course not the only one that one can imagine. As discussed in [K81], genetic/memetic code could also have translation to control commands represented by pairs of MEs orthogonal to DNA strand/axon. In latter case orthogonal pairs of MEs must move along axon with the same velocity as nerve pulse pattern. Stationary EEG MEs translate the nerve pulse patterns to the patterns of light-like vacuum currents. TGD based model of EEG and nerve pulse [K81] predicts two kinds of EEG waves: moving and stationary, and it might be that they correspond to these two kinds of codings. The properties of moving/stationary EEG waves suggest their association to left/right brain hemisphere. Left brain might favour the coding of memetic codons to moving EEG ME pairs whereas right brain might favour the coding of nerve pulse patterns to stationary EEG MEs.

The notion of neural window

The notion of neural window, which was the original form of the hologram idea, allows to see information processing in brain from a slightly different point of view.

1. Massless extremals act as quantum antennae and generate coherent light and also provide waveguides along which BE condensed photons can propagate like Cooper pairs in super conductor. The photons radiated by the space-time sheets representing objects of the perceptive field and propagating along microtubules could provide neurons with a neuronal window. This picture would abstract just the bare essentials of the idea of holographic brain: small piece of hologram is like a small window yielding the same picture as larger window but in blurred form.

2. Massless extremals associated with neural activity could also represent or be accompanied by association sequences making possible geometric memories representing simulations of future and past. What is mysterious from the point of view of the standard neuroscience is that left part of the body sends sensory stimuli to the right brain hemisphere and vice versa. In TGD framework the mystery disappears: the maximization of the axonal lengths maximizes the durations of the association sequences and hence optimizes geometric memory.

3. Neuronal window idea would perhaps make it possible to realize the idea about iterative computation of conscious experiences involving guesses and comparisons. Neuronal windows would generate representations of various perceptive landscapes in disjoint parts of thalamus (sensory organs feed their input in separate parts of thalamus) and mental imagery would construct guesses for the cognitive representations for the objects of the external world realized in the cortex as mind-like space-time sheets radiating coherent light. The neural pathways from cortex to thalamus would provide thalamus with a neural window to cortex and comparison of the landscapes from cortex and sensory organ would be possible. Simple comparison circuits might be at work: neuron would fire when its neural windows to the cortex and sensory organ give sufficiently similar views.

4. One can sharpen the neuronal window idea by combining it with the music metaphor. This would mean that the massless extremal associated with a given axon would correspond to a Bose-Einstein condensate of photons (or WCW photons) with one particular frequency. This would mean vision at neuronal level (nothing to do with our vision realized in EEG frequency scale). Thus one can say that each neuronal window is either covered by curtains or provides a view to single sensory landscape at single frequency.

The experiments of Mark Germine

MEs could also serve as a communication link between living matter and magnetic bodies representing levels of collective consciousness responsible for the cultural aspects of our consciousness.

The experiments of Mark Germine [J104] provide evidence for the notion of ELF self and associated collective memory. What was studied was the evoked EEG response to a series of

random quantum stimuli, which consisted of series of identical stimuli with randomly located deviant stimulus. Two subject persons, A and B, were involved, the first one experienced stimuli as pictures in computer monitor, the second one as sounds. In case that A observed the differing stimulus 1 second before B, the evoked EEG response of B became incoherent. Since evoked stimulus was oscillation at EEG frequency of about 11 Hz in case that A had not observed the stimulus, one could understand the mechanism as a direct evidence for collective "ELF ME" at this frequency interacting with brains of both A and B. When ELF ME had already heard the stimulus once, it did not react to it in similar manner. Rather interestingly, 11 Hz corresponds to the 10.7 Hz cyclotron frequency associated with Fe_{++} ion in a magnetic field of .2 Gauss (Earth's magnetic field has nominal value of .5 Gauss). Ca^{++} cyclotron frequency in this field is equal to 15 Hz and would explain the effects of ELF fields on vertebrate brain occurring at harmonics of this frequency.

MEs and long term memory

MEs provide a mechanism of long term memory which differs from ordinary sensory perception only in that the ME giving rise to a geometric memory has much longer duration with respect to the geometric time than the ME giving rise to ordinary sensory perception. To remember classically is to look at a mirror located at a distance of light years. The ends and branching points of magnetic flux tubes are good candidates for the mirrors where MEs are reflected.

In TGD framework synaptic strengths code only cognitive representations and learned associations, not genuine information about events of the geometric past. Long term memory is coded in the classical em field and in coherent light generated by ME in hologram like manner. Any finite space-time region receiving the classical field of coherent light generated by it gets hologram like picture containing info about entire geometric time interval spanned by ME. If vacuum current is localized to some restricted space-time region (it can be!), the holographic information is about this region and receiver anywhere along the ME gets more or less the same information since hologram is in question. ELF selves can perhaps control this localization. Note also that the light-likeness of the boundary of ME implies that ME selves have temporal extension defined by the length of ME.

The fact that memory is stored to the moment of geometric time at which event occurred explains why we know that mental image is memory. It is quite possible that MEs are involved with sensory perception, say vision and auditory experience, and make possible to develop time-like entanglement (possibly negentropic) with the sources of light as belonging to the external world. Geometric memory allows also understand identification experiences and transpersonal experiences in which person can experience events of the distant past not related to the personal history. Anticipation of future in turn could be also understood as particular kind of geometric memory, the MEs involved are now p-adic representation intentions, plans, and expectations. Later a more detailed model of long term memories will be developed.

6.2.3 Generalized Notions Of Sensory Experiencing And Motor Activity

The general view about brain is as a system moving of a fractal energy landscape of quantum spin glass containing valleys inside valleys inside... Brain is not only an on observer of the external world but also of its own position in the spin glass landscape. Brain is not only activator of ordinary motor programs but generates also movements in the spin glass energy landscape. Thus the general functional division sensory experience-motor action generalizes and provides completely new insights to the brain circuitry and functioning. For instance, one could perhaps understand why neural loops are bi-directional. The first loop provides sensory information about the position of brain region in its spin glass landscape and the second loop mediates the motor action: just like in case of the spinal chord.

The sensory experiences giving information about spin glass landscape can be interpreted as giving rise to a generalized sensory and emotional input. Emotions correspond to entropy gradients of various types for selves. A mental image with a positive/negative emotional color results from negentropy/entropy feed to sub-self. If the sign of entropy feed to mental images correlates with the entropy gradient of the system represented by sub-self, emotions become sensory qualia. Emotions provide perhaps the most important "Is it going well" type information about the state of brain

and body. Entropy gradients can be also used as an active control tool: sub-selves are rewarded by negentropy feed and punished by a entropy feed. Note that the generalized motor action inducing motion in the spin glass landscape is identifiable as emotional expression and generates entropy gradients and thus emotions.

6.2.4 The Paradigm Of Four-Dimensional Brain

Four-dimensionality of brain is crucial for the understanding long term memories as multitime experiences receiving contributions from several moments of geometric time. This identification makes it unnecessary to have any memory storage mechanisms. Rather, the activities of the memory circuits can be seen as increasing the probability that memory recall occurs. Reverberating memory circuits in which experience is echoed indeed do this by extending the deep memory valley in spin glass landscape to a long canyon in time direction. This increases the probability that mind-like space-time sheets enter in the region of four-dimensional spin glass landscape representing the memory. The deepness of the spin glass valley correlates with the emotionality of the memory. Childhood memories are especially emotional and therefore stable. Memories are result of creative action and memory circuit involving hippocampus seem to be active in carving out the art works representing geometric memories worth of remembering. TGD based approach solves the basic problems of the neural net approach resulting from the fact that the formation of new memories destroys old memories and from the fact that it is difficult to understand how the component of experience is known to be a memory.

Four-dimensional brain provides a completely new view about how gemeralized sensory experiences are generated, how generalized motor actions are planned and how memories are constructed. This process is like creating an artwork. *Four* -dimensional spin glass landscape representing a rough scetch is gradually refined by adding details and corrections in increasingly shorter time scales: this corresponds to neural activities of four-dimensional brain generating motion leading to the desired part of spin glass energy landscape. This picture is consistent with the observed $1/f$ noise and fractality of nerve pulse patterns. Absolutely essential is self-organization and related dissipation forcing the Darwinian selection leading to end product which is charicature rather than photo.

6.2.5 Music Metaphor And The Function Of The Nerve Pulses And EEG

Music metaphor allowing to see brain as a music instrument. gradually changed from a guiding principle to a prediction of TGD inspired theory. In case of brain the music played is EEG and ZEG spectra. EEG frequencies serve as resonant frequencies at which various quantum phase transitions occur resonantly. Various sensory qualia correlate with EEG frequencies and place coding and possibly also temporal coding by cyclotron frequency scale is possible. Stochastic resonance and pendulum metaphor, which are discussed in [K81], allow to understand the mechanisms for the transformation of EEG waves to nerve pulse patterns and vice versa.

The picture about brain as self-organizing system suggests that neurons are subject to strong selective pressures and specialize to produce highly specialized fixed components of our experience so that music metaphor holds true. If music metaphor holds true generally, the nerve pulses involving fast transmitters can be said to pick the strings of the sensory instrument represented by axons and spatio-temporal patterns of nerve pulses determine the overall pattern of the sensory experience. Nerve pulses inducing motor action in sensory landscape represent pushes and pulls in spin glass energy landscape. These pushes and pulls induce motion in the spin glass landscape and generate both neuronal and our emotions. It seems that simplest emotions with no association telling the cause or object of emotion, are determined by the nerve pulse pattern only.

This picture suggests for neurotransmitters two obvious basic functions: they mediate nerve pulses from presynaptic neuron to postsynaptic neuron and modify the properties of synapse and postsynaptic neuron. Fast neurotransmitters controlling directly ion channels are involved with mediation and the relevant time scale is one millisecond: no long term change of the postsynaptic neuron is involved. Sensory experiences and motor actions are mediated by direct neurotransmitters. Slow neurotransmitters involving second messanger action are involved with modulation of

the response of the postsynaptic neuron and the time scales can be of order minutes. In this case the properties of the postsynaptic neuron are changed.

Emotional reactions involve typically slow transmitters and the effect of them can be regarded as a generalized motor action inducing motion of neuron in the spin glass energy landscape of the neuron. The large information flows associated with neurotransmitters imply entropic gradients and thus also emotions. Some neurotransmitters such as serotonin and dopamine, which generate sensations of pleasure, should reduce entropy and thus fight against the second law of thermodynamics. This presumably occurs at the neuronal level and could be only represented at the level of the sensory selves, where some other mechanisms of the entropy reduction and generation could be at work. An interesting question relates to the warriors in the war against second law. Could glial cells play key role here as is suggested by the observations that depression (in which mental images becomes very entropic and emotional flatness and emptiness results) involves abnormally small amount of glial cells in forebrain and abnormally strong emotional reactions of amygdala.

One can see associations at neuronal level as formed by the pairs of input and output. Input corresponds to the sensory experiences associated with active presynaptic neurons and output to the activity in the axons. The postsynaptic receptors serve as sensory receptors and each neuron could be specialized to its own sensory modalities which are same for the entire sensory pathway. Alternatively, primary qualia are associated with the sensory receptors or sensory organs: this option provides very elegant understanding of what imagination and dreams are. Boolean axons give rise to "Boolean modality" representing thoughts. Typically sensory-Boolean associations are associated with the associative regions of brain and are realized as a fusion of mental images. The formation of an association corresponds to the fusion of space-time sheets representing pre- and post-synaptic neurons to single space-time sheet. The space-time sheets formed by the orbits of synaptic vesicles form the 4-dimensional flux tube. Fusion to single space-time sheet makes possible conscious association containing both inputs and output as a single experience. This picture also explains the time directedness of association. "Our" associations are superpositions of neuronal associations associated with various neuronal circuits.

6.2.6 Connection With The Functionalistic View About Brain

The basic counter argument against quantum theories of consciousness is that the so called classical theories of brain can quite well explain all the relevant aspects of brain functioning whereas quantum theories of consciousness seem to add very little if anything to this understanding. It seems that huge misunderstandings are involved on both camps.

The notion of self is fundamental for consciousness. For some reason the proponents of quantum consciousness (including me hitherto) have however failed to realize that they should perhaps try to formulate this notion as a quantum-physical concept. Indeed, "What is the quantum counterpart of self" was the bottleneck question in TGD approach and led to the final breakthrough.

Neuroscientists (and also many quantum physicists) in turn seem to have wrong view about what the term "classical" means. This wrong view reflects the wrong view about time and dissipation, which in TGD framework can be understood elegantly in terms of the subjective time development identified as a sequence of quantum jumps between quantum histories. It is of crucial importance that this development can occur only inside selves! Dissipation is the basic correlate of consciousness and consciousness is the basic prerequisite of "classicality" understood in the erratic manner. Thus, from the TGD point of view, Hodkin-Huxley equations have nothing to do with genuinely classical world. Rather, they model phenomenologically the development of neurons by quantum jumps between quantum histories. Quantum jumps (and dissipation) inside neurons is possible only because neurons act as sub-selves and dissipate. Our self can be regarded as a system making something like 10^{38} quantum jumps per second. This implies macrotemporality but this macrotemporality has absolutely nothing to do with classicality in the sense as it appears in the field equations of say General Relativity.

The notion of self as quantum self-organizing system justifies the use of cybernetic notions such as circuits, loops, feedback, feedforward, inhibition and excitation. The general neuroscientist's view about brain as a complex neuronal circuitry finds justification and one ends up with rather concrete identifications for what kind of conscious (not necessary conscious to us –) experiences are associated with various brain circuits. The essentially new elements are 4-dimensionality

of brain and realization of qualia and Boolean mind in terms of macroscopic quantum phases and these additional elements lead to genuine understanding of what happens in brain.

The randomness of the quantum jump is certainly a strong argument against quantum theories of consciousness and for me it took quite a long time to realize how serious this objection actually is. One can quite well claim that it leaves only one option: standard non-equilibrium thermodynamics in which dissipation in the presence of external energy feed selects the self-organization patterns. The possibility of negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) in the intersection of real and p-adic worlds is what changes the situation and removes the randomness of quantum jump so that unitary process U and its powers define an iterative self-organization process leading to generation of fractal structures and quantum computation like processes possible. This makes also possible conscious goal directed actions and the existence of genuine information rather than only lack of dis-information is what makes possible also learning at the fundamental level.

6.2.7 Brain As An Associative Net

Brain can be regarded as an associative net. At neural level association is a pair of incoming axons and outgoing axon: during synaptic transfer the space-time sheets of pre- and postsynaptic neuron fuse to form a larger space-time sheets and the corresponding conscious experience is association formed by the experiences determined by pre- and postsynaptic neurons. Neurons have their own sensory qualia associated with transmitter-receptor combinations: also neuronal seeing and hearing is possible. These qualia are probably not ours. From the point of view of our consciousness, nerve pulse patterns are most important and give rise to symbolic representations of sensory input. Frequency coding is involved and memetic code is reduced to genetic code. Membrane oscillations correspond to full memetic code and higher level cognition. Emission of at least slow neural transmitter gives rise to neuronal emotion. During synaptic firing the association pair becomes conscious. The most elegant option is that sensory qualia are at the level of primary sensory organs.

Also motor actions, in particular the transformation of Boolean statements to speech, can be regarded as associations of this kind. Motor action would be time reversal of sensory perception in appropriate time scales, and the motor actions initiated from some level higher than muscle cells correspond to motor imagination. Speech represents translation of memes to motor actions analogous to the translation of genes to proteins. For instance, logical reasoning develops as associations respecting basic rules of logic. This could explain why we are so poor in performing conscious logical deduction. On the other hand, rules of logic could be unconsciously inherited at the level of experience pairs from the physical world which obeys logic.

The most general possibility is that he output of a complex neuron is some function of the inputs. Music metaphor however suggests much simpler possibility: output is the same always and represented by nerve pulse pattern inducing postsynaptic qualia which depend on the receptor-transmitter combinations involved. This assumption has very strong consequences. Especially interesting are the sequences of associations associated with closed neural loops. The assumption that projections are topographically organized and that given axon is always in the same state mean that all closed circuits are reverberatory. Thus elementary single neuron association sequences associated with various brain circuits would be fixed and nerve pulse patterns should be determined the content of various conscious experiences constructed from these elementary experiences: the analogy with music would be very close. This would have quite strong consequences as far as the general structure of the brain circuits are considered.

1. Memories could quite correspond to asymptotic nerve pulse patterns reverberating in memory circuits. Nerve pulse patterns in closed would determine the content of memory and memories would result as fixed point patterns of self-organization. Very probably also microtubular representations of long term memories are important.

2. Motor plans would be represented by nerve pulse patterns reverberating in motor circuits and selected by self organization and realized as genuine motor actions only in case that the geometrically time reversed process starts from the muscle cells.

3. In case of Boolean thoughts reverberating circuits correspond to tautologies so that one can question the hypothesis that axons are permanently in the same state. Of course, there is no need to assume that thoughts correspond to closed circuits.

Negentropic space-like quantum entanglement between neurons, neuronal membranes and DNA strands, and DNA strands and magnetic body adds to this picture a further element necessary if one wants to speak about conscious brain able to learn. Synaptic transmission becomes the molecular counterpart of enlightenment experience in which neuronal sub-selves experience an expansion of consciousness. Learning as gradual evolution of synaptic strengths can be understood as the space-time correlate for the evolution defined by the unitary process U and its powers in the space of zero energy states representing M-matrices allowing an interpretation as abstractions describing the "laws of physics" as experienced by brain.

6.3 Quantum Tools For Biocontrol And -Coordination

Coordination and control are the two fundamental aspects in the functioning of the living matter. TGD suggests that at quantum level deterministic unitary time evolution of Dirac equation corresponds to coordination whereas time evolution by quantum jumps corresponds to quantum control. More precisely, the non-dissipative Josephson currents associated with weakly coupled super conductors would be the key element in coordination whereas resonant dissipative currents between weakly coupled super conductors would make possible quantum control.

This view allows to consider more detailed mechanisms. What is certainly needed in the coordination of the grown up organism are biological clocks, which are oscillators coupled to the biological activity of the organ. Good examples are the clocks coordinating the brain activity, respiration and heart beat [I57]. For example, in the heart beat the muscle contractions in various parts of heart occur in synchronized manner with well defined phase differences. Various functional disorders, say heart fibrillation, result from the loss of this spatial coherence. For a control also biological alarm clocks are needed. An alarm clock is needed to tell when the time is ripe for the cell to replicate during morphogenesis. Some signal must tell that is time to begin differentiation to substructures during morphogenesis: for example, in case of the vertebrates the generation of somites is a very regular process starting at certain phase of development and proceeding with a clockwise precision.

6.3.1 Massless Extremals, Magnetic Flux Tubes, And Electrets

Massless extemals (MEs), magnetic flux tubes and magnetic body, and electrets define the basic new notions of TGD inspired theory of consciousness and quantum biology and it is good to introduce them first before discussing the quantum tools.

Massless extremals

The identification of mind-like space-time sheets as "massless extremals" (MEs) together with the notion of magnetic body leads to a very general vision about bio-consciousness and an explanation for the fact that the effects of ELF em fields on biomatter occur only for certain amplitude windows [J44] (these effects are discussed in detail in [K17, K18]

1. What MEs are?

Massless extremals (MEs) define a very general solution set of field equations associated with Kähler action [K44] and representing various gauge fields and gravitational [A30] [K68]. Being scale invariant, MEs come in all size scales. The geometry has axial symmetry in the sense that CP_2 coordinates are arbitrary functions of two variables constructed from Minkowski coordinates: light-like coordinate $t - z$ and arbitrary function of the coordinates of the plane orthogonal to the z-axis defining the direction of propagation. The polarization of the electromagnetic field depends on the point of the plane but is temporally constant. MEs represent waves propagating with velocity of light in single direction so that there is no dispersion: preservation of the pulse shape makes MEs ideal for classical communications.

Electric and magnetic parts of various gauge fields are orthogonal to each other and to the direction of propagation. Classical gauge has as its source light-like vacuum current. The time dependence of the vacuum current is arbitrary, this is only possible by its light-likeness. This makes it possible to code all kinds of physical information to the time dependence of the vacuum current. MEs can have finite spatial size and in this case they are classical counterparts of virtual photons exchanged between charged particles and represent classical communication between material space-time sheets. MEs carry gravitational waves and various classical color and electroweak gauge fields propagating with light velocity.

MEs can also carry constant electric and magnetic fields but in this case the boundaries of ME contain necessarily the sources of this field. Light-like vacuum currents or elementary particles in massless phase could serve as sources MEs could also form double-sheeted structures with wormhole contacts serving as effective sources. It took quite a time to realize that the wormhole contacts have interpretation as gauge bosons and their super partners. Therefore quantum classical correspondence between classical fields and field quanta emerges automatically. In the case of single-sheeted MEs the interpretation is as a space-time correlate for fermion or a super-partner of fermion.

TGD allows the possibility that the two sheets have opposite time orientations and therefore also opposite classical energies. In zero energy ontology this might be always the case for the double sheeted MEs assigned to bosons and their super-partners. The opposite sign of the energy makes it possible to realize virtual particles as pairs of on mass shell particles of opposite sign of energy and this of utmost importance in the recent formulation of quantum TGD [K110, K10]. A natural guess would be that pairs of positive (negative) energy MEs correspond to massless on mass shell particles and pairs of MEs with opposite energies represent naturally virtual particles. The objection is that it is difficult to understand how the spin of on mass shell gauge boson could be represented in terms of fermion and anti-fermion spins associate with the throats of the wormhole contact. Massless Dirac equation seems to allow only longitudinal net polarization for the resulting gauge bosons. The resolution of the problem is based on Kähler-Dirac action which mixes M^4 chiralities. This mixing is also behind the massivation of elementary particles. Quite generally, the exchange of a double-sheeted ME between material space-time sheets can correspond to arbitrary value of the exchanged momentum. Also fermions and their superpartners are assumed to topological condense in in the interaction region and become temporarily double-sheeted but the other sheet need not be ME anymore.

This kind of structures are obvious candidates for cognitive structures since classical non-determinism is localized in a finite space-time volume and direct connection with the notion of virtual particle characterizing the non-determinism of quantum theories emerges. World should be full of MEs with all possible sizes since they have vanishing action: addition of ME with finite time duration yields new absolute minimum of Kähler action since Kähler action does not change in this operation. This suggests that MEs should be of crucial importance in TGD Universe.

2. Interaction of MEs with matter

The basic interaction mechanisms of MEs with superconducting flux tubes are magnetic induction generating supercurrents, the action of MEs as Josephson junctions between magnetic flux tubes, and magnetic quantum phase transitions stimulating radiation of coherent light which in turn BE-condenses on MEs and defines a feedback loop.

Many-sheeted ionic flow equilibrium defines the basic control mechanism with superconducting magnetic flux tubes taking the role of master and atomic space-time sheets taking the role of slave. Magnetic phase transitions could make possible chemical senses based on an endogenous NMR type spectroscopy. Also other than magnetic quantum transitions, such as changes of protein (in particular enzyme-) conformations, could occur coherently at superconducting space-time sheets, so that superconducting space-time sheets could allow an extremely effective high precision quantum control of the biochemistry. Magnetic quantum phase transitions make possible place coding by if the thickness of magnetic flux tube varies and this coding is crucial in the model for how various features are associated with objects of perceptive field at a given position.

MEs allow at their light-like boundaries representations of super conformal– and super-symplectic algebras with gigantic almost-degeneracies of states due to the almost-commutativity of Poincare algebra and super-symplectic algebra. Super-symplectic states define genuine quantum gravitational state functionals in the space of 3-surfaces, the "world of classical worlds", and

correspond to a higher abstraction level than ordinary quantum states defined in the "world" (space-time). This "world of classical worlds" aspect of quantum gravitational states explains why quantum gravity is crucial for consciousness.

3. Possible functions of MEs

MEs serve as receiving and sending quantum antennae [K68]. Light-like vacuum current generates coherent light. Also coherent gravitons are generated. MEs serve also as templates for BE condensation of photons and gravitons with momenta parallel to the light-like vacuum current. Linear structures, say DNA and microtubules, are natural but not the only candidates for structures accompanied by MEs. Since MEs are massless, they carry maximal possible momentum. This makes exchange of ME ideal mechanism for locomotion. The possibility of negative energy MEs is especially fascinating since it suggests "buy now, pay later" mechanism of energy production: perhaps living matter uses MEs to generate coherent motions [K72, K71].

Perhaps the most important function of MEs in living matter is communication and control. MEs can connect different parts of biological body at various levels. For instance, they can be attached to magnetic flux tubes. MEs would be also involved with the communications between magnetic body and biological body and EEG would represent one particular example of this kind of communication. MEs would be also ideal quantum entanglers in time direction and could serve as correlates for the mediators of negentropic quantum entanglement. The communication of sensory data to magnetic body could take via MEs and also the control actions of magnetic body could be mediated by MEs to biological body via MEs.

The original idea was that MEs could induce Josephson junctions and more general current carrying bridges between bio-structures. This is possible but magnetic flux tubes are more natural looking structures in this respect because they can be stationary.

1. Since the electric field of ME is orthogonal to the direction of the propagation of vacuum current, the Josephson junction with potential difference is formed most naturally when super conductors are joined by flux tubes to ME in the direction of the electric field associated with ME. MEs can in principle be arbitrary thin so that the thickness of Josephson junction can be much smaller than the dominating wavelength of ME.

2. The electric field of ME can contain also a constant component. This is possible if there is a vacuum charge density or ordinary elementary particles in a massless phase in the time scale considered (Higgs field vanishes) at the boundaries of ME generating the field. If this charge density is absent, ME is necessary double sheeted with the constant electric and magnetic fields created by the wormhole throats at the boundaries of ME serving as effective charges. Both single and double sheeted MEs could give rise to the Josephson junctions with a constant potential difference. The coding of the transversal potential difference associated with ME to Josephson frequency could be a fundamental information coding mechanism in living matter. ME can contain also oscillating electric field over Josephson junction at magnetic or some other transition frequency so that MEs are ideal for control purposes.

4. MEs and the interaction of the classical em fields with biomatter

MEs acting as Josephson junctions and containing oscillating em field at ELF frequency give rise to a harmonic perturbation inducing quantum jumps of the magnetic states of ions and explains the effect of ELF em fields on biomatter. Also the presence of the mysterious intensity windows [J63, J40] can be understood. Josephson current paradigm allows to understand this effect if radio frequency or microwave MEs associated with the external field act as Josephson junctions.

1. The external electric field oscillating with frequency ω (now radio frequency) defines slowly varying potential difference over Josephson junction of length d acting as Josephson junction provided that the condition

$$\omega \ll \omega_J(max) = ZeV = ZeEd$$

holds true. This gives

$$d \gg \frac{\omega}{ZeE} \quad .$$

For $E \sim .1$ V/m and $\omega \sim GHz$ which are typical values used in experiments [J44], this condition gives $d \gg 10^{-6}$ meters which is satisfied if Josephson junctions have size not smaller than cell length scale.

2. For fixed length of Josephson junction amplitude window results if the maximal Josephson frequency $\omega_J(max)$ is slightly above some transition frequency since in this case the stationary maxima and minima of amplitude lead to long lasting resonant excitation of quantum transitions. Denoting the relative width of the resonance by $\Delta\omega/\omega = P$, the ratio of the time spent in resonance at $\Omega_J(max)$ to the time spent off resonance at Ω_J is of order

$$\frac{t(max)}{t} \sim \sqrt{1 - \frac{\Omega_J^2}{\Omega_J^2(max)}} \times \frac{1}{\sqrt{P}} \quad .$$

For a narrow resonance width this ratio can be very large so that amplitude window results for fixed value of d.

3. Amplitude window results if there is a correlation between the thickness of ME and transversal electric field so that $\omega_J(max) = ZeEd(E)$ satisfies resonance condition for some values of E only, if any. In absence of this correlation Josephson junctions must have discrete spectrum of effective lengths for amplitude window to result.

4. For electric fields in the range .1 V/m the frequencies ω_J are above GHz for d larger than 3×10^{-5} meters and correspond to the frequencies for the conformational dynamics of proteins. There are obviously a large number of frequencies of this kind and several intensity windows. EM fields with these strengths should have special effects on living matter: it could be even that some kind of feature recognition process involving self-organization occurs at these field strengths. Note that the minimal size of Josephson junctions corresponds to the p-adic length scale $L(173) \simeq 1.6 \times 10^{-5}$ meters characterizing structures next to cells in the p-adic length scale hierarchy.

5. MEs and quantum holography

Sokolov and collaborators [B13] have proposed a model of quantum holographic teleportation in which the *classical* photocurrents from the sender to receiver take the role of a dynamical hologram. The connection with MEs is obvious.

1. MEs are carriers of classical light-like vacuum currents (one of the basic differences between TGD and Maxwell theory). This suggests that MEs could be interpreted also as *classical* holograms, which are *dynamical* as in quantum information theory. Light-like current would be like a dynamical (four-dimensional) diffraction grating. Light-like vacuum currents and vacuum Einstein tensor generate also coherent states of photons and gravitons and MEs serve as templates for the topological condensation of photons and gravitons to the Bose-Einstein condensate of photons collinear with ME. The Bose-Einstein condensation of collinear photons and their generalizations to colored WCW photons should affect the vacuum current by adding to the reference current what might be called evoked response. This condensation process could generate conscious experience and higher level qualia. Thus it would seem that MEs have a triple role as receiving and sending quantum antennae as well as classical holograms.

2. The proposal of [B13] generalizes to the case of MEs provided one can device a method of coding quantum states of photon field to the vacuum currents. The high efficiency photodetector matrix is in which each pixel gives rise to a photocurrent [B13], is replaced with ME or set of parallel MEs. The neural window hypothesis states that neuronal axons are accompanied by parallel MEs carrying information between sensory organs and brain and various parts of brain. This is only a less standard manner to say that ME represents classical

dynamical hologram. The possibility of local light-cone coordinates allows also MEs which define curved deformations of the simplest cylindrical MEs.

The concrete realization of holographic teleportation proposed in [B13] brings strongly in mind the architecture of the visual pathways. Thus one can wonder whether brain is performing internal teleportation of photonic quantum states with spike patterns being directly coded to the pattern of the vacuum currents flowing along MEs. If spike patterns code the dynamical hologram, a surprisingly close relationship with Pribram's views about hologrammic brain results. Nerve pulse patterns could be seen as specifying the necessary classical aspects of the quantum teleportation (in TGD classical physics is essential part of quantum physics, rather than some effective theory).

3. The light-like vacuum current at a 3-dimensional time-like section of ME as a function function of time defines a dynamical 3-dimensional hologram. This is consistent with the fact that our visual experience is two-dimensional: the information is always about outer boundaries of the objects of the perceptive field. The values of the vacuum current at a given point are non-deterministic which means that vacuum current is ideal for coding information. Classical data also propagate without dispersion with light velocity obeying the laws of geometric optics and MEs imply channelling so that MEs are tailor-made for classical information transfer.

4. Space-time sheets can have both positive and negative time orientations and the sign of energy depends on time orientation in TGD framework. This means that classical communication can occur both in the direction of the geometric future and past: this is essential for the classical model of the long term memories as a question commmunicated to the geometric past followed by answe. The dynamical nature of the holograms means that there is no need to combine 2- or 3-dimensional holograms associated with several moments of geometric time to single hologram. To remember is to perceive an object located in the geometric past. Of course, fractality might make possible temporally scaled down versions of the geometric past but the principle would remain the same.

5. Quantum hologram view suggests that the super-symplectic representations at the light-like boundaries of MEs characterized by gigantic almost-degeneracies are the real carriers of biological information. According to the general theory of qualia [K39] this information would become conscious since elementary qualia would correspond to quantum jumps for which increments of the quantum numbers correspond to the quantum numbers labelling super-symplectic generators in the complement of Cartan algebra. In this view superconducting magnetic flux tubes could perhaps be seen as intermediate level in the control circuitry controlled by MEs and controlling atomic level.

6. The model for visual qualia leads to the hypothesis that, besides ordinary photons, also colored WCW photons are possible and characterized by WCW Hamiltonian which is labelled by orbital spin quantum number J (in two-dimensional sense) and by color quantum numbers. The coherent states of these massless WCW photons would be responsible for visual colors and polarization sense and the corresponding holograms might be the crux of quantum control in living matter.

Magnetic flux tubes and the notion of magnetic body

The notion of magnetic/field body is one of the features of TGD inspired biology challenging the standard views about living matter.

1. Magnetic body has a fractal onion like structure with decreasing magnetic field strengths and the highest layers can have astrophysical sizes. Cyclotron wave length gives an estimate for the size of particular layer of magnetic body. $B = .2$ Gauss is the field strength associated with a particular layer of the magnetic body assignable to vertebrates and EEG. This value is not the same as the nominal value of the Earth's magnetic field equal to .5 Gauss. It is quite possible that the flux quanta of the magnetic body correspond to those of wormhole magnetic field and thus consist of two parallel flux quanta which have opposite time orientation. This is true for flux tubes assigned to DNA in the model of DNA as a topological quantum computer.

2. The layers of the magnetic body are characterized by the values of Planck constant and the matter at the flux quanta can be interpreted as macroscopically quantum coherent dark matter. This picture makes sense only if one accepts the generalization of the notion of embedding space.

3. In the case of wormhole magnetic fields it is natural to assign a definite temporal duration to the flux quanta and the time scales defined by EEG frequencies are natural. In particular, the inherent time scale.1 seconds assignable to electron as a duration of zero energy space-time sheet having positive and negative energy electron at its ends would correspond to 10 Hz cyclotron frequency for ordinary value of Planck constant. For larger values of Planck constants the time scale scales as $\hbar$. Quite generally, a connection between p-adic time scales of EEG and those of electron and lightest quarks is highly suggestive since light quarks play key role in the model of DNA as topological quantum computer.

4. TGD predicts also hierarchy of scaled variants of electro-weak and color physics so that ZXG, QXG, and GXG corresponding to Z^0 boson, W boson, and gluons appearing effectively as massless particles below some biologically relevant length scale suggest themselves. In this phase quarks and gluons are unconfined and electroweak symmetries are unbroken so that gluons, weak bosons, quarks and even neutrinos might be relevant to the understanding of living matter. In particular, long ranged entanglement in charge and color degrees of freedom becomes possible. For instance, TGD based model of atomic nucleus as nuclear string suggests that biologically important fermionic could be actually chemically equivalent bosons and form cyclotron Bose-Einstein condensates.

The list of possible functions of the magnetic body is rather impressive.

1. Magnetic body controls biological body and receives sensory data from it. Together with zero energy ontology and new view about time explains Libet's strange findings about time lapses of consciousness. EEG, or actually fractal hierarchy of EXGs assignable to various body parts makes possible communications to and control by the various layers of the magnetic body. WXG could induce charge density gradients by the exchange of W boson.

2. The flux sheets of the magnetic body traverse through DNA strands. The hierarchy of Planck constants and quantization of magnetic flux predicts that the flux sheets can have arbitrarily large width. This leads to the idea that there is hierarchy of genomes corresponding to ordinary genome, supergenome consisting of genomes of several cell nuclei arranged along flux sheet like lines of text, and hypergenomes involving genomes of several organisms arranged in a similar manner. The prediction is coherent gene expression at the level of organ, and even of population. In this picture the big jumps in evolution, in particular, the emergence of EEG, could be seen as the emergence of a new larger layer of magnetic body characterized by a larger value of Planck constant. For instance, this would allow to understand why the quantal effects of ELF em fields requiring so large value of Planck constant that cyclotron energies are above thermal energy at body temperature are observed for vertebrates only.

3. The strands of DNA could serve as intermediation structure analogous to brain hemispheres with active strand analogous to motor areas and passive strand analogous to sensory areas of cortex. The passive strand would serve as a relay station through which sensory data about the cellular environment is transferred to the magnetic body. Here MEs topologically condensed to the flux sheets could be in key role. The flux tubes connecting DNA nucleotides and cell membrane and various biomolecules would mediate the sensory data to the passive DNA strand.

4. Magnetic body makes possible information process in a way highly analogous to topological quantum computation. The model of DNA as topological quantum computer assumes that flux tubes of wormhole magnetic field connect DNA nucleotides with the lipids of the lipid layer of nuclear or cell membrane. The flux tubes would continue through the membrane and split during topological quantum computation. The time-like braiding of flux tubes makes possible topological quantum computation via time-like braiding and space-like braiding makes possible the representation of memories. The model allows general vision about the deeper meaning of the structure of cell and makes testable predictions about DNA.

One prediction is the coloring of braid strands realized by an association of quark or antiquark to nucleotide. Color and spin of quarks and antiquarks would thus correspond to the quantum numbers assignable to braid ends. Color isospin could replace ordinary spin as a representation of qubit and quarks would naturally give rise to qutrit, with third quark would have interpretation as unspecified truth value. Fractionization of these quantum numbers takes place which increases the number of degrees of freedom. This prediction would relate closely to the discovery of topologist Barbara Shipman that the model for the honeybee dance suggests that quarks are in some manner involved with cognition. Also microtubules associated with axons connected to a space-time sheet outside axonal membrane via lipids could be involved with topological quantum computation and actually define an analog of a higher level programming language.

5. The strange findings about the behavior of cell membrane, in particular the finding that metabolic deprivation does not lead to the death of cell, the discovery that ionic currents through the cell membrane are quantal, and that these currents are essentially similar than those through an artificial membrane, suggest that the ionic currents are dark ionic Josephson currents along magnetic flux tubes. A high percent of biological ions would be dark and ionic channels and pumps would be responsible only for the control of the flow of ordinary ions through cell membrane.

6. These findings together with the discovery that also nerve pulse seems to involve only low dissipation lead to a model of nerve pulse in which dark ionic currents automatically return back as Josephson currents without any need for pumping. This does not exclude the possibility that ionic channels might be involved with the generation of nerve pulse so that the original view about quantal currents as controllers of the generation of nerve pulse would be turned upside down. Nerve pulse would result as a perturbation of kHz soliton sequence mathematically equivalent to a situation in which a sequence of gravitational penduli rotates with constant phase difference between neighbors except for one pendulum which oscillates and oscillation moves along the sequence with the same velocity as the kHz wave. The oscillation would be induced by a "kick" for which one can imagine several mechanisms.

The model explains features of nerve pulse not explained by Hodkin-Huxley model. These include the mechanical changes associated with axon during nerve pulse, the outwards force generated by nerve pulse with a correct prediction for its order of magnitude, the adiabatic character of nerve pulse, and the small rise of temperature of membrane during pulse followed by a reduction slightly below the original temperature.

The model predicts that the time taken to travel along any axon is a multiple of time dictated by the resting potential so that synchronization is an automatic prediction. Not only kHz waves but also a fractal hierarchy of EEG (and EXG) waves are induced as Josephson radiation by voltage waves along axons and microtubules and by standing waves assignable to neuronal (cell) soma. The value of Planck constant involved with flux tubes determines the frequency scale of EXG so that a fractal hierarchy results.

The model forces to challenge the existing interpretation of nerve pulse patterns and the function of neural transmitters. Neural transmitters need not represent actual/only) signal but could be more analogous to links in quantum web. The transmitter would coding the address of the receiver, which could be gene inside neuronal nucleus. Nerve pulses would build a connection line between sender and receiver of nerve pulse along which actual signals would propagate. Also quantum entanglement between receiver and sender can be considered.

7. Acupuncture points, meridians, and Chi are key notions of Eastern medicine and find a natural identification in terms of magnetic body lacking from the western medicine. Also a connection with well established notions of DC currents and potentials discovered by Becker and with TGD based view about universal metabolic currencies as differences of zero point energies for pairs of space-time sheets with different p-adic length scale emerges.

Chi would correspond to these fundamental metabolic energy quanta to which ordinary chemically stored metabolic energy would be transformed. Meridians would most naturally correspond to flux tubes with large $\hbar$ along which dark supra currents flow without dissipation and transfer the metabolic energy between distant cells. Acupuncture points would

correspond to points between which metabolic energy is transferred and their high conductivity and semiconductor like behavior would conform with the interpretation in terms of metabolic energy storages. The energy gained in the potential difference between the points would help to kick the charge carrier to a smaller space-time sheet. It is possible that the main contribution to the of charge at magnetic flux tube is magnetic energy and slightly below the metabolic energy quantum and that the voltage difference gives only the lacking small energy increment making the transfer possible. Also direct kicking of charge carriers to smaller space-time sheets by photons is possible and the observed action spectrum for IR and red photons corresponds to the predicted increments of zero point kinetic energies.

8. Magnetic flux tubes could also play key role in bio-catalysis and explain the magic ability of biomolecules to find each other. The model of DNA as topological quantum computer [K2] suggest that not only DNA and its conjugate but also some amino-acid sequences acting as catalysts could be connected to DNA and other amino-acids sequences or more general biomolecules by flux tubes acting as colored braid strands. The shortening of the flux tubes in a phase transition reducing the value of Planck constant would make possible extremely selective mechanisms of catalysis allowing precisely defined locations of reacting molecules to attach to each other. With recently discovered mechanism for programming sequences of biochemical reactions this would make possible to understand the miraculous looking feats of bio-catalysis.

9. The ability to construct "stories", temporally scaled down or possible also scaled up representations about the dynamical processes of external world, might be one of the key aspects of intelligence. There is direct empirical evidence for this activity in hippocampus. The phase transitions reducing or increasing the value of Planck constant would indeed allow to achieve this by scaling the time duration of the zero energy space-time sheets providing cognitive representations.

The list of nice things made possible by the magnetic body is impressive and one can ask whether there is any experimental support for this notion. The findings of Peter Gariaev and collaborators give evidence for the representation of DNA sequences based on the coding of nucleotide to a rotation angle of the polarization direction as photon travels through the flux tube and for the decoding of this representation to gene activation [I31], for the transformation of laser light to light at various radio-wave frequencies having interpretation in terms of phase transitions increasing $\hbar$ [I30, I3], and even for the possibility to photograph magnetic flux tubes containing dark matter by using ordinary light in UV-IR range scattered from DNA [K113] , [I42].

Electrets

Electrets are by definition spontaneously electrically polarized structures. Living matter is full of electrets. Practically all important biomolecules are electrets. Cell membrane is an electret and liquid crystal. Microtubules are electrets as are also various larger structures such as collagens.

The dipolar nature of bio-molecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [I43]. This cohesion gives rise to liquid [F4] [D4] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [I58, I46, I43] . For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [K19]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [I45] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

In TGD framework electrets could serve as sensory receptors. In capacitor model of sensory qualia the flow of quantum numbers between the plates of this kind of capacitor would give rise to sensory qualia. The process would be self-organization process with energy flow replaced with a more general flow of quantum numbers.

6.3.2   Homeostasis As Many-Sheeted Ionic Flow Equilibrium?

The experimental work of Ling, Sachs and Qin [I43, I65] and other pioneers [I34, I27] challenges the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic pumps. The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! this challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane: ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why it is so difficult to get the water out of it?

These puzzling observations can be understood if the homeostasis of cell and its exterior is regarded as an ionic flow equilibrium in the many-sheeted space-time. Ionic super currents from superconducting controlling space-time sheets flow to controlled atomic space-time sheets and back. Currents are of course ohmic at the atomic space-time sheets. One can understand how extremely small ionic densities and super currents at cellular space-time sheets can control ionic currents and much higher ionic densities at atomic space-time sheets. Immense savings in metabolic energy are achieved if the ohmic currents at the atomic space-time sheets flow through the cell membrane region containing the strong electric field along superconducting cell membrane space-time sheet (rather than atomic space-time sheets) as a non-dissipative supra current. This clever energy saving trick makes also the notion of ionic channels obsolete for weak ionic currents at least.

Superconducting space-time sheets contain a plan of the biosystem coded to ion densities and magnetic quantum numbers characterizing the super currents. Biocontrol by em fields affects these super currents and one can understand the effects of ELF em fields on biosystem in this framework. The model relies crucially on the liquid crystal property of biomatter (hamburger mystery!) making possible ohmic current circuitry at the atomic space-time sheets as a part of the many-sheeted control circuitry. There is a considerable evidence for this current circuitry, Becker is one of the pioneers in the field [J35]: among other things the circuitry could explain how acupuncture works.

One can add several new elements to this picture.

1. The phase transition changing the value of Planck constant induces a change of the length of the magnetic flux tube scaling as $\hbar$. Therefore the reduction of the Planck constant for a flux tube connecting two biomolecules can bring them near to each other. This suggests that biomolecules form a kind of Indra's net and that these phase transitions together with the reconnection of magnetic flux tubes changing the topology of this net are the basic mechanisms explaining the miracles of bio-catalysis and induce various phases transitions typically accompanying contractions and expansions of the matter in the cell interior. One could actually see the phase transitions of living matter as being induced from the motor actions of the magnetic body.

2. Zero energy ontology predict is that the CDs assignable to elementary particles have temporal size scale given by the secondary p-adic time scale. For electron and quarks (assigned to the ends of magnetic flux tubes in the model of topological quantum computation) these time scales are 100 milliseconds and 1 millisecond respectively and identifiable as fundamental biological time scales. A deep connection between biology and elementary particle physics seems to exist.

3. Negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) transforms the bio-molecules from dead matter to conscious entities so that the nano-scaled molecules are just what they seem to be in light of experimental nano-biology: intelligent conscious entities having intentions and plans and willing and able to collaborate.

6.3.3   Quantum ModelFor Pattern Recognition

The general neuroscience based model for recognition relies one learning made possible by synaptic plasticity. It is expected to have a TGD based quantum variant [K89]. The model of pattern

recognition to be discussed below relies on supra currents and Josephson currents assignable to cell membrane and various other binary structures, and could define a building brick of the general model. For instance, the model of nerve pulse relies on Josephson currents [K81].

Time translation invariant pattern recognition circuit can be realized by using two coupled super conductors. The first superconductor contains the reference supra current and second super-conductor contains the supra current determined by the sensory input. Supra currents are assumed to have same spatially and temporally constant intensity. If the supra currents have spatially constant phase difference, also Josephson currents are in the same phase and sum up to a large current facilitating synchronous firing. The temporal phase difference of supra currents does not matter since it affects only the overall phase of the Josephson current. Therefore patterns differing by time translations are treated as equivalent. Quite generally, the requirement of time translational invariance, favours the coding of the sensory qualia to transition frequencies.

The destructive interference of supra currents provides an tool of pattern cognition in situations when the precise timing is important. The pattern to be recognized can be represented as a reference current pattern in some neuronal circuit. Input pattern determined by sensory input in turn is represented by supra current interfering with the reference current. If the interference is destructive, synchronoous generation of nerve pulses in the circuit occurs and leads to a conscious pattern recognition. Obviously the loss of time translation invariance makes this mechanism undesirable in the situations in which the precise timing of the sensory input does not matter. One can however imagine situations when timing is important: for instance, the deduction of the direction of the object of the auditory field from the phase difference associated with signals entering into right and left ears could correspond to this kind of situation.

In both cases one can worry about the regeneration of reference currents. The paradigm of four-dimensional quantum brain suggests that sensory input leads by self-organization to a stationary spatial patterns of supercurrents and this process depends only very mildly on initial values. Thus self-organization would generate automatically pattern recognizers.

6.3.4   General Mechanism Making Possible Biological Clocks And Alarm Clocks, Comparison Circuits And Novelty Detectors

Weakly coupled super conductors and auantum self-organization make possible very general models of biological clocks and alarm clocks as well as comparison circuits and novelty detectors.

The Josephson junction between two superconductors provides a way to realize a biological clock. Josephson current can be written in the form [D14]

$$
\begin{aligned}
J &= J_0 sin(\Delta\Phi) = J_0 sin(\Omega t) \ , \\
\Omega &= ZeV \ ,
\end{aligned}
\tag{6.3.1}
$$

where Ω is proportional to the potential difference over the Josephson junction. Josephson current flows without dissipation.

In BCS theory of superconductivity the value of the current J_0 can be expressed in terms of the energy gap Δ of the super conductor and the ordinary conductivity of the junction. When the temperature is much smaller than critical temperature, the current density for a junction is given by the expression [D14]

$$
J_0 = \frac{\pi}{2e}\frac{\sigma_s \Delta}{d} \ .
\tag{6.3.2}
$$

Here σ_s is the conductivity of the junction in the normal state assuming that all conduction electrons can become carriers of the supra current. d is the distance between the super conductors. The current in turn implies a position independent(!) oscillation of the Cooper pair density inside the two super conductors. By the previous arguments the density of the Cooper pairs is an ideal tool of biocontrol and a rhythmic change in biological activity expected to result in general. Josephson junctions are therefore good candidates for pacemakers not only in brain but also in heart and in respiratory system.

In the presence of several parallel Josephson junctions quantum interference effects become possible if supra currents flow in the super conductors. Supra current is proportional to the gradient of the phase angle associated with the order parameter, so that the phase angle Φ is not same for the Josephson junctions anymore and the total Josephson current reads as

$$ J \quad = \quad \sum_n J_0(n) sin(\Omega t + \Delta\Phi(n)) \quad . \tag{6.3.3} $$

It is clear that destructive interference takes place. The degree of the destructive interference depends on the magnitude of the supra currents and on the number of Josephson junctions.

There are several options depending on whether both super conductors carry parallel supra currents or whether only second super conductor carries supra current.

1. If both super conductors carry supra currents of same magnitude but different velocity, the phases associated with the currents have different spatial dependence and destructive interference occurs unless the currents propagate with similar velocity. This mechanism makes possible comparison circuit serving as a feature detector. What is needed is to represent the feature to be detected by a fixed supra current in the second super conductor and the input as supra current with same charge density but difference velocity. The problem is how the system is able to generate and preserve the reference current. If case that feature detector "wakes-up" into self state when feature detection occurs, the subsequent quantum self-organization should lead to the generation of the reference current representing the feature to be detected.

2. If only second super conductor carries supra current and of this supra current for some reason decreases or becomes zero, constructive interference occurs for individual Josephson currents and net Josephson current increases: current causes large gradients of Cooper pair density and can lead to the instability of the structure. When the supra current in the circuit dissipates below a critical value, instability emerges. This provides a general mechanism of biological alarm clock.

   Assume that the second super conductor carriers a supra current. As the time passes the reference current dissipates by phase slippages [D12, D14]. If the reference current is large enough, the dissipation takes place with a constant rate. This in turn means that the Josephson current increases in the course of time. When the amplitude of the Josephson current becomes large enough, the density gradients of the charge carriers implied by it lead to a non-stability of the controlled system: the clock rings. Since the dissipation of (a sufficiently large) Josephson current takes place at constant rate this alarm clock can be quite accurate. It will be found that a variant of this mechanism might be at work even in the replication of DNA. The instability itself can regenerate the reference current to the clock. If the alarm clock actually "wakes-up" the alarm clock to self state, self-organization by quantum jumps must lead to an asymptotic self-organization pattern in which the supra current in the circuit is the original one. Actually this should occur since asymptotic self-organization pattern depends only weakly on the initial values.

3. Novelty detector can be build by feeding the outputs of the feature detectors to an alarm clock circuit. In alarm clock circuit only the second super conductor carries supra current, which represents the sum of the outputs of the feature detectors. Since the output of a feature detector is non-vanishing only provided the input corresponds to the feature to be detected, the Josephson current in additional circuit becomes large only when the input does not correspond to any familiar pattern.

6.4   Sensory Representations

In this section concrete model for the sensory representations is developed on basis of the general vision already outlined. What is new as compared to the earlier vision is the role of zero energy ontology and CDs as embedding space correlates for sub-selves.

6.4.1 Where Me Is?

The motion of eye or head does not induce the sensation that the world is moving although the sensory image moves around the cortex. Rather, brain acts like a (possibly moving) canvas at which the sensory input is projected and monitored by an external observer. This very simple observation is a strong objection against the idea that the ultimate sensory representations reside inside brain, and leads to the view that the magnetic flux tube structures associated with the primary and secondary sensory organs define a hierarchy of sensory representations outside brain. The question is where these representations are realized and one can imagine two alternatives.

Are higher level sensory representations realized at the magnetic body?

Magnetic flux tube structures would serve as the sensory canvas to which sensory images are projected from brain and possibly sensory organs and even neurons. MEs serve as projectors and place coding by magnetic transition frequency associated with ME wakes-up sensory sub-selves at various positions of magnetic flux tubes having varying thickness and associate thus various sensory qualia and even more complex attributes to the objects of the perceptive field.

This view can be defended also by the neat separation of the information processing from its representation occurring also in case of the ordinary computers as well as by Uncertainty Principle for EEG waves. If primary qualia are at the level of primary sensory organs and entangled with cortex, one can understand why imagination, which involves much the same neural processes as perception, does not give rise to sensory qualia.

EEG MEs correspond to our level in this hierarchy of projections. The simplest possibility is that the sizes of these sensory selves are of the order of EEG ME sizes ($L(EEG) = c/f(EEG)$) and thus can be of the order of Earth size! Thus the ultimate sensory representations are magnetic gigants in TGD and diametrical opposites of the neurophysiological dwarfs of standard neuroscience populating also TGD brain.

The known strange effects of large scale perturbations of Earth's magnetic field on consciousness (say, statistics about the effects of magnetic storms in mental state and tectonic activity inducing UFO experiences) provide a rich palette of anomalies supporting this view. The conservation of magnetic flux makes the magnetic flux tube structures of Earth size (or even larger) very stable: thus physical death presumably means only that our magnetic body redirects its attention to something more interesting. Near death experiences discussed in more detail in [K19] indeed support this view.

Two requirements must be satisfied for this scenario to work.

1. The projectors to the magnetic body cannot rotate when head rotates so that a fixed direction of perceptive field corresponds to the fixed direct at the magnetic body. This can be achieved if the projectors are magnetic structures with a fixed orientation with respect to the Earth's magnetic field.

2. Retinae must act like windows for this scenario to work. This means that the primary qualia mental images (sub-selves) at retina are entangled with the corresponding cognitive mental images at cortex, keep their attention directed to that part of the perceptive field that they represent as the direction of the gaze changes. Perhaps the retinal mental images are stationary with respect to the liquid phase not comoving with the eye ball. The retina-external world entanglement would also keep retinal attention fixed. This applies also to the saccadic motion, and the loss of visual consciousness when saccadic motion is prevented, could mean simply that retinal mental images lose consciousness when their motor activity with respect to eye ball is prevented: just like we lose our consciousness if not allowed to move!

Could the sensory representations about position of the object be realized in the perceptive field?

There is also a more conservative realization of sensory representations (if I had invented it first, I would probably have never considered the representations at the magnetic body!).

1. If retina-external world entanglement is present as suggested by the argument above, sensory canvas for the primary sensory representations could be provided by the perceptive field itself. The series of quantum entanglements from sensory organs to brain to magnetic body would define the entire sensory-cognitive representation involving also the cognitive aspects. There would be no absolute need for topographic representations at the magnetic body although the appearance of a hierarchy of topographic representations in brain suggest that topographic representations continues. The magnetic representations could however be more abstract higher level representations: somewhat like the manual of an electronic instrument as compared with the photograph of the instrument.

2. One can also imagine that the magnetic body is not involved at all since also in this case the sensory representation would be organized topographically by the entanglement with the objects of the perceptive field. Now brain would entangle to the objects of the external world cognitive mental images. One could say, that me is the entire perceptive field plus physical body. In this case however the function of EEG remains unclear. Also the model of long term memories also suggests that EEG MEs in length scales of light life-time are involved.

Of course, neither of these views about human consciousness is new. In particular, the first one is shared by all spiritual practices. What is new is the concrete physical model realizing this view physically. Here I cannot avoid the temptation to fall for a moment in manifesto mood: what makes me sad is that the materialistic neuroscience so strongly advocates the brain centered view about consciousness with physical death meaning the absolute end. The belief in this world view deprives life from its meaning and reduces it to a vulgar fight for survival or, depending on one's tastes, to a pre-determined performance of a robot. It is also deeply frustrating that the stubborn belief on materialism prevails despite the fact that this dogma contains so many internal contradictions that it would not even deserve to be called world view.

6.4.2   Concrete Realization Of Sensory Representations

The vision about the concrete realization of the sensory representations conscious-to-us has developed rather slowly. A good measure for the uncertainties involved is that the sizes of the primary sensory organs and EEG ME lengths $L(EEG) = c/f$ have represented the two extreme options for the size scale of the sensory representations conscious-to-us. It seems however more and more clear that TGD forces a dramatic deviation from the prevailing view about cortex as the seat of the ultimate sensory representations. The sensory representations conscious-to-us are outside the body and that the relevant length scale could be most naturally the length scale $L(EEG) = c/f$ defined by the EEG frequencies. In case of long term memories much longer length scales in the range of the light lifetime are necessarily involved and the realization of long term memories forces to conclude that human sensory consciousness is a cosmic phenomenon.

Qualia as quantum phase transitions and as discharges of quantum capacitor

In TGD framework the meaning of the primary quale is associated with the mental images created by the self-organization process. If the quale corresponds to an average increment of quantum numbers or zero modes in a long quantum jump sequence, the quantum jump with same increment must occur repeatedly. One can imagine at least two mechanism inducing qualia.

  1. Quantum phase transition produce qualia

Quantum phase transition in which single particle transition occurs coherently for some macroscopic quantum phase produces qualia defined by the increments of quantum numbers in the transition. Quantum phase transition could be induced by the transition frequency: quantum phase transition leading to the generation of new kind of macroscopic quantum phase is in question. Transition frequencies themselves as such serve as symbols initiating this process, much like subprogram call initiates subprogram. They act like the name of dog: when dog hears its own name, dramatic self-organization process is initiated.

  2. Discharge of quantum capacitor produces primary qualia

Quantum capacitor discharge provides an attractive model for how the primary sensory qualia at the level of sensory receptors emerge.

The flow of particles with fixed quantum numbers between "electrodes" of what might be called a quantum capacitor induces qualia defined by the quantum numbers of the particles involved. The "electrodes" carry opposite net quantum numbers. Second electrode corresponds to the sub-self defining the quale mental image. Obviously cell interior and exterior are excellent candidates for the electrodes of the quantum capacitor. Also neuron and postsynaptic neuron. In fact, living matter is full of electrets defining capacitor like structures. The model of sensory receptor as a quantum capacitor will be discussed later. The model applies to various chemical qualia and also to color vision and predicts that also cells should have senses. Ordinary cells would sense only the nearby chemical environment whereas neurons would experience via synapses also representations of external world chemically: at our level of conscious experience these representations could give rise to emotions. The strange behavior of ionic currents leads to the view that even ionic channels and pumps are actually ionic and voltage receptors.

3. Higher level qualia at the level of brain and magnetic body

Higher level sensory qualia at the level of magnetic body are expected to relate to the geometric aspects of sensory input such as shape or size of objects of the perceptive field.

The capacitor model in principle generalizes to the level of brain and magnetic body. What is needed is a phase transition transforming one Bose-Einstein condensate type phase with definite quantum numbers to a second one. Music metaphor suggests that only the ratios of transition frequency to, say, cyclotron frequency can code for qualia. Only the ratios of Larmor and cyclotron frequencies and frequencies characterizing CDs and the intensities of the Fourier components for various harmonics can affect self-organization process. Furthermore, quale together with its emotional aspects depend on a simultaneous occurrence of several quantum phase transitions induced by the EEG pattern containing several magnetic transition frequencies. Different values of Planck constant could define a hierarchy of representations.

Zero energy ontology and geometric qualia

Zero energy ontology is a 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 (see **Fig. http://tgdtheory.fi/appfigures/timemirror.jpg** or **Fig. ??** in the appendix of this book) 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 generalize 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 charactering 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.

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 $\mathrm{sub}-CD$ leaving the other tip of $\mathrm{sub}-CD$ invariant could also code for the velocity of object.

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 hypercharge 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 [A12] and I have proposed a model for what might be involved [K39].

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 codable 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 [K116].

Place coding by cyclotron frequency scale

One of the basic aspects of conscious information processing is concrete geometric representation of even very abstract concepts and information as imagined objects of perceptive field. The observations about geometric qualia suggest to magnetic transition frequencies code for positions of sub-selves represented by magnetic flux tubes. Particular EEG frequency wakes-up particular sub-self in a specific position and orientation and gives rise to a "feeling of existence" in some part of the virtual world of brain of magnetic body. The sensation of motion of object of perceptive field cold result automatically when sub-self moves inside self. Alternatively, Lorentz boost for the sub-CD could represent the velocity of motion of object represented by it. For instance, one could represent coordinate curves as magnetic flux tubes with varying thickness: by magnetic flux conservation thickness codes the coordinate to magnetic field strength to cyclotron frequency.

Cortex as a collection of attributes assigned to the objects of perceptive field represented at magnetic canvas

One of the basic problems related to the understanding of the information processing in brain is how various attributes are assigned to the object of the perceptive field. What is known that brain recognizes features and these features/attributes seem to be located in a more or less random looking manner all around cortex. This brings strongly in mind random access memory or

computer game in which various little program modules realized as records in random access memory represent collection of standard sound effects. A strong hint is the empirical evidence for the view that the resonance frequencies associated with the autocorrelation functions of nerve pulse patterns, and thus presumably also coding EEG frequencies, are same for the features associated with a given object of the perceptive field. The challenge is to understand how the picture based on a collection of MEs projecting features to the magnetic canvas could allow to understand what is behind these observations.

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

1. Cortex can be regarded as a collection of regions specialized to represent various kinds of standard features. Features need not be simple qualia: arbitrary complicated collections of them, such as familiar faces are also possible features. Even entire dynamical processes (selves) could serve as features.

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

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

4. Features would be basically associated with sensory organs, various neural pathways and brain areas and coded partially by nerve pulse patterns. Features could be practically all kinds of sub-selves generated by brain activity. Primary qualia could be realized at the level of sensory receptors if entire sensory pathways entangle with the magnetic body.

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

6. In this coding EEG MES would entangle with essentially all information about the perceptive field and the spectroscopy of consciousness to be discussed below would be realized in rather strong sense.

7. The model becomes even more predictive if it is assumed that DNA double strands act as a relay station. This encourages to think that also the decomposition of brain to motor and sensory areas has a counterpart at the level of the magnetic body so that the sensory input coming from the cell membrane is mediated through flux sheets going through the passive strand to the sensory magnetic body and motor actions of the motor magnetic body are mediated through theflux sheets going through active strand. One would have a closed loop in which the phase transition induced by the sensory input coming via the passive DNA strand to the sensory magnetic body generates cyclotron radiation inducing a phase

transition in the motor part inducing cyclotron radiating inducing effect in the active DNA strand.

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

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

The projector regions would serve as kind of central entanglers. Also the nuclei believed to somehow generate EEG resonance frequencies responsible for the binding of mental images are good candidates for the central entanglers. In standard neuroscience thalamus is believed to generate 40 Hz rhythm and is thus a good candidate for the central sensory entangler and projector. In TGD framework this rhythm would be more naturally generated by the magnetic body assignable to thalamus. Hippocampus -or more naturally its magnetic body- generates hippocampal theta and could be the central memory entangler and projector. Frontal lobes generate slow EEG waves during cognitive activities and could act as cognitive entanglers and projectors.

This kind of architecture is expected to be realized at various length scales. The metaphor for consciousness as a computer sitting at its own terminal, which originally stimulated my attempts to understand consciousness, conforms this picture. Computer screen would correspond to the sensory magnetic body. The one who sits there presumably could be identified as the motor part of the magnetic body (as far as conscious-to-me intentions are considered). The central unit corresponds to the brain and DNA double strands are the fundamental hardware responsible for communication and control and through which all information flows. They intronic parts of DNA strands would also provide the hardware for topological quantum computation programs. Sensory projector MEs are generated automatically by the nerve pulse activity and code the picture at the monitor. MEs would be active quantum holograms acting as control commands on the active DNA strand serving as the keyboard generating nerve pulse patterns. Thus it would seem that those aspects of the computer (monitor, keyboard, etc), which are usually not regarded as fundamental in Turing machine paradigm are the most crucial for understanding the consciousness and computer programmers could be mimicking what happens inside (and outside) their own brain.

Anomalous visual percepts and sensory canvas hypothesis

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

One can also consider the possibility of "vision" based solely on the ELF input from brain and body having no correlate with the visible light entering into retina or even with neural activity. Even genuinely three-dimensional vision in which own body is seen as it would be seen by the external world suggests itself. The dropping of ions from the atomic space-time sheets to the magnetic flux tubes so that they end up to high n cyclotron states decaying via the emission of photons at frequencies which are harmonics of the cyclotron frequency would generate the projector MEs needed for the sensory representation of the physical body or part of it as seen by the environment.

In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero

point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated. In the following only the "dropping" option is discussed.

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. This might have interpretation as ELF vision involving a feedback from magnetic sensory canvas to brain to "qualiafy" the percept.

2. Becker tells in his book "Cross currents" [J134] 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 tumour correctly. If sensory receptors are necessary for visual qualia, the needed data must be received from somewhere by brain, and be projected to the visual receptors like during dreaming. The simplest option is that body parts can in some sense "see" each other. In particular, brain can "see" body parts (note that bacteria possess a primitive IR vision based on microtubules). Bio-holography provides support for the body as a hologram. For instance, an electric stimulation of ear during Kirlian imaging of a finger tip creates a Kirlian photo from which it is possible to abstract a hologram of ear (see [I67] and [K45] .

3. Also the OBE experiences, for instance those associated with NDEs, could have an analogous interpretation. The sensory input from eyes would be absent but brain would give feedback to visual receptors to "qualiafy" the input which it might receive from other levels of self hierarchy. If even the input from neural activity is absent during NDEs so that the visual experience should be determined by the background ELF component emanating from the brain and body. The third person perspective associated with OBEs might be always present but be masked by the strong sensory input or by the absence of feedback to visual receptors. It is possible to have experiences about contact with deceased by a therapy based on rhythmic eye movements [J30, J72]. The function of eye movements might be to establish a feedback to certain brain regions serving as receivers of input from magnetic bodies of deceased or from magnetosphere.

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

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

Place coding of features inside brain

Place coding for various geometric parameters characterizing simple geometric "features" inside brain could be realized using the variation of the cyclotron frequency along a magnetic flux tube of varying thickness. The hierarchy of the sensory canvases allows a modular structure in which a geometric feature such as triangle, line, or ellipse represented at a lower level sensory canvas is projected to a *single* point of "our" sensory canvas.

Becker tells in his book "Cross Currents" [J134] about a technique discovered by Dr. Elizabeth Rauscher, a physicist, and William Van Bise, an engineer. The technique uses magnetic fields generated by two coils of wire, each oscillating at a slightly different frequency and directed so as to intersect at the head of the subject person. When two energy beams with different frequencies intersect at some point in space, a third frequency, so called beat frequency is formed as the difference of the frequencies. What Bise and Rauscher found that this ELF frequency (unfortunately, I do not know what the precise frequency range was) generates simple visual percepts like circles,

ellipses and triangles and that the variation of the second frequency induces the variation of the shape of the percept.

The simplest interpretation is that the beat frequency is extracted by nonlinear effects in brain and induces a magnetic quantum phase transition at magnetic tubes whose thickness varies and codes for a parameter (say scaling in some direction) characterizing the geometry of the primitive percept (or "feature"). An analogous phenomenon occurs also for auditory inputs with slightly different frequencies fed into ears and makes it possible to "hear" sounds below the audible range. The mechanism could be the same.

If primary sensory qualia are realized only at the level of the primary sensory organs, one can make two conclusions. ELF wave wakes up a "feature" analogous to an imagined percept, and presumably realized as a particular nerve pulse pattern. ELF wave also induces a projection from the brain to the retinae "qualiafying" this feature. Blind subjects should not have these extra-sensorily induced percepts.

One can imagine two options concerning the ultimate representation of a simple geometric feature depending on whether the feature corresponds to a *collection* of points or *single* point at "our" sensory canvas.

1. The visual percept corresponds to a *collection* of activated points at "our" sensory canvas and activated geometric point corresponds to a standard mental image represented at brain level and assigned to a point of sensory canvas. The magnetic phase transition would initiate a process eventually activating particular projectors and the position of the quantum phase transition at the magnetic flux tube would determine the shape of the feature. One can criticize this option. The brain applies modular hierarchy in the information processing and simple percepts like triangles and circles which are also fundamental in the elementary geometry, are ideal for basic features assignable with a *single* point of "our" sensory canvas rather than being represented as composites of elementary features (points). The very fact that the place coding for the geometric shape of the feature is involved, suggests the same.

2. The visual percept is represented as a mental image inside brain or, more probably, at some lower level sensory canvas so that the hierarchy of the sensory canvases would directly relate to the modularity of our sensory representations and sensory canvases would be in an intense interaction by quantum entanglement much like various subprograms of a computer program. This geometric mental image is assigned with a *single* point of "our" sensory canvas by quantum entangling it with a projector ME projecting to a particular point of "our" sensory canvas. The position of the feature at the sensory canvas might be determined by the position of the volume of intersection for the beams.

Since sinmple objects are in question and the change of the shape corresponds to a scaling in one direction, the representation of the change of shape of the object could be in terms of a Lorentz boost of sub-CD representing the object and leaving the tip of the sub-CD invariant.

The relation of mental imagery to sensory experiences

Mental imagery is something which is difficult to understand in the framework of the standard neuro science. There are empirical results suggesting that mental images correspond to patterns of activity inside cortex, which are three-dimensional and continuous so that neural activation provides a concrete recognizable image about object [J140]. Rather remarkably, also imaginative thought resembles very much visual imagery as is clear from the fact that language is full of visual metaphors [J140]. It is also known that imagery uses same regions of the cortex as real sensory experience and the problem is to understand why there is almost sensory experience involved with imagery.

In the framework of the standard neuroscience the obvious question is why the pattern of the imagery activity is not accompanied by a direct sensory experience. Also the boundary between direct sensory experience and imagination is sometimes problematic. For instance, in the state between sleep and awake sensory images often enter into mind. During dreams one can have sensory images and eidetic memory is essentially sensory memory. I have a personal experience about an extended state of consciousness, or rather whole-body consciousness (this experience actually made me consciousness theoretician!). During this state I could see my thoughts as vivid

visual images and had also peculiar odour and taste experiences also reported to occur during mystic experiences.

The original belief was that imagination could involve p-adic-to-real phase transitions transforming p-adic imagery to nerve pulse patterns or membrane oscillations. The genuinely p-adic aspect of imagination would be analogous to a free choice of initial values in a computer simulation, which are then transformed to their real counterparts initiating neural activity.

It has truend out that this view is probably wrong. In the adelic vision about world both real and p-adic sectors for all p-adic number fields are present simultaneously. Imagination involves both cognitive and sensory aspect.

Why imagination does not involve sensory qualia could be explained in several ways.

1. Primary sensory qualia are realized at the level of sensory receptors and brain constructs only higher level symbolic representations of the sensory input and quantum entanglement binds these representations together. For imagination sensory receptor level is absent. This would also explain rapid eye movements during dreams as being related to the construction of visual qualia. Dreaming is indeed a cognitive activity which is learned gradually (at young age dreamer sees only static images). One could understand why motor activities are not accompanied by sensory experiences associated with motor pathways. The obvious reason for why sensory imagination should not create lively images is that this would lead to a dangerous mixing of the real and virtual. If this interpretation is correct, the study of whether feedback from brain to sensory organs occurs during sensory hallucination, provides a way to test whether sensory hallucination is a telepathic experience resulting from the sharing of mental images or whether it might be constructed in brain by feedback to sensory receptors.

2. Imagination could rely on membrane oscillations just as higher level cognition. The finding that imagination does involve patterns of activity at visual cortex similar to those associated with ordinary visual perceptions does not support this idea.

3. If higher level sensory representations are realized at the magnetic canvas, the difference between imagination and real sensory experience could result from the absence of the projection to the sensory canvas. Also the absence of negentropic entanglement could be the reason. This state of affairs could have a detectable EEG correlate: for instance, in 40 Hz resonance band. The projector MEs responsible for the cognitive representation could be activated but be p-adic and project only cognitive images. One can however wonder why magnetic body is at all conscious about imagined mental images if it does not share these mental images.

   If this explanation is correct, it would be also possible to have sensory experiences at brain level only. For instance, unconscious seeing would would be possible. This kind of blind vision is indeed known to be possible and will be discussed later.

Motor output and the ultimate output giving rise to our sensory experience might be very closely related: motor action could be like printing or some control activity and sensory and cognitive representations like pictures at the monitor screen. This picture looks attractive but might neglect some deep differences suggested already by the anatomy of the central nervous system. There are reasons to expect that the construction of sensory percepts and motor activity could be geometric time reversals of each other at some levels of the self hierarchy (MEs in certain time scales). This view would mean that motor action starts from a rough sketch for the outcome of the motor action and quantum jump by quantum jump ends up to the complete performance by a process which might be regarded as a gradual carving of a four-dimensional sculpture relying on both ordinary and time reversed dissipation serving as a Darwinian selectors so that the very many sketches would lead to the same outcome. Both these views might make sense: which view is correct depends on what time scale one is considering.

Are the space-time sheets and sub-CDs representing objects of the perceptive field generated automatically?

One of the poorly understood aspects of sensory perception is how objects of the perceptive field are generated at the level of cognitive representations. The problem is especially difficult in the

computational approach to consciousness. Natural idea is that the objects of cognitive representation directly reflect the objects of the physical world and that direct physical interaction creates these objects automatically. Various visual illusions demonstrate that also apparent objects are generated by sensory experience which suggests that it is nerve pulse patterns at the level of cortex which give rise to the objects of the perceptive field. In neural net approach to brain consciousness it is however far from trivial what these objects could be.

In TGD approach objects of the perceptive field correspond to mental images and thus sub-selves. sub-selves in turn naturally correspond to mind-like space-time sheets. Therefore the problem reduces to that of understanding how sensory input gives rise to mind-like space-time sheets: in particular, how the sensory input or nerve pulse activity induced by it determines the boundaries of the mind-like space-time sheets.

On of the basic laws about sensory experiencing is that only changes are experienced. Quantum model for the contents of consciousness of self implies this law at quantum level: only the averages of the increments of quantum numbers and zero modes are experienced consciously. By "Ontogeny recapitulates phylogeny" principles this law should have realization also at the level of dynamics of the space-time surface.

A possible space-time level counterpart of this law is that the primary at the level of primary sensory organ or secondary sensory stimulus at the level of cortex generates Kähler electric field proportional to the gradient of the stimulus. This creates however a problem. Kähler electric flux must be conserved in the approximation that vacuum Maxwell's equations are satisfied (they are not exactly satisfied since vacuum can carry currents of Kähler charge). Suppose that stimulus has a strong gradient: where does the Kähler electric flux go? The answer is simple: mind-like space-time sheet is generated and the flux goes to the mind-like space-time sheet through wormhole contacts! Since sensory stimulus varies rapidly at the boundaries of the objects of the external world, this means that the objects of the perceptive field are automatically represented by mind-like space-time sheets and give rise to selves, mental images in the cognitive representation! Several cognitive representations with different decomposition into objects are possible.

Also an alternative formulation of the title is as a question whether the sub-CDs serving as embedding space correlates for the mental images are generated automatically. One could argue that quantum jump sequence generates these sub-CDs and that directed attention could induce them. Negentropy Maximization Principle suitably generalized to state that the difference for the negentropies of the final and initial state is as large as possible for a given CD might favor the generation of negentropic sub-CDs. Also the argument for the arrow of psychological time suggests that NMP should have this kind of generalization.

Spectroscopy of consciousness

In its original form the spectroscopy of consciousness stated that one could assign to various qualia - say colors, tastes, or odors- frequencies so that the frequency patterns would provide a spectroscopic signature of the microscopic structure of conscious experience just like frequency patterns allow to deduce highly detailed information about the structure of a distant star. Spectroscopy of consciousness could be for the brain science what atomic spectroscopy has been for physics and chemistry.

In its original form this idea turned out to be un-realistic. Sensory qualia as such do not seem to correspond to frequencies. Rather, frequencies would code for the geometric data. For the cyclotron frequencies at least only the frequency ratios seem to have a deeper meaning. The fundamental frequencies assignable to CDs however define an exception in this respect. Spectroscopy of consciousness in a more realistic form would relate to the coding of geometric data such as positions, size scales and state of motion for the objects of the perceptive field. Frequency scales could also distinguish between higher level sensory representations assigned to brain regions of various size scales. The basic frequencies would be fundamentals and their harmonics assignable to CDs, cyclotron frequencies, and Josephson frequencies.

1. Spectroscopy of consciousness and size scales of brain structures

The size scales for various parts of brain could mapped to frequency scales characterizing the sizes of the parts of dark magnetic body so that a kind of collection of zoomed up images of brain regions would be obtained. Images of brain regions would be mental images assignable to

them to the sensory receptors entangled with them.

1. In [K84] it is found that a simple scaling law $v = \lambda f$ relating the apparent wavelength and phase velocity of EEG wave and more general em waves with its frequency allows to understand the basic anatomical structure of the central nervous system as reflecting evolution regarded as the emergence of new p-adic length scales. Scaling law allows also to predict which frequencies correspond to qualia experienced at a given level of the p-adic self hierarchy for a given conduction velocity of nerve pulses identified as an effective propagation velocity of EEG waves. Scaling law could also relate the sizes $L(magn) \sim L(EEG)$ of the radial magnetic flux tube structures (magnetic canvas or magnetic body) associated with the secondary sensory organs of size $L \sim \lambda$: $L(magn) \sim L(EEG) = c/f = (c/v)L$. Wave length of EEG could code for the size of the structure defining a kind of zoom-up of the brain region in question at the magnetic body.

2. The hierarchy of Planck constants allows to understand how photons for which the energies $E = hf$ are much below the thermal energy in standard quantum theory can be so important biologically. EEG photons would obviously have a rather large value of Planck constant. This hypothesis encourages the identification of the above defined velocity ratio as $r = c/v = \hbar/\hbar_0$. $\hbar$ would be Planck constant for say ELF photons communicating the signal to the corresponding dark layer of the magnetic body. In brain the dark photons could be transformed to ordinary short wave length photons by a leakage to $r = 1$ page of the Big Book in an energy conserving manner. The part of the magnetic body at a particular page of the Big Book would represent an r-fold zoom up of the brain region considered. If one takes seriously the proposal that DNA double strands act as relay stations between the brain and magnetic body, these values of Planck constants could be assigned with the flux tubes assigned to DNA nucleotides. I have proposed a similar scenario but with motivations coming from an attempt to understand how the realization of the genetic code at the level of dark nucleon physics discovered for few years ago could relate to the biochemistry and DNA [L2, K42, K113], [L2].

3. The fundamental frequencies would be most naturally cyclotron frequencies of charged elementary particles and biologically important ions at the magnetic flux tubes with large $\hbar$. TGD based nuclear physics predicts also the possibility of exotic chemically equivalent bosonic counterparts of the ordinary fermionic ions so that Bose-Einstein condensate of also these ions at cyclotron states could define macroscopic quantum phases. The corresponding higher level qualia would correspond to phase transitions changing cyclotron quantum numbers. Cyclotron energies scale as $\hbar$ so that energy scale would distinguish between different pages of the Big Book whereas frequency would be the same form them if the strength of the magnetic field is same for all the pages. Energy coding would be in question. These photons would be naturally generated at the magnetic flux tubes which suggests that they could be used for communications from the magnetic body to biological body.

2. Spectroscopy of consciousness, CDs, and Josephson junctions

Zero energy implies the notion of CD as embedding space correlate of self and the moduli space of CDs should play a key role in the understanding of the geometric qualia. Hence the spectroscopy of consciousness could relate very closely to the scales of CDs.

1. For a fixed value of $\hbar$ rather few size scales for CDs would be involved (nuclei, quarks, electron plus their possibly existing p-adically scaled up variants). The fundamental frequencies assignable to CDs would correspond to the time scales of CDs and would scale like $1/\hbar$ whereas energy would not be affected in the scaling of $\hbar$.

2. The problem is that for energies above thermal energy at physiological temperatures the size scale of CD should correspond to those assignable to very heavy particles. If only photon energies above thermal energy are relevant for biology the frequencies 10 Hz and 1 kHz assigned to electron and quarks would be excluded. If the leakage of classical em oscillations of given frequency leaking between different pages of the Big Book automatically generates

photons with scaled up energies, the problem disappears. Each of the r sheets of the many-sheeted covering would carry single quantum with the original frequency. The frequency would be r-fold harmonic of the frequency of the fundamental for the scaled up CD.

3. Also Josephson frequencies associated with the cell membrane identified as Josephson junction (also flux tubes connecting the membrane to DNA strand could serve as Josephson junctions) are involved. Josephson energies do not depend on $\hbar$ since the frequencies behave like $1/\hbar$ so that a hierarchy of representations at the pages of the Big Book in different time scales would be obtained as kind of spatio-temporal zoom-ups. In this case the communications would be naturally from the biological body tothe magnetic body and sensory data could be communicated in this manner.

4. The photon energy $E \sim .05$ eV assignable to the cell membrane potential energy is at the border of the thermal threshold and corresponds to a wave length $\lambda = 2.4 \times 10^{-5}$ meters. For M_{89} corresponding to intermediate gauge bosons one has $L(89,2) = L(178) \simeq 1.2 \times 10^{-4}$ m - the size scale of a large neuron and only 5 time longer than λ so that $r = 5$ would allow to overcome the thermal threshold. Could even intermediate gauge boson length scale be relevant for biology? The lifetime of intermediate gauge boson is much shorter than this time scale but one can ask whether photons could correspond to M_{89}.

3. Spectroscopy of consciousness and the moduli space of CDs

Consider next the concrete realization of the spectroscopy of consciousness in terms of the moduli space of CD.

1. The moduli space of CDs which is Cartesian product of part associated with M^4 degrees of freedom and CP_2 dgrees of freedom.In M^4 degrees of freedom one has the position of say lower tip parameterized by M^4 and the coordinates for the relative position of tips defining sub-set of the future directed light-cone M_+^4. The position in M^4 for the lower tip of sub-CD could code for the position of the object of the perceptive field.

2. The quantization of the proper time distance between the tips in octaves reduces the situation to a union of hyperboloids and a further discretization to a lattice of hyperboloid is suggestive by number theoretical considerations. The interaction of a photon with this kind of hyperboloid representing sub-CD is resonant if the frequency corresponds to the temporal difference between the tips as measured in the rest system of CD so that frequency coding of the Lorentz boost performed for sub-CD results.

3. One particular application would be the coding of the velocity (including its direction) of an object of perceptive field to the boost applied to sub-CD leaving its lower tip invariant. The positions of sub-CDs would not be updated continually and the sensation about continuous motion would result from the separate representation of the velocity. This interpretation is supported by a syndrome in which patient does not perceive motion and the positions for the objects of the perceptive field are updated with so long time intervals that the ordinary street traffic is too dangerous for the patient. The size scales of sub-CDs would give rise to a natural length scale hierarchy characterizing the sizes of the details of the representation. $M^2 \subset M^4$ fixed partially by the tips of CD defines preferred quantization axes for energy and spin and this choice would be relevant for purely quantal aspects of the sensory representation. The Lorentz boosts of discrete spectroscopies would code for the motion of the objects of perceptive field.

4. In CP_2 degrees of freedom moduli would correspond to $CP_2 \times CP_2$ such that for both factors a preferred point and a homologically trivial geodesic sphere S^2 has been selected. Thes choices give rise to flag manifold $SU(3)/U(1) \times U(1)$ labeling the choices of the quantization axes. In the recent case color rotations for the tips would represent the geometric data at the basic level. Also now discretization for the CP_2 points assignable with the second tip would be natural. $M^8 - H$ duality is fundamental element of quantum TGD and means that CP_2 points code for hyper-quaternionic planes of hyper-octonionic M^8 containing a preferred M^2. This would suggest that CP_2 could also code for geometric data as is suggested by the

findings of Barbara Shipman concerning the role of the flag-manifold $SU(3)/U(1) \times U(1)$ in the model of honeybee dance [A12]. The hyper-quaternionic plane assignable to the point of space-time surface at given point identified as a plane spanned by the Kähler-Dirac gamma matrices would correspond to a point of CP_2.

Spectroscopy of consciousness is considered in detail in [K84] - the spirit is of course extremely adventurous since so little is known and potential reader can take this as a mere exercise perhaps helping to identify the rules of the game. Especially fascinating is the possible connection of the theory of the magnetic qualia with atomic and nuclear spectroscopy: the structure of the periodic table could reflect itself directly itself in the spectroscopy of consciousness via cyclotron frequencies inversely propotional to the masses of ions. Various full electronic shells (He, Ne, Ar, Kr, Xe) correspond to a hierarchy of geometric qualia relating directly with the band structure of EEG. The periods also could also relate to the five-layered structure of sensory cortex (primary, secondary, etc... areas).

6.4.3   Is The Pain In The Toe In The Toe, In Brain, Or Somewhere Else?

The basic question concerns about the seat of the primary sensory experience. There are three options.

1. Standard neuroscience says that our sensory experience can be localized to cortex.

2. The apparently very naïve view is that sensory experience receives a contribution also from the primary sensory organs. Certainly primary sensory organs could be experiencers in TGD framework (and probably are) but this experience need not contribute to our sensory consciousness unless there is a negentropic entanglement between brain and sensory organs. Let us assume further that magnetic body plays no role.

3. The notion of magnetic suggests that sensory representations conscious-to-us correspond to a sequence of entanglements connecting the magnetic body and the primary sensory organ and perhaps including even to the object of the external world. This pictures differs in even more radical manner about the view of standard neuroscience. As far as the analysis of the sensory data is considered, this view need not differ in an essential manner from the standard view: magnetic sensory canvas could be analogous to a passive monitor screen. Magnetic body could also participate actively to the construction of the percept by sending virtual sensory feed-back through brain to the sensory organs.

The view 2) is not automatically excluded in TGD framework as it is in standard neuroscience.

1. The experiments of Libet about passive aspects of consciousness [J70] could be seen as supporting the hypothesis that the data is sent to the magnetic body, which causes the time lapse meaning that the sensory data is .3-.5 seconds old [K116].

2. The location of primary qualia to the level of sensory receptors would also allow to understand why sensory pathways are specialized to definite qualia despite the fact that there seems to be no obvious structural or functional differences at neuronal level. As already found, one could also understand the difference between imagination and sensory experience and why feedback to visual receptors (REM) is present during dreaming.

3. The identification of long term memories as multitime experiences containing contributions from the distant geometric past forces to consider the possibility that sensory organs are primary sensory experiencers whereas the standard dogma of the neuro science is that all sensory experiences occur at brain level at geometric now. The idea that also primary sensory organs are seats of the primary sensory experiences, could explain Libet's experiments, explains the observation that persons who have become blind gradually, lose their ability to have dreams and also the rapid eye movements and feedback from brain to auditory organs during REM sleep. It must be emphasized that these phenomena can be understood also in options 1) and 3).

One can represent several objections against the identification of the primary sensory organs as seats of our primary sensory experience (Option 2)[1].

1. The first class of objections is that our sensory perception involves a lot of computation (consider stereo vision as an example) and this computation cannot be performed at the level of the sensory organ. These objections look at first rather convincing but relate only to the cognitive aspects of sensory perception, not the to the primary sensory qualia. The computation can be carried out and involve also magnetic body and the back-projection to the primary sensory organs could allow to construct the percept as an artwork at the level of primary sensory organ.

2. The second class of objections is related to the explanatory power of the idea of standard neuroscience that entire sensory pathways containing also neurons of cortex are seats of the sensory experience (For option 1) they are involved with the construction of the sensory experience). This idea allows to regard brain as kind of musical instrument such that each neuron produces its characteristic sensory experience so that our experiences are combinations of the primitive neuronal experiences. For conscious information processing this is a crucial advantage: for instance, incoming nerve pulse patterns in associative regions of brain are consciously differentiated from each other as different modalities so that same nerve pulse pattern can have different meaning as sensory modalities. This objection suggests that the idea of restricting sensory experiences at the level of primary sensory organs is wrong. On the other hand, neuronal pathways and brain could be specialized to build cognitive representations and primary sensory qualia could be at the level of sensory receptors. The feedback from brain to the sensory receptor level could also make possible to manipulate the sensory input.

3. The view about brain as a collection of standard features which are activated by the sensory input and projected to the magnetic canvas and thus associated with the objects of perceptive field is in conflict with the idea that our experience receives a direct contribution from the primary sensory organs. Situation of course changes if one allows entanglement of brain with sensory organs.

4. The phenomena like dreams, hallucinations, synesthesia, phantom limb, and the experiences generated by stimulating neurons of sensory pathways and projected pain are obvious counter arguments against the idea that sensory organs are primary sensory experiencers (or form parts of them). The identification of the long term memories as multitime experiences allows in principle to overcome these objections, and a more detailed discussion of this point is in order.

In the following the explanations of various strange phenomena of sensory consciousness are studied and the explanations provided by the options 1), 2) and 3) are compared. It must be emphasized that the possibility that even sensory organs (and even neurons) have senses is not excluded by these arguments: what is however clear that *our* sensory landscape is constructed in cortex.

Back projections and cross projections

During REM sleep rapid eye movements occur and are thought to accompany dreaming. It is not however clear to me whether the correlation between rapid eye movements and visual dreaming is one-to-one. The ringing of the ears is a real physical process occurring in ear and these oto-acoustic emissions, as they are called, can be sometimes heard by even outsider [K80]. Rapid eye movements during dreams and oto-acoustic emissions can be regarded as back-projections from brain to primary sensory organs.

1. These phenomena can be understood without any difficulties in the options 1) and 3). For instance, rapid eye movements could be understood as feedback generated by a visual dream.

---

[1] The topic of discussion might look rather academic from the point of view of neuro science but it is not that in TGD framework: it took years to decide whether this idea could make sense or not.

2. For the option 2) rapid eye movements could be seen as necessary prerequisite of dreaming and to "qualiafy" imagined mental images.

Synesthesia involves cross-modal associations of form $A \to B$ (say visual to auditory).

1. In option 2) both dreams, hallucinations, and synesthesia rely on the feedback from brain to sensory organs to "qualiafy" the mental images. The prediction is that there should be a feedback, not only between sensory areas, but between sensory organs or the cross-associated qualia. This prediction is certainly testable. For instance, auditory-visual synesthesia should be lost if eyes are damaged.

2. The simplest view allowed by options 1) and 3) is that this kind of sensory leakage occurs at the level of neuronal connections.

Projected pain and phantom leg

Projected pain and phantom leg provide a further test for the proposed options.

1. For the standard explanation (option 1)) one must assume that the experience of pain is localized to the somato-sensory map in brain. The explanation of the projected pain is based on the observation that projected pain is felt in the body part which was very near to the body part contain the actual cause during early developmental stages. If somatosensory maps are not updated properly, projected pain becomes possible. This applies also to option 2).

2. For option 2) the explanation of phantom pain as a remembered pain and thus as a real pain in the geometric past when the limb still existed, is the simplest one. Projected pain cannot be however interpreted as a remembered pain since the physical cause of pain is in the geometric now. The assumption that the sensory pain (as distinguished from psychic pain) is a cortical sensation whereas only pure sensory experiences would be located in the primary sensory organs looks rather strange taking into account the universality of emotions as entropic qualia. What goes wrong with this argument is that the experience of pain is confused with the experience about where the pain is. The wrong location could result when the mental image about pain is projected in a wrong manner to the body map. A leakage between sensory pathways could cause the wrong localization.

3. Also for option 3) the simplest explanation of the phantom leg phenomenon is that the pain is geometrically remembered pain from the period when the leg still exists and thus would have a real cause. These memories would be analogous to the sensory memories of idiot savants allowing their memory feats and to the sensory memories created by the stimulation of temporal lobes. Why sensory memories are so rare has a simple explanation: their interference with sensory input from recent moment could have disastrous effects. Most memories are non-sensory sine they can be distinguished from the sensory input.

Also other possibilities can be imagined. The loss of the physical limb need not mean the loss of its magnetic counterpart so that phantom pain might be caused by either by a sensory input from other parts of leg projected to the part of the magnetic sensory canvas representing the lost leg. This could explain also the projected pain. The magnetic map of body coded by MEs could be partially out-of-date so that some parts of this map correspond to the structure of biological body during the early developmental periods. The pain in left arm during heart attack could be understood in this manner.

Color constancy and sensory organs as primary experiencers

The phenomenon of color constancy [J6], which forms one of the most important aspects of vision, is a further objection against the identification of sensory organs as primary sensory experiences. At least if one believes that colors are primary sensory qualia. If the object of the visual field is illuminated with a monochromatic light of constant intensity, its color does not change. This is quite contrary to what one might expect on basis of what is expected to happen in the color sensitive cones in retina detecting wavelengths concentrated around blue, red and green. A particular case of the color constancy phenomenon arises when entire visual field is illuminated with a monochromatic

light of a constant intensity: what is experienced is complete darkness. The ability to see the real colors of the objects of the external world, which is made possible by the color constancy phenomenon, is of course extremely valuable for survival purposes.

1. For option 1) color constancy is a challenge. Color constancy suggests that retina cannot be the primary sensory experiencers of color qualia since in this case our subjectively experienced world would be changing its colors continually. This conclusion might be too hasty. In fact, one could defend the hypothesis about sensory organs as primary sensory experiencers and use color constancy as a guide line in the attempts to guess how sensory representations for the objects of the external world are generated as sub-CDs residing at the retina.

2. In option 2) and 3) it can be assumed that the subtraction of the background involves computational processing at the level of brain. If the objects of the perceptive field are generated at the level of brain by nerve pulse patterns, this is probably the case. The subtraction of the background is possible to realize by excitatory and inhibitory projections and mathematically one can regard the sensory image of a colored object of a perceptive field as an integral function for the gradient of the intensity of the sensory input. For a monochromatic constant input the derivative vanishes as also integral function. The task therefore is to realize this integral function in terms of a neural circuit using excitatory and inhibitory inputs and outputs.

The explanation of the color constancy could reduce to the hypothesis that sensory qualia correspond to increments of quantum numbers rather than quantum numbers themselves.

1. If the color perception generated by the illumination at a particular wavelength depends only on the spatial gradient of the illumination, color constancy follows as a consequence. Since the eye is performing saccadic motion, this translates to a temporal gradient of illumination. The temporal change of the illumination at a particular wavelength should thus induce a particular color quale. But this is consistent with the assumption that color qualia correspond to the increments of color quantum numbers in the quantum jump. This model explains also why the saccadic motion is necessary to generate color qualia, and qualia at all. Quite sensory percepts result only when physical change is involved. Saccadic motion maps the gradients of illumination to increments of color quantum numbers.

2. One might also understand why a rotating Benham top containing only black and white regions can produce color sensations. Since both the saccadic motion and the motion of disk are involved, one can imagine that for a rotating disk the proportions of various primary qualia are affected such that a net color is perceived. For instance, the intensity of the perceived color could depend on the velocity with which the eye crosses the intensity gradient and this dependence could depend on wavelength.

All geometric aspects of sensory experiences should reduce to representations generated by zero modes, in particular zero modes characterizing classical Kähler field, which can reduce to pure electromagnetic (vision?) or Z^0 field (auditory experience?). Color constancy could be understood if the incoming light intensities associated with the wavelengths around three basic colors generate Kähler electric fields proportional to the gradient of the intensity. If the gradient is strong, as it is on the boundary of the retinal or neural image of the object, the conservation of the Kähler electric flux forces the generation of mind-like space-time sheet at which part of the flux goes.

Thus retina would automatically create representation for the objects of the visual field as mind-like space-time sheets, which in turn could give rise to sub-selves representing objects of the visual field as mental images! These objects need not however correspond to our conscious experiences. In fact, the boundaries of all objects of perceptive field should be generated by strong gradients and same principle would apply also to the higher level representations of sensory information. A gradient of Kähler (electric) field proportional to the gradient of primary/secondary sensory stimulus is generated in primary/secondary sensory organ and automatically generates mind-like space-time sheets, which give rise to sub-selves representing the decomposition of the perceptive field to objects.

Blind sight and Anton's syndrome

In blind sight cortically blind patient claims to be blind but is actually able to locate objects in the visual field when asked to do that. By training the patient can even develop some kind of primitive conscious experience of motion, shape and color.

1. For option 1) blind sight looks first problematic since the basic assumption is that primary visual qualia are generated at the level of retina. If the entanglement with retina is lost the visual qualia at retina are not assigned with the magnetic sensory canvas and the person is not conscious that his eyes see. The primitive conscious experiences of motion, shape and color would arise at the sub-cortical level make it possible to locate objects in the visual field. Blind sight would be also vision without cortical cognition (such as feature recognition). Training would generate gradually entanglement between sub-cortical areas and the cortical areas responsible for projections to the sensory magnetic canvas.

2. In option 2) the explanation for the blind sight would be the existence of two separate visual systems. Possible candidates for these systems as regions of cortex have been even identified [J26].

3. In option 3) blind sight has several explanations. The simplest explanation is that the negentropic entanglement between magnetic body and brain is absent so that brain would see consciously but not the magnetic body representing us. Blind sight could thus be interpreted as a support for the notion of magnetic body. A test for the magnetic canvas hypothesis might be based on the elimination of the MEs responsible for the sensory projection to the magnetic canvas somehow. This option is of course not the only possible one. There is entire p-adic hierarchy of increasingly refined visions involving retinal vision, amygdalar vision, and various visions corresponding to sensory areas of cortex.

The patient suffering from Anton's syndrome is cortically blind but claims that he sees but behaves as if he were blind and confabulates all kinds of explanations for his behavior.

1. The advocate of option 1) could argue that patient sees at the subcortical level and hence has pure experience of vision without any cortical cognitive processing of what he is seeing. Person is cognitively blind. There would be no recognition of objects in the visual field, to say nothing about associations and memories related to these objects. Therefore sensory (or subcortical) seeing would not help the patient much and he would behave effectively as a blind person. One could even consider the possibility that patient gradually loses the ability to see because this ability is not useful anymore. A possible test (probably already carried out) for the hypothesis is to check whether patient can show the direction of an intensive light source (even this might require "cognitive seeing").

2. The standard explanation (option 2) is that patient is not conscious about being blind: the fact that patent seems to gradually accept the situation that he does not see, supports this explanation. It would be possible to have the experience of seeing without actually seeing.

3. Option 3) would allow the possibility that the parts of the cortex responsible for projecting sensory data to the sensory magnetic canvas remain intact and that the visual images are visual memories. It would not be surprising that this useless vision would be gradually lost. Note however that lower level visual systems might work.

Woman without body

In his book "The man who mistook his wife for a hat" [J117] Oliver Sacks tells about a tragic situation in which his patient lost totally her body image. Body image is provided by proprioception together with vision and sense of balance. The sensory neurite suffered by the patient destroyed patient's proprioceptive sensory pathways. Patient did not however lose tactile senses. The proprioceptive homunculi in patient's parietal lobes suffered no injury. Patient learned to cope with everyday activities by using vision and sense of balance and all kinds of clever feedback and feedforward mechanisms to compensate the lost proprioception. For instance, patient regained her

ability to speak, to keep her bodily posture and walk. She however lost her balance immediately if she closed her eyes. Patient did not however get back her phenomenal body image in this manner.

The loss of body image is not a problem for option 2) since neural pathways are prerequisites of quantum entanglement between brain and sensory receptors (also these might have been destroyed). Options 1) and 3) can explain the loss of body image without difficulties. These options could even allow to regain the body image artificially, for instance by artificial neuronal stimuli providing a representation for the positions of various body parts. In both cases artificial electric stimulation of cortex should generate tactile sensations of some kind.

Part II

TIME AND CONSCIOUSNESS

Chapter 7

Time and Consciousness

7.1 Introduction

The identification of moments of consciousness as quantum jumps between quantum histories suggests that our common sense picture about the time evolution of universe might be badly misguided by the restrictions posed by the basic features of our conscious experience. What one can do is to try to develop the most general picture about the cosmology of consciousness consistent with our own conscious experiences and try to identify our position in this picture. Already in its recent form TGD inspired theory of consciousness can give quite restrictive constraints on this Grand Scenario.

The understanding of how psychological time and its arrow emerge has been perhaps the most longstanding problem of quantum TGD and TGD inspired theory of consciousness. By quantum classical correspondence the arrow of subjective time should be mapped to the arrow of geometric time at the level of conscious experience. In similar way the asymmetry between subjective future and past should be correspond to an asymmetry between geometric future and past. What this means at the level of details has been far from clear and I have proposed many partial answers to the question about the arrow of geometric time.

For instance: the geometric future inside light-cone contains much more room than geometric past so that the space-time region about which the contents of conscious experience are about tends to diffuse to the direction of the geometric future defined by light-cone proper time; perhaps the flow of geometric time corresponds to a wave front of intentional action identifiable as a phase transition changing intentions identified as p-adic space-time sheets transformed to real space-time sheets; maybe the space-time sheet assignable to self topologically condensed to a larger space-time sheet shifts in quantum jumps to the direction of geometric future some average temporal distance perhaps defined by CP_2 length scale. All these proposals have provided only partial answers, have led to paradoxes, and failed to give a firm quantitative grasp about the situation.

Also the original wrong view about the correspondence of real and p-adic numbers has generated a lot of confusion. The natural belief of topologist would be that p-adic space-time sheets are mapped to their real counterparts by a continuous map (some variant of what I called canonical identification making sense in p-adic thermodynamics). This map did not however respect symmetries and was inconsistent with field equations. Finally I was able to accept the natural belief of algebraist: reals and various p-adic number fields must be glued to together along rationals and common algebraic numbers to achieve generalization of the number concept and also that of embedding space. What was difficult to accept was the highly non-intuitive implication that most points of p-adic space-time sheets are at spatial and temporal infinity in real (but not in p-adic) sense so that cognition and intentionality would be literally cosmic phenomena and only cognitive representations would be realized in a finite space-time volume in real sense (causal diamond) in terms of intersections of real and p-adic space-time sheets consisting of rational and some algebraic points.

The development visions about zero energy ontology (ZEO) and about hierarchy of Planck constants labelling a fractal hierarchy of quantum criticalities and dark matters have been instrumental in developing the recent phenomenology of consciousness and time.

I have tried to tidy up the chapters so that they would not contain too many mammoth bones. Since I can use only a finite amount of time to documentation purposes, I have not been completely successful and this chapter as also others might contain statements which represent earlier archeological strata. I hope that reader could forgive this. Benevolent reader might even take these chapters as documents about how ideas have developed.

7.1.1   The Concepts Of Self, Time, And Subjective Memory

The notion of self has developed gradually to its recent form. Consider first the original proposal and its evolution before the discovery of zero energy ontology (ZEO).

1. I identified self as a subsystem able to remain unentangled during quantum jumps consisting of unitary processes U defining what I called "informational time evolutions" followed by a state function reduction which in zero energy ontology includes also state preparation occurring for the negative energy part of the state (zero energy state corresponds to physical event in positive energy ontology with negative and positive energy parts of the state being identified as the counterparts of the initial and final states of the event). The obvious counter argument is of course that un-entangled states are not stable.

2. Bound state entanglement is stable against state function reduction so that consciousness would be lost the bound state entanglement is generated. This would stop the sequence of state function reductions initiated after the U-process.

3. The notion of number theoretic entropy allows to assign entanglement negentropy to algebraic entanglement probabilities so that NMP favors the generation of entanglement in this kind of situation. This encourages the hypothesis that subsystem does not lose consciousness if it generates algebraic entanglement with environment. This would correspond to the fusion to the sea of consciousness in the spiritual terminology. Algebraic entanglement is possible in the intersection of real and p-adic worlds which in turn encourages the proposal that living matter corresponds to this intersection, and is therefore a critical phenomenon in number-theoretical sense so that evolution involves in an essential way the generation of algebraic entanglement.

   It turned out that consistency with quantum measurement theory requires that density matrix for the reduced state is projector and thus proportional to unit matrix. Unitary entanglement - typically associated with quantum computers - gives rise to projector as density matrix in the case of two entangled systems. This only generalizes the standard quantum measurement theory in that the reduced density matrix an be a higher-dimensional projector.

4. One can say that self is a subsystem behaving like its own sub-Universe (with respect to NMP). What this really means quantitatively is far from obvious.

The precise definition of self however remained a longstanding problem and I have been even ready to identify self with quantum jump. Also the understanding of the relationship between experienced time and geometric time has been a longstanding challenge. Zero energy ontology allows what looks like the final solution of the problems.

1. Self indeed corresponds to a sequence of quantum jumps integrating to single unit, but these quantum jumps correspond to state function reductions to a fixed boundary of CD leaving the corresponding parts of zero energy states invariant. The zero energy state is a superposition of the zero energy states associated with the CDs with only second boundary at fixed light-cone boundary. Hence the distance between the tips of CDs in the superposition varies.

2. In positive energy ontology these repeated state function reductions would have no effect on the state but in TGD framework there occurs a change for the second boundary. This explains how the experience of subjective time and its arrow emerges. The average distance between the tips of CDs increases and self experiences flow of time. These repeated state function reductions correspond to unitary process. Self dies when the first reduction to opposite boundary of CD occurs and creates new self. The lifetime of self is the increase of average distance between the tips of CDs in superposition. The first quantum jump to

the opposite boundary corresponds to the act of free will or wake-up of new self. In particle physics time scales this first corresponds to the quantum measurement.

The hypothesis that the experiences of self associated with the quantum jumps occurred after the "wake-up" sum up to single experience, implies that self can have memories about earlier moments of consciousness. Therefore self becomes extended object with respect to subjective time and has a well defined "personal history". If temporal binding of experiences involves kind of averaging, quantum statistical determinism makes the total experience defined by the heap of the experiences associated with individual quantum jumps reliable. Subjective memory associated with sensory mental images has duration of about .1 seconds from the temporal resolution of sensory experience: it is quite possible that our self has much longer duration. The subjectotemporal sequences of sub-selves make possible to remember the digits of a phone number.

The identification of the fundamental volume of attention as a causal diamond (CD) provides answers to more detailed questions. This identification means also that at the level of embedding space causal diamond of embedding space (or their superposition) serves as the correlate of self whereas at space-time level space-time surface (or their superposition) serves as a correlate of self.

Subsystem X possessing self behaves essentially as a separate sub-Universe with respect to NMP. An attractive hypothesis is that the experience of self is abstraction in the sense that the experiences of sub-selves X_{ij} of X_i are abstracted to average experience $\langle X_{ij} \rangle$. This implies that the experiences of sub-sub-...selves of X are effectively unconscious to X. This self hierarchy is infinite and has entire Universe, God at the top. Temporal binding with averaging implies that experiences of individual selves are reliable and abstraction brings in the possibility of quantum statistical determinism at the level of ensembles.

7.1.2 Negeentropy Maximization Principle And Ethics

Negentropic entanglement corresponds to a density matrix, which is higher-dimensional projection operator. Number theoretic entanglement negentropy for a prime appearing as a factor of the dimension of the density matrix is indeed positive. Negentropic entanglement could be seen as a quantum physical correlate for love, understanding, and various states of consciousness with positive coloring.

NMP states that the entanglement entropy is reduced in the first state function reduction to the opposite boundary of CD. The subsequent reductions do not change the part of the state at this boundary so that negentropy is not changed. The negentropy for sub-CDs associated with the mental images of self can however increase by repeated state function reductions to the opposite boundary of sub-CD.

NMP allows too variants.

1. The strong variant of NMP implies that entanglement entropy of the state at opposite boundary of CD is not only reduced in state function reduction but also the entanglement negentropy of the resulting state at opposite boundary of CD cannot be lower than it was at original boundary of CD. One can wonder whether this leaves any free will and whether only good deeds, which would not be deeds since no selection is involved, are possible.

2. Second variant of NMP allows reduction to any sub-space of the space defined by a projection matrix appearing in the density matrix. Self can thus choose between good and evil. In this case, entanglement entropy would be always reduced in state function reduction but the entanglement negentropy of the state at the opposite boundary of CD need not be higher than that at the original boundary.

In religious view these options correspond to God which allows only good deeds and to God that allows the sinner to choose between Evil and Good.

7.1.3 Cosmology Of Consciousness

The idea about cosmology of consciousness is inspired by the prediction of the infinite self hierarchy and by quantum-classical correspondence principle [K56]. The expectation is that the fractal structure of the many-sheeted space-time should directly reflect the general structure for the cosmology

of consciousness. For instance, the p-adic evolution of consciousness should have its counterpart at the space-time level. Indeed, there are good reasons to believe that 4-surfaces have decomposition into real regions and p-adic regions and that one can assign to each real region a finite prime p characterizing the effective p-adic topology of the real space-time region (or of light-like 3-surface or partonic 2-surface) and the p-adic topology which the real region is near criticality to transform to. In zero energy ontology this transformation indeed makes sense. Just like configuration space is conjecture to have a decomposition into regions D_P labelled by infinite p-adic primes P, the space-time surface decomposes into real regions labelled by finite primes appearing in the decomposition of P.

Fractality suggests that there are conscious universes within conscious universes and the nested structure of the topological condensate suggests that experiences of universes involve kind of abstractions about the experiences of the sub-universes they contain. The prediction of infinite hierarchy of selves and summation hypothesis for the experiences of selves is in accordance with this expectation.

Mind-like space-time sheets were introduced originally as space-time sheets of finite temporal duration or alternatively as space-time sheets for which the classical determinism in the standard sense of the word fails. In zero energy ontology all space-time sheets have finite temporal scale and zero energy states associated with them have mind-like aspects. For instance, the positive and negative energy parts of the fermionic state define a quantum representation for an abstraction for the Boolean statement $A \to B$ with various instances of a and b appearing in the superposition.

Since mind like space-time sheets have a bounded time duration, one cannot assign to a quantum jump a single value of the geometric time. Rather, our psychological time would be associated with one of the infinitely many irreducible sub-experiences associated with mind like space-time sheets and the values of the psychological time range from zero to infinity. Since selves contain sub-selves with various values of psychological time, experiences are actually multitime experiences with respect to both geometric and subjective time. The entire 4-dimensional space-time is a living system: both the geometric future and past are living and participate in each moment of consciousness. Selves have increasingly longer geometric and subjective memories and that at the limit of entire universe selves have infinitely long subjective memory.

7.1.4   Four-Dimensional Brain

The hypothesis that entire space-time surface is populated by mind like space-time sheets realized in concrete way in zero energy ontology in terms of causal diamonds (CDs) representing systems participating in every moment of consciousness, means also dramatically new way to understand brain. For instance, the problem of memory trivializes. Geometric memory provides simulations and expectations for what happened and will happen whereas subjective memory has interpretation as immediate short term memory. The most plausible interpretation of long term memories is as geometric memories represented by multitime snapshots. This hypothesis explains the practically unlimited capacity of autobiographical memory and also other basic aspects of long term memories and avoids the counter arguments against the neural net models of long term memory.

The paradigm of four-dimensional brain (and body!) forces to reconsider the basic dogma of neuroscience stating that sensory consciousness is associated with brain only and explains nicely the results of Libet's experiments. A concrete model of the long term memory is based on quantum mirror mechanism: experience long term memory means looking at a quantum mirror at a distance of say light years. The attribute "quantum" means that there is no need to code information to a classical signal, just time like entanglement made possible by the classical nondeterminism of Kähler action and by p-adic nondeterminism is enough.

In ZEO self-organization is 4-D. It is 4-D pattern (time evolution of say magnetic body) which evolves quantum jump by quantum jump to the asymptotic pattern. This has profound implications for understanding of say morphogenesis and emergence of behavioral patterns.

7.1.5   Evidence For TGD Based Time Concept

The new concept of time follows from the quantum jump between quantum histories concept so that tests for the latter are indirect tests for the former. Perhaps the strongest support for the new concept of time comes from the requirement of the internal consistency of the world view.

The phenomenon of dissipation is paradoxical from the point of view of standard physics. It is generally accepted that fundamental laws of classical physics are reversible whereas everyday reality is manifestly irreversible. Thus the situation is rather schizophrenic. Two worlds, the reversible and extremely beautiful world of fundamental physics and the irreversible and mathematically rather ugly, irreversible "real" world, seem to exist simultaneously. Quantum jumps between quantum histories concept solves the paradox and one can understand dissipative world as an effective description forming "almost" envelope for the sequence of reversible worlds understood as entire time evolutions.

Quantum jumps between quantum histories concept explains the peculiar time delays of consciousness revealed in the experiments of Libet and Kornhuber relating to active and passive roles of consciousness [J70, J34] and the causal anomalies revealed by the experiments of Radin and Bierman [J36, J37, J56]. TGD predicts "tribar effect" as a general signature for the quantum jump between quantum histories concept.

A further implication is quantum theory of self-organization. Self-organization means the organization of selves leading to fixed point patterns analogous to those generated in Benard flow. This means that dissipation serves as a Darwinian selector of both genes and memes. Dissipation is present also at the elementary particle level and leads to the selection of the p-adic effective topologies of elementary particle space-time sheets. Black-hole elementary particle analogy suggests that the allowed p-adic primes are given the p-adic length scale hypothesis $p \simeq 2^k$, k power of prime.

ZEO brings in an even more radical new aspect. What evolves in quantum self-organization is not a superposition of 3-surfaces but a superposition of 4-D time evolutions represented by preferred extremals of Kähler action connecting two space-like 3-surfaces at the opposite boundaries of CD evolves. These space-time surfaces represent 4-D patterns, behaviours rather than 3-D states of say brain. Entire quantum history of space-time approaches in self-organization to an asymptotic quantum history. This view has very powerful implications - consider only the modelling of morphogenesis and learning.

A further new aspect of self-organization relates to the hierarchy of Planck constants and NMP. The basic prediction is that the value of Planck constant $h_{eff} = n \times h$ labelling an infinite hierarchy of critical systems tends to increase spontaneously (criticality is reduced as some conformal gauge degrees of freedom having conformal structure become physical), and that living systems tend to stay at criticality (homeostasis and metabolism) and therefore oppose this process. One can indeed understand this in terms of NMP.

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` [L17].

7.2   TGD Based Concept Of Time

TGD based notion of time involves several new aspects.

1. Quantum jump as occurring between entire quantum histories rather than time=constant snapshots of a single history is certainly the most decisive new element. The necessity to differentiate between subjective and geometric time is immediate implication of this identification.

   The basic challenges could be formulated as questions. What is the precise identification of self and how does self relate to quantum jump? How does the experienced flow of time emerge? How does this flow correlate with the increase of the value of geometric time around which the contents of consciousness experiences are located? How the arrow of time emerges?

2. The classical non-determinism of Kähler action is a fundamental ingredient: without it time would be lost in the sense that the contents of our conscious experience would not be localized with respect to geometric time and one could not understand the emergence of psychological time and its arrow. Non-determinism leads to the notions of ZEO (ZEO) and causal diamond (CD) defining the embedding space correlate of self.

3. As discussed in the introduction, ZEO eventually led to the identification of self as a sequence of state function reductions to a fixed (call it passive) boundary of causal diamond (CD) and leave the part of zero energy state at it unchanged.

   (a) In standard quantum measurement theory the repeated state function reductions have no effect on the quantum state. In ZEO the boundary of CD at which reductions take place (call it active) can change. This occurs in elementary particle time scales in every quantum measurement and the sequences of state function reductions at passive boundary are short. In ZEO they the sequences of state function reductions to a fixed boundary give rise to the experienced flow of time and self.

   (b) The experienced flow of time corresponds to the increase of the average distance between the tips of CDs appearing in quantum superposition of CDs. The arrow of subjective time can correspond to both directions of geometric time and changes when the first quantum jump to the opposite boundary of CD - eventually forced by NMP to occur - takes place.

      Self dies when a reduction to the opposite boundary of CD eventually forced by Negentropy Maximization Principle (NMP) occurs and creates new self at it.

   (c) A further new element is related to the change of the arrow of geometric time occurring when the first state function reduction to the opposite boundary of CD occurs and induces a dramatic change of the state. The interpretation is as an act of volition. The change of the arrow of geometric time makes also possible classical communications with geometric past, which leads to a new view about memory. The new view about time leads also to the notion of four-dimensional brain implying a new manner to see what long term memories are, and the vision about space-time as a four-dimensional organism.

   (d) CD serves as embedding space correlate of self - kind of 4-D perceptive field - and space-time surface inside CD as space-time correlate of consciousness. Our conscious experience is about 4-D space-region - or rather about changes in the superposition of these region occurring during repeated reductions at the passive boundary of CD. Naturally the change occurs at active boundary of CD whereas the passive boundary remains unchanged and corresponds to system remaining un-entangled as long as self "lives".

4. TGD Universe is postulated to be quantum critical. Classical non-determinism leads to the realization of quantum criticality of TGD Universe as an infinite hierarchy of critical systems labelled by the values of Planck constant $h_{eff} = n \times h$. TGD Universe is like a hill at the top of hill at the top of hill... The increase of Planck constant corresponds to a reduction of criticality and tends to occur spontaneously: it is however governed by NMP.

   Living systems can be seen as systems trying to stay at criticality (homeostasis and metabolism). During single sequence of reductions at passive boundary of CD its CD size would increase linearly by integer shifts but neither h_{eff} nor negentropic entanglement in the scale of CD would increase.

   The flow of time defined by the sequence of the first reductions at opposite boundary of CD would naturally correspond to average increase of h_{eff} and by NMP generation of or at least possibiity of generatio of negentropic entanglement. This depends on whether NMP only allows reduction to a higher- than 1- dimensional space assignable to the projector part appearing in the density matrix or whether NMP forces. My personal experiences about real world suggests that the first option is more realistic. This does not however mean that wisdom can be gained only by dying. The values of h_{eff} of sub-CDs associated with mental images would increase and mental images of self would get wiser and this could postpone the first state function reduction at the opposite boundary of CD for self.

   This view looks like the exact opposite of the standard view inspired by second law but is not in conflict with it since the two notions of negentropy are different.

7.2.1 The Three Non-Determinisms

TGD Universe is characterized by a "holy trinity" of non-determinisms. The first non-determinism is associated with quantum jumps between quantum histories and is what makes possible subjective existence and consciousness. One achieve determinism by giving up the assumption that initial values at fixed time define the time evolution and replaces 3-dimensional sections of space-time surface with what I have called "mind-like" space-time sheets. The attempt to realize this picture geometrically led to zero energy ontology. Second non-determinism is classical non-determinism of Kähler action and is to symbolic representations and perhaps also with macroscopic volition. The third non-determinism is inherent to all p-adic field equations and might correspond to the non-determinism of imagination and thus makes possible cognition and intentionality. There is no conscious experience associated with classical nor with p-adic non-determinism as dualist might think. These three non-determinisms have turned out to be basic building bricks of TGD inspired theory of consciousness.

The original identification of the geometric correlates of selves was as mind like space-time sheets. In ZEO all real space-time sheets satisfy the criterion for "mind-likeness" and therefore serve as correlates for selves. Therefire the notion of "mind-likeness" becomes reduntant.

7.2.2 Some Aspects Of Classical Non-Determinism

The general view about the classical non-determinism of Kähler action and its role in TGD and TGD inspired theory of consciousness has developed gradually and still does so. The newest developments relate to the application of quantum gravitational hologram principle in TGD framework. What has been however clear for a long time is that TGD inspired theory of consciousness falls or stands with the classical non-determinism.

Vacuum extremals

Any 4-surface which belongs to $M^4_+ \times Y^2$, where Y^2 is so called Legendre manifold of CP_2 representable as

$$P_i = \nabla_i f(Q_1, Q_2), \quad i = 1, 2 \ ,$$

where f is arbitrary function and (P_i, Q_i) are some canonical coordinates of CP_2, is vacuum extremal of Kähler action. For these vacuum extremals the signature of the induced metric can be either Minkowskian or Euclidian. There are also vacuum extremals with Euclidian signature of the induced metric. The so called CP_2 type vacuum extremals have light like random curve as light cone projection. These extremals are isometric with CP_2 so that the signature of the induced metric is Euclidian. These extremals provide a model for elementary particle.

Only the non-vacuum deformations of the vacuum extremals are physical. The remnants of the huge vacuum non-determinism are expected to give rise to the non-determinism required by symbolic representations of conscious experience at the level of space-time dynamics giving rise to language as a special case. Of course, classical nondeterminism of the Kähler action might also relate to the nondeterminism of volition. It seems that the CP_2 type extremals representing cognitive neutrino pairs are crucial for our cognitive consciousness and its transformation to symbolic representations.

"Mind-like" space-time sheets as deformations of vacuum extremals

The original proposal that "mind-like" space-time sheets and "matter-like" space-time sheets differ in the sense that the first ones are non-deterministic and consist of a collection of 3-surfaces with time-like separations whereas the latter are deterministic or at least have infinite size in time direction by standard conservation laws. In zero energy ontology "mind-like"ness in this sense holds true quite generally.

Physical intuition suggests that the gluing vacuum extremals to a material space-time sheet $X^3(Y^3)$ by # (topological sum) contacts, an interaction results and deforms vacuum extremal slightly and that in some cases this leads to a new preferred extremal with a slightly larger value of Kähler function and hence a larger value of the vacuum functional making the 3-surface more

probable. These deformed vacuum extremals are expected to be still non-deterministic although the non-determinism should be reduced considerably. Via their interactions with the environment, ("mind-like") space-time sheets provide sensory and symbolic representations for some aspects of the surrounding world. Hence they are quite generally natural geometric counterparts of selves. For instance, the time evolution of our body would correspond to this kind of deformed vacuum space-time sheet with a finite time duration. The space-time surfaces $X_i^4(Y^3)$ are expected to be very nearly identical outside the time-interval characterizing the size of the mind like space-time sheet: this in turn implies time localization for the non-determinism of quantum jump and therefore for the contents of conscious experiences associated with the mind like space-time sheet.

In ZEO "mind-like" space-times sheets correspond to a collection of 3-surfaces belonging to boundaries of causal diamond (CD) and its sub-CDs corresponding to the classical correlate for radiative corrections. Generalized causality makes it possible to avoid paradoxical situation: assuming that space-time surface $X^4(Y^3)$ is preferred extremal of the Kähler action for Y^3 one might always find a new 4-surface giving rise to a smaller Kähler action by gluing suitable vacuum extremal to $X^4(Y^3)$.

Massless extremals as quantum gravitational holograms

Massless extremals (MEs) belong to the fundamental solutions of field equations. It has become also clear that they play the role of quantum gravitational holograms. The hologram principle of quantum gravitational theories roughly states that the quantum theory in space-time with boundary reduces to a conformal quantum field theory at the boundary. If Kähler action were deterministic, precisely this would happen. The construction of WCW geometry relies crucially on the assumption that the complications due to the non-determinism of Kähler action does not radically modify the construction based on the assumption of a complete determinism.

It has indeed turned out that the basic construction in which everything reduces to the light like boundary of M_+^4 (moment of big bang) acting as a hologram in quantum gravitational sense and defining conformal quantum theory, generalizes. This construction survives as a template in a more general construction in which also the light like boundaries of MEs having always light like M_+^4 projection are taken into account besides δM_+^4 as surfaces at which initial values can be fixed arbitrarily. This brings in also time absent in a strictly deterministic theory. Thus the quantum gravitational hologram defined by δM_+^4 is replaced by a fractal structure formed by δM_+^4 and Russian doll hierarchy of the light like boundaries of MEs inside MEs. The super-canonical and super-conformal invariances of the light like boundaries indeed generalize in an elegant manner thanks to the basic properties of MEs.

The "light like selves" defined by the boundaries of MEs cold be fundamental in TGD inspired theory of consciousness. The super-symplectic quantum states associated with these boundaries are genuine quantum gravitational states defined by WCW functionals, whose dependence on the bosonic fiber degrees of freedom of WCW does not reduce to a mere vacuum functional given by the exponent of Kähler action. This means that these states do not possess any quantum field theoretic counterparts. They are state functionals in the world of worlds (WCW), so to say, and therefore should represent highest level in the hierarchy of quantum control in living systems. Thus it is the higher abstraction level of quantum gravitational states which connects conscious intelligence and quantum gravitation.

7.2.3 Quantum Jump As Moment Of Consciousness

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

The general structure of quantum jump

It seems that TGD involves "holy trinity" of dynamics.

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

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

3. The dynamics of state function reductions at opposite boundary of CD defines the dynamics of volition (active aspects of consciousness).

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

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

$$\Psi_i \to U\Psi_i \ ,$$

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

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

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

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

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

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

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

$$\Psi_f^0 \to \ldots \to \Psi_f \ ,$$

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

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

1. The assumption that localization occurs in zero modes of the WCW would pose very important consistency condition: there is one-one correlation between the quantum numbers in quantum fluctuating degrees of freedom in some state basis and the values of the zero modes. This in fact has interpretation in terms of holography: classical degrees of freedom in space-time interior correlate with fermionic degrees of freedom assignable to string world sheets and partonic 2-surfaces. This together with the fact that zero modes are effectively classical variables, implies that the localization in zero modes corresponds to a state function reduction.

2. Measurement theory requires an entanglement between zero modes and quantum jumps of the physical state. The addition of a measurement interaction term to the Kähler-Dirac action coupling to four-momentum and color quantum numbers of the state and also to more general conserved quantum numbers allows an explicit realization of this coupling and induces the addition of an analogous measurement interaction term to Kähler action [K121]. This term implies the entanglement of the quantum numbers of the physical states with zero modes.

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

Is the complete localization in zero modes really necessary?

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

1. QFT picture strongly suggests that sub-system must be defined as a tensor factor of the space of WCW spinors at given point Y^3 of WCW . This suggests that subsystem should be defined as a function of Y^3 and should be a local concept. An important consequence of this definition is that entanglement entropy gives information about space-time geometry.

2. WCW spinor field can be formally expressed as superposition of quantum states localized into the reduced configuration space consisting of 3-surfaces belonging to light cone boundary. Hence WCW spinor field can be formally written as

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

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

3. WCW has fiber space structure. WCW metric is non-vanishing only in the fiber degrees of freedom and since the propagator for small fluctuations equals to the contravariant metric, fiber degrees of freedom correspond to genuine quantum fluctuations. WCW metric vanishes in zero modes, which can be identified as fundamental order parameters in the spirit of Haken's theory of self organization. The requirement that various local symmetries act as gauge symmetries, provides good reasons to expect that *entanglement coefficients in the fiber degrees of freedom are gauge invariants and depend on the zero modes parametrically*. The one-one correlation between quantum numbers of the state assignable to fiber degrees of freedom and classical variables identified as zero modes would encourage the assumption the a complete localization occurs in zero modes. A weaker condition is that localization occurs only modulo a finite measurement resolution.

4. The original argument was that the non-existence of metric based volume element in zero modes forces the wave functions in zero modes to have a discrete locus. There however exists a symplectic measure defined by the symplectic form in zero modes. It does not however allow a complexification to Kähler form as it does in quantum fluctuating degrees of freedom. This symplectic from could define a hierarchy of integration measures coming as restrictions of $J \wedge J... \wedge J$ with n factors to $2n$-dimensional sub-manifolds. Under some additional conditions- maybe the homological non-triviality of J and the orientability of the sub-manifold are enough, this measure would define a positive definite inner product and one would have a hierarchy finite-dimensional sub-spaces of zero modes. The maxima of Kähler function with respect to zero modes replace naturally the continuum with a discrete set of points and define the counterpart of the spin glass energy landscape consisting of the minima of free energy. Effective finite-dimensionality and even effective discreteness would be achieved.

5. The time development by quantum jumps in zero modes is effectively classical: Universe is apparently hopping around in the space of the zero modes. This looks very attractive physically since zero modes characterize the size, shape and classical Kähler fields associated with 3-surface. Therefore each quantum jump gives very precise conscious geometric information about space-time geometry and about WCW in zero modes. This also means that Haken's classical theory of self-organization generalizes almost as such to TGD context. The probability for localization to given point of zero mode space is given by the reduced probability density Q defined by the integral of the probability density R defined by WCW spinor field over fiber degrees of freedom. The local maxima of Q with respect to zero modes appear as attractors for the time development by quantum jumps. Dissipative time development could be regarded as a sequence of quantum jumps leading to this kind of local maximum.

6. Effective localization in zero modes is completely analogous to spontaneous symmetry breaking in which scalar field attains vacuum expectation value with the difference that the number of degrees of freedom is infinite unlike in typical models of symmetry breaking. Thus the general structure of the WCW spinor field together with TGD based quantum jump concept automatically implies spontaneous symmetry breaking in its TGD version (note however that particle massivation results from both p-adic thermodynamics and coupling to Higgs like field of purely geometric origin in TGD framework). TGD Universe is superposition of parallel

classical universes (3-surfaces). Therefore quantum entangled state can can be regarded as a superposition of parallel entangled states, one for each 3-surface. Formally entanglement coefficients can be regarded as coefficients containing the WCW coordinates of 3-surfaces as additional index. The analogy with the spin glass also supports the localization in the zero modes.

7. Effective localization in the zero modes provides simple explanation for why the universe of conscious experience looks classical: moment of consciousness makes it classical. It also explains why the physics treating space-time as a fixed arena of dynamics has been so successful. As already found, a further important consequence is first principle description of the state function reduction.

7.2.4   The Notion Of Self

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

Originally p-adic regions were interpreted as physical (non-conscious) correlates for imagination and cognition whereas real regions correspond to matter and sensory perception. The original belief was that the transformation of p-adic space-time sheets to real ones in quantum jump would correspond to the realization of intention as action. It is now clear that this hypothesis is both un-necessary and difficult to realize mathematically. Rather, TGD Universe is adele meaning that both embedding space, space-time, and WCW are adelic structure containing real sector and various p-adic sectors as correlates of cognition.

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

Assumptions about the structure of conscious experience of self

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

1. The contents of consciousness of self are determined as the average over the quantum jumps occurred after it was created (the real or p-adic space-time region corresponding to self appeared in quantum jump). Selves can have sub-selves and self experiences them as mental images. Self can represent a mental image of a higher level self. Self experiences only the average of its sub-sub-selves. Thus statistical averaging is involved in both subjecto-temporal sense and spatially and is of central importance in the theory of qualia. This suggests that the foundations of, not only quantum measurement theory, but also statistical physics, reduce to the theory of consciousness. Quantum entanglement between sub-selves means fusion of mental images. The simplest assumption is that entangling self loses its consciousness.

2. The sharing of mental images by quantum entanglement is purely TGD based prediction. What happens is rather paradoxical: the sub-selves of unentangled selves bound state entangle so that the resulting fused mental image is shared by both selves. This is not possible if one applies the standard notion of quantum mechanical sub-system as a tensor factor. The p-adic hierarchy of space-time sheets forces to generalize the notion of sub-system (note that also real space-time sheets are characterized by p-adic prime determining the size scale).

   Smaller space-time sheets glued to larger space-time sheets are glued to it by wormhole contacts having size of order CP_2 length and having Euclidian signature of the induced metric.

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

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

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

The mathematical description for this length scale dependent view about sub-systems relies on inclusions of hyper-finite factors of type II_1 (HFFs) [K120].

The notion of length scale resolution and self

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

1. The idea that even slightest entanglement leads to a loss of consciousness does not sound realistic. This suggests that entanglement should be defined only modulo finite measurement resolution. System would be conscious only provided that its entanglement entropy with the external world is below the value defined by the measurement resolution. For hyper-finite factors of type II_1 the notion of finite measurement resolution is unavoidable. The concrete interpretation at space-time level would be that space-time sheets (sub-selves) topologically condensed at larger space-time sheets (selves) can be connected by flux tubes to form an entangled state. The selves represented by the larger space-time sheets would remain unentangled in the resolution applying to the systems themselves (flux tubes would be invisible in this resolution). This invisible entanglement would however give rise to a sharing and fusion of mental images implying what might be called stereo consciousness.

2. How the notion measurement resolution should be defined is far from obvious. p-Adication approach suggests that finite measurement resolution boils down to a pinary cutoff for the p-adic entanglement entropy represented as a series in powers of p. This pinary cutoff should have also space-time correlate. For hyper-finite factors of type II_1 and type III_1 emerging naturally in quantum TGD entanglement entropy is always defined only modulo finite measurement resolution, which can be characterized in terms of inclusions of hyper-finite factors [K120]. The included factor defines the measurement resolution in the sense that its action creates states not distinguishable from the original in the resolution used. There should exist a connection between the two approaches.

3. A further complication is due to the fact that also the p-adic variants of Shannon entropy obtained by replacing the logarithm of probability with the logarithm of the p-adic norm of probability make sense if entanglement probabilities are rational or have values in some algebraic extension of rationals. The fact that number theoretic entanglement entropy can be negative is especially attractive from the point of view of consciousness theory and also quantum computation since entanglement indeed carries information. There is also a temptation to identify evolution as the emergence of increasingly complex systems having negative entanglement entropy. The generation of negative entanglement entropy might correspond to a kind of enlightenment experience - fusion to a sea of consciousness - instead of a loss of consciousness.

4. This forces to reconsider the original vision that everything is conscious but consciousness can be lost as the system entangles in U process. U process generates highly entangled states and the sub-sequent state function reduction (possibly modulo measurement resolution) repeatedly decomposes the Universe (or CD) into unentangled pairs of subsystems. The process stops for any subsystem for which all subsystem pairs have either bound state entanglement or negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book). If the bound state entanglement is entropic, the entangled subsystems lose consciousness. If the entanglement beween the subsystems in negentropic the process stops but subsystems remain conscious. Mystics might associate the entropic entanglement to what they calls attachment and negentropic entanglement to a relationship which they might characterize as love.

NMP and self

The development of the view about Negentropy Maximization Principle (NMP) [K56] has meant also development of the notion of self.

(a) The original formulation of NMP was in positive energy ontology and made same predictions as standard quantum measurement theory. The only new element was that the density matrix of sub-system defines a fundamental observable and the system goes to its eigenstate in state function reduction.

(b) p-Adic physics led to the realization that for rational and even algebraic entanglement probabilities it is possible to define number theoretic entanglement negentropy satisfying the same basic axioms as the ordinary Shannon entropy but having negative values and therefore having interpretation as information. NMP would force the generation of negentropic entanglement and stabilize it. Negentropic entanglement resources of the Universe - one might call them Akashic records- would steadily increase.

(c) It turned out that the consistency with the quantum measurement theory demands that the density matrix for the final state is projector as also in the standard quantum measurement theory but can project also to a higher-dimensional space. This additional condition allows also to identify negentropic entanglement uniquely: without this restriction one could not really say whether this is the case since rationals form dense set of reals.

(d) The next step was to realize that this form of NMP is not realistic. NMP would force the Universe to be the best possible one, and this does not seem to be the case. Also ethically responsible free will would be very restricted since self would be forced always to do the best deed that is increase maximally the negentropy serving as information resources of the Universe. This led to the notion of weak form of NMP. Instead of maximal negentropy corresponding to n-dimensional projector self can choose also lower-dimensional sub-spaces and 1-D sub-space corresponds to the vanishing entanglement and negentropy assumed in standard quantum measurement theory.

Weak form of NMP suggests how to understand the notions of Good and Evil. Various choices in the state function reduction correspond to Boolean algebra, which suggests an interpretation in terms of what might be called emotional intelligence [K116]. Also it turns out that one can understand how p-adic length scale hypothesis - actually its generalization - emerges from NMOP [K119].

(a) One can start from ordinary quantum entanglement. It corresponds to a superposition of pairs of states. Second state corresponds to the internal state of the self and second state to a state of external world or biological body of self. In negentropic quantum entanglement each is replaced with a pair of sub-spaces of state spaces of self and

external world. The dimension of the sub-space depends on the which pair is in question. In state function reduction one of these pairs is selected and deed is done. How to make some of these deeds good and some bad?

(b) Obviously the value of $h_{eff}/h = n$ gives the criterion in the case that weak form of NMP holds true. Recall that weak form of NMP allows only the possibility to generate negentropic entanglement but does not force it. NMP is like God allowing the possibility to do good but not forcing good deeds.

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

For the maximal dimension of this sub-space the negentropy gain is maximal. This deed would be good and by the proposed criterion the negentropic entanglement corresponds to love or more neutrally, positively colored conscious experience. Interestingly, there are $2^n - 1$ possible choices which is almost the dimension of Boolean algebra consisting of n independent bits. The excluded option corresponds to 0-dimensional sub-space - empty set in set theoretic realization of Boolean algebra. This could relate directly to fermionic oscillator operators defining basis of Boolean algebra- here Fock vacuum would be the excluded state. The deed in this sense would be a choice of how loving the attention towards system of external world is.

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

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

ZEO and self

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

The most important input from ZEO is that state function reductions can occur to both boundaries of CD. The natural identification of self is as a sequence of state functions occurring at fixed boundary of CD leaving the state at it invariant but affecting the opposite position of opposite boundary. This if one has superposition of CDs with zero energy states

associated with them and of unitary process generates quantum superposition of CDs in the moduli space of CDs and if the unitary process is followed by a localization in this moduli space. The first quantum jump to opposite boundary corresponds to a state function reduction in ordinary sense and has interpretation as volitional act. Self dies and reincarnates at the opposite boundary of CD.

In this picture one can assign to self a definite age as the increase of the proper time distance between the tips of CD. Also the experience of time flow can be understood. In each death of self a reversal of geometric time occurs. This conforms with the old proposal of Fantappie that the notion of syntropy makes sense in living systems [J97],

Space-time correlates of self

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

1. If space-time sheets serve as correlates for selves, the space-time correlate for the entanglement is the presence of magnetic flux tubes connecting the space-time sheets serving as correlates for selves. The entanglement which corresponds to join along boundaries bonds associated with sub-selves (smaller space-time sheets topologically condensed at the space-time sheet representing self) is below the measurement resolution assignable to self. In this kind of situation selves remain conscious whereas sub-selves loose consciousness for positive entanglement entropy and fuse to form single stereo mental image of self. For negative entanglement entropy sub-selves would remain conscious.

2. In zero energy ontology [K25] one is forced to ask whether the correlates of self should be identified also at the level of embedding space rather than only at the level of space-time sheets so that a given CD would serve as a correlate for self. This identification leads to a beautiful argument for how the arrow of subjective time, the flow of subjective time, and the localization of the contents of conscious experience around a narrow time interval takes place [K7]. There is no reason for why CDs should not be allowed to overlap and this overlap would be a natural correlate for the sharing and fusion of mental images. Both of these identifications look natural and one can argue that the geometric correlates of self exist at both embedding space and space-time level.

3. If both space-time sheets and CDs serve as correlates for selves, the magnetic flux tube contacts could connect space-time sheets associated with the two. CDs and would belong to their intersection. One can also require that the CDs are at the same p-adic level of hierarchy. In other words, CDs correspond to the same value of p-adic prime near a power of two meaning that the temporal distance between the tips of CDs is same octave of CP_2 time for the standard value of Planck constant. The hierarchy of Planck constants [K36] means an additional complication in this picture but does not bring in anything essentially new.

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

Dark matter hierarchy and self

The notion of dark matter hierarchy has dramatically improve the understanding of the notion of self and together with NMP [K56] allows to even answer questions concerning Good and Evil and Life and Death [K116].

1. The idea about hierarchy of Planck constants emerged from anomalies of biology and the strange finding that planetary orbits could be regarded as Bohr orbits but with a gigantic value of Planck constant. This lead to the vision that dark matter corresponds to ordinary particles but with non-standard value of Planck constant and to a generalization of the 8-D

embedding space to a book like structure with pages partially characterized by the value of Planck constant. Using the intuition provided by the inclusions of HFFs one ends up to a prediction for the spectrum of Planck constants. This inspires the proposal that dark matter could be in quantum Hall like phase localized at light-like 3-surfaces with macroscopic size and behaving in many respects like black hole horizons.

2. The physical interpretation for the hierarchy of Planck constants would be in terms of a hierarchy of quantum criticalities concretizing the vision about quantum criticality of TGD Universe. TGD Universe would be like a hill at the top of a hill at .... The larger the Planck constant the larger the size scale of the hill. Criticality involves crucially the notion of conformal gauge symmetry. The conformal symmetries correspond to some sub-algebra of the full algebra isomorphic to it acting as gauge symmetries and with conformal weights coming as n-multiples of those for the full symmetry algebra. $h_{eff} = n \times h$ would label the levels of the hierarchy. This hierarchy would correspond directly to the hierarchy of measurement resolutions and to hierarchy of HFFs. Also now one obtains infinite hierarchies of symmetry breakings and the identification with the hierarchies of inclusions of HFFs is compelling. Hence various hierarchies reflect the same underlying phenomenon.

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

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

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

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

7.2.5   Four Views About How The Arrow Of Psychological Time Could Emerge

The notion of quantum jump implies a new view about time. Experienced/subjective time corresponds to a sequence of sub-quantum jumps and cannot be identified with the geometric time defined as the fourth space-time coordinate. This is of course obvious for anyone: consider only the reversibility of geometric time contra irreversibility of experienced time, and the fact that both geometric past and future exist whereas only subjective past exists. The fact that the contents of conscious experience is about 4-D rather than 3-D space-time region, motivates the notions of 4-D brain, body, and even society. In particular, conscious existence continues after biological death since 4-D body and brain continue to exist.

Quantum classical correspondence predicts that the arrow of subjective time is somehow mapped to that for the geometric time. The detailed mechanism for how the arrow of psychological time emerges has however remained open. Also the notion of self has been problematic. I have explained the most feasible solution to both problems already in the introduction and describe in the following other approaches which all rely on the same basic idea: the future for a point inside future light-cone has more room than past so that particle diffusing inside the light-cone gradually drifts to future.

1. First trial

The earliest model assumes that the space-time sheet assignable to observer ("self") drifts along a larger space-time sheet towards geometric future quantum jump by quantum jump: this is like driving car in a landscape but in the direction of geometric time and seeing the changing landscape. There are several objections.

1. Why this drifting?

2. If one has a large number of space-time sheets (the number is actually infinite) as one has in the hierarchy the drifting velocity of the smallest space-time sheet with respect to the largest one can be arbitrarily large (infinite).

3. It is alarming that the evolution of the background space-time sheet by quantum jumps, which must be the quintessence of quantum classical correspondence, is not needed at all in the model.

2. Second trial

Second model relies on the idea that intentional action -understood as p-adic-to-real phase transition for space-time sheets and generating zero energy states and corresponding real space-time sheets - proceeds as a kind of wave front towards geometric future quantum jump by quantum jump. Also sensory input would be concentrated on this kind of wave front. The difficult problem is to understand why the contents of sensory input and intentional action are localized so strongly to this wave front and rather than coming from entire life cycle.

3. Third trial

The third explanation for the arrow of psychological time considered earlier looks rather elegant but the explanation based on superpositions of CDs and state function reductions occurring at either boundary of CD looks more attractive.

1. In standard picture the attention would gradually shift towards geometric future and space-time in 4-D sense would remain fixed. Now however the fact that quantum state is quantum superposition of space-time surfaces allows to assume that the attention of the conscious observer is directed to a fixed volume of 8-D embedding space. Quantum classical correspondence is achieved if the evolution in a reasonable approximation means shifting of the space-time sheets and corresponding field patterns backwards backwards in geometric time by some amount per quantum jump so that the perceiver finds the geometric future in 4-D sense to enter to the perceptive field. This makes sense since the shift with respect to M^4 time coordinate is an exact symmetry of extremals of Kähler action. It is also an excellent approximate symmetry for the preferred extremals of Kähler action and thus for maxima

of Kähler function spoiled only by the presence of light-cone boundaries. This shift occurs for both the space-time sheet that perceiver identifies itself and perceived space-time sheet representing external world: both perceiver and percept change.

2. Both the landscape and observer space-time sheet remain in the same position in embedding space but both are modified by this shift in each quantum jump. The perceiver experiences this as a motion in 4-D landscape. Perceiver (Mohammed) would not drift to the geometric future (the mountain) but geometric future (the mountain) would effectively come to the perceiver (Mohammed)!

3. There is an obvious analogy with Turing machine: what is however new is that the tape effectively comes from the geometric future and Turing machine can modify the entire incoming tape by intentional action. This analogy might be more than accidental and could provide a model for quantum Turing machine operating in TGD Universe. This Turing machine would be able to change its own program as a whole by using the outcomes of the computation already performed.

4. The concentration of the sensory input and the effects of conscious motor action to a narrow interval of time (.1 seconds typically, secondary p-adic time scale associated with the largest Mersenne M_{127} defining p-adic length scale which is not completely super-astronomical) can be understood as a concentration of sensory/motor attention to an interval with this duration: the space-time sheet representing sensory "me" would have this temporal length and "me" definitely corresponds to a zero energy state.

5. The fractal view about topological quantum computation strongly suggests an ensemble of almost copies of sensory "me" scattered along my entire life cycle and each of them experiencing my life as a separate almost copy.

6. The model of geometric and subjective memories would not be modified in an essential manner: memories would result when "me" is connected with my almost copy in the geometric past by braid strands or massless extremals (MEs) or their combinations (ME parallel to magnetic flux tube is the analog of Alfven wave in TGD).

This argument leaves many questions open. What is the precise definition for the volume of attention? Is the attention of self doomed to be directed to a fixed volume or can quantum jumps change the volume of attention? What distinguishes between geometric future and past as far as contents of conscious experience are considered? How this picture relates to p-adic and dark matter hierarchies? Does this framework allow to formulate more precisely the notion of self?

4. The recent view

As mentioned in the beginning, ZEO forces a generalization of quantum measurement theory explaining how the flow and arrow of time emerge. ZEO also reduces the notion of self to observer identified as the sequence of state function reductions to a fixed boundary of CD, whose size (or possibly average quantum size) increases during the sequence of reductions. There is also strong temptation to identify the sequence of reductions at fixed boundary of CD as sequence of unitary evolutions inducing shift of the integer n characterizing the size of CD.

The first state function to the opposite boundary of CD would correspond to a scaling scaling of CD size by the integer $m = n_f/n_i$ defined by the integers h_{eff}/h for scaled up CD and the original one. A sequence of transitions reducing quantum criticality would be in question and all big ideas of quantum TGD would find each other in the picture. Minimization of assumptions and maximization of predictive power selects this model as the most plausible one.

7.2.6 What Really Distinguishes Between Future And Past?

Our knowledge about geometric future is very uncertain as compared to that about geometric past. Hence we usually use words like plan/hunch/hope/... in the case of geometric future and speak about memories in the case of geometric past. We also regard geometric past as something absolutely stable. Why cannot we "remember" geometric future as reliably as the geometric past?

Is it that geometric future is highly unstable as compared to the geometric past? Why this should be the case? Or could it be that it does not really exist?

ZEO provides again the most convincing explanation for the asymmetry between future and past. The low unchanging boundary of CD corresponds to the most remote geometric past and is completely stable during the sequence of state function reductions defining self. The active, changing boundary of CD (or superposition of them), which corresponds to "sensory now" is replaced with a new one in every reduction. The geometric past corresponds to the regions of CD "below" it. This asymmetry between future and past explains why remembering future is difficult if note even impossible for given self.

The fact is however that we can make predictions about our future. One can indeed consider a loop-hole making possible to predict future to some extent. As self dies and new self wakes up at opposite boundary of corresponding CD the arrow of time changes and past becomes future. This self has memories about what corresponds to the future of the original self. If this information is preserved when the original self wakes up and is accessible to it, this self can pre-cognize its future to some degree. An attractive idea is that during sleep the sub-self representing "wake-up me" dies and is replaced with a new one. During sleep the new self would recall information about its geometric past and this information would be partially accessible to the original sub-self after wake-up.

7.2.7   Two Views About Flow Of Time

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

1. The first view would identify the flow of time with life cycle of period and essentially with sensory perception defining the passive aspects of consciousness. This view is consistent with the ZEO based about self and looks rather feasible. One can wonder how repeated state function reduction give rise to the increase of the average size of CD (possibly in superposition of CDs). Why the entire zero energy state and CD do not remain unchanged in state function reduction? What is the unitary process defining the dynamics of dispersion in the moduli space of CDs? One must admit that this aspect is not well-understood yet and more detailed view about what the sequences of state function reductions really means.

2. Second view that I have considered assigns the flow of time with active aspects of consciousness.

   (a) The acts of volition would give rise to an experience about flow of time. The proposal is that in ZEO act of volition corresponds to the first state function reduction at the opposite boundary of some sub-CD. Some self in the hierarchy dies in this process and NMP forces it to occur although it does not fix the outcome.

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

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

      One can also argue that there is no actual choices between good and evil. This is certainly not the case if weak form of NMP which only allows the reduction to any

subspace of the subspace with the dimension of the projection operator appearing in density matrix.

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

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

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

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

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

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

3. Interesting questions relate to the constraints coming from number theoretical universality forced by adelization. Could the increase of h_{eff} correspond to the increase of p-adic prime characterizing the system? What about p-adic counterpart of unitary evolution: the existence of the exponential $exp(iP_0t)$ requires that t has p-adic norm below some upper bound. This could give an upper bound to the life time of self as a real number since the p-adic counterpart of life-time would be below this upper bound.

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

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

2. At the level of sub-selves this scalings can occur for self and would correspond to mental images with are born and die. Also motor action would correspond to a transition changing the arrow of time for a mental image representing the intention and will to perform the motor action.

3. One can argue that the increase of h_{eff} giving also rise to an increase in negentropy becomes unavoidable eventually. This criticality could mean that the size scale of CD becomes integer multiple of the original one.

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

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

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

5. The scaling of CD inducing the increase of $h_{eff} = n \times h$ occurring spontaneously represented as an exponential of scaling generator - call it L_0 - seems to be precede the first reduction. I have already considered conditions on this dynamics. Note that translations are replaced with scalings by integer valued ratios $m = n_f/n_i$, which predicts that periodicity is replaced by periodicity with respect to the logarithm of ordinary embedding space time. A unique signature of dynamics of consciousness, which I have proposed as an explanation for the hyperbolic decay law for the emission of bio-photons.

6. The scaling of CD inducing the increase of $h_{eff} = n \times h$ occurring spontaneously is naturally represented as an exponential of scaling generator - call it L_0. Translations are replaced with scalings by integer valued ratios $m = n_f/n_i$, which predicts that periodicity is replaced by periodicity with respect to the logarithm of ordinary embedding space time. A unique signature of dynamics of consciousness, which I have proposed as an explanation for the hyperbolic decay law for the emission of bio-photons.

7. The phase transitions increasing $h_{eff}/h = n$ can be said to begin from some prime value $n = p$ - the smallest prime power appearing in n: one could even say that the basic label for the sequences of breakings of super-symplectic symmetries are labelled by primes. This strongly suggests a connection with p-adicity.

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

7.3   Intention, Cognition, And Time

Intentions involved time in an essential manner and this led to the idea that p-adic-to-real quantum jumps could correspond to a realization of intentions as actions. It however seems that this hypothesis posing strong additional mathematical challenges is not needed if one accepts adelic approach in which real space-time time and its p-adic variants are all present and quantum physics is adelic. I have already earlier developed the first formulation of p-adic space-time surface in [K122] and the ideas related to the adelic vision in [K69, K67, K6].

The recent view involving strong form of holography would provide dramatically simplified view about how these representations are formed as continuations of representations of strings world sheets and partonic 2-surfaces in the intersection of real and p-adic variants of WCW ("World of

Classical Worlds") in the sense that the parameters characterizing these representations are in the algebraic numbers in the algebraic extension of p-adic numbers involved.

7.3.1   What Intentions Are?

One of the earlier ideas about the flow 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 that p-adic-to-real transition could correspond to the 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 transitons. This picture does not explain why and how intention gradually evolves stronger and 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 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 assignment of fermions separately to the every factor of 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 sensed and cognized would reside in 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 NMP 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.

7.3.2   P-Adic Physics As Physics Of Only Cognition?

There are two views about p-adic-real correspondence corresponding to two views about p-adic physics. According to the first view p-adic physics defines correlates for both cognition whereas second view states that it provides correlates for cognition only.

1. Option A: The older view is that p-adic -to-real transitions realize intentions as actions and opposite transitions generate cognitive representations. Quantum state would be either real or p-adic. This option raises hard mathematical challenges since scattering amplitudes between different number fields are needed and the needed mathematics might not exist at all.

2. Option B: Second view is that cognition and sensory aspects of experience are simultaneously present at all levels and means that real space-time surface and their real counterparts form a larger structure in the spirit of what might be called Adelic TGD. p-Adic space-time charts could be present for all primes. It is of course necessary to understand why it is possible to assign definite prime to a given elementary particle.

This option could be developed by generalizing the existing mathematics of adeles by replacing number in given number field with a space-time surface in the embedding space corresponding that number field. Therefore this option looks more promising. For this option also the development of intention can be also understood. The condition that the scattering amplitudes are in the intersection of reality and p-adicities is very powerful condition on the scattering amplitudes and would reduce the realization of number theoretical universality and p-adicization to that for string world sheets and partonic 2-surfaces.

For instance, the difficult problem of defining p-adic analogs of topological invariant would trivialie since these invariants (say genus) have algebraic representation for 2-D geometries. 2-dimensionality of cognitive representation would be perhaps basically due to the close correspondence between algebra and topology in dimension $D = 2$.

Most of the following considerations apply in both cases.

7.3.3 Some Questions To Ponder

The following questions are part of the list of question that one must ponder.

Do cognitive representations reside in the intersection of reality and p-adicities?

The idea that cognitive representation reside in the intersection of reality and various p-adicities is one of the key ideas of TGD inspired theory of consciousness.

1. All quantum states have vanishing total quantum numbers in ZEO, which now forms the basis of quantum TGD [K24]. In principle conservation laws do not pose any constraints on possibly occurring real–p-adic transitions (Option A) if they occur between zero energy states.

   On the other hand, there are good hopes about the definition of p-adic variants of conserved quantities by algebraic continuation since the stringy quantal Noether charges make sense in all number fields if string world sheets are in the real–p-adic intersection. This continuation is indeed needed if quantum states have adelic structure (Option B). In accordance with this quantum classical correspondence (QCC) demands that the classical conserved quantities in the Cartan algebra of symmetries are equal to the eigenvalues of the quantal charges.

2. The starting point is the interpretation of fermions as correlates for Boolean cognition and p-adic space-time sheets space-time correlates for cognitions [K103]. Induced spinor fields are localized at string world sheets, which suggests that string world sheets and partonic 2-surfaces define cognitive representations in the intersection of realities and p-adicities. The space-time adele would have a book-like structure with the back of the book defined by string world sheets.

3. At the level of partonic 2-surfaces common rational points (or more generally common points in algebraic extension of rationals) correspond to the real–p-adic intersection. It is natural to identify the set of these points as the intersection of string world sheets and partonic 2-surfaces at the boundaries of CDs. These points would also correspond to the ends of strings connecting partonic 2-surfaces and the ends of fermion lines at the orbits of partonic 2-surfaces (at these surfaces the signature of the induced 4-metric changes). This would give a direct connection with fermions and Boolean cognition.

   (a) For option A the interpretation is simple. The larger the number of points is, the higher the probability for the transitions to occur. This because the transition amplitude must involve the sum of amplitudes determined by data from the common points.

   (b) For option B the number of common points measures the goodness of the particular cognitive representation but does not tell anything about the probability of any quantum transition. It however allows to discriminate between different p-adic primes using the precision of the cognitive representation as a criterion. For instance, the non-determinism of Kähler action could resemble p-adic non-determinism for some algebraic

extension of p-adic number field for some value of p. Also the entanglement assignable to density matrix which is n-dimensional projector would be negentropic only if the p-adic prime defining the number theoretic entropy is divisor of n. Therefore also entangled quantum state would give a strong suggestion about the value of the optimal p-adic cognitive representation as that associated with the largest power of p appearing in n.

Could cognitive resolution fix the measurement resolution?

For p-adic numbers the algebraic extension used (roots of unity fix the resolution in angle degrees of freedom and pinary cutoffs fix the resolution in "radial" variables which are naturally positive. Could the character of quantum state or perhaps quantum transition fix measurement resolution uniquely?

1. If transitions (state function reductions) can occur only between different number fields (Option A), discretization is un-avoidable and unique if maximal. For real-real transitions the discretization would be motivated only by finite measurement resolution and need be neither necessary nor unique. Discretization is required and unique also if one requires adelic structure for the state space (Option B). Therefore both options A and B are allowed by this criterion.

2. For both options cognition and intention (if p-adic) would be one half of existence and sensory perception and motor actions would be second half of existence at fundamental level. The first half would correspond to sensory experience and motor action as time reversals of each other. This would be true even at the level of elementary particles, which would explain the amazing success of p-adic mass calculations.

3. For option A the state function reduction sequence would correspond to a formation of p-adic maps about real maps and real maps about p-adic maps: real $\rightarrow$ p-adic $\rightarrow$ real $\rightarrow$ ..... For option B it would correspond the sequence adelic $\rightarrow$ adelic $\rightarrow$ adelic $\rightarrow$ .....

4. For both options p-adic and real physics would be unified to single coherent whole at the fundamental level but the adelic option would be much simpler. This kind of unification is highly suggestive - consider only the success of p-adic mass calculations - but I have not really seriously considered what it could mean.

What selects the preferred p-adic prime?

What determines the p-adic prime or preferred p-adic prime assignable to the system considered? Is it unique? Can it change?

1. An attractive hypothesis is that the most favorable p-adic prime is a factor of the integer n defining the dimension of the $n \times n$ density matrix associated with the flux tubes/fermionic strings connecting partonic 2-surfaces: the presence of fermionic strings already implies at least two partonic 2-surfaces. During the sequence of reductions at same boundary of CD n receives additional factors so that p cannot change. If wormhole contacts behave as magnetic monopoles there must be at least two of them connected by monopole flux tubes. This would give a connection with negentropic entanglement and for $h_{eff}/h = n$ to quantum criticality, dark matterm and hierarchy of inclusions of HFFs.

2. Second possibility is that the classical non-determinism making itself visible via super-symplectic invariance acting as broken conformal gauge invariance has same character as p-adic non-determinism for some value of p-adic prime. This would mean that p-adic space-time surfaces would be especially good representations of real space-time sheets. At the lowest level of hierarchy this would mean large number of common points. At higher levels large number of common parameter values in the algebraic extension of rationals in question.

How finite measurement resolution relates to hyper-finite factors?

The connection with hyper-finite factors suggests itself.

1. Negentropic entanglement can be said to be stabilized by finite cognitive resolution if hyper-finite factors are associated with the hierarchy of Planck constants and cognitive resolutions. For HFFs the projection to single ray of state space in state function reduction is replaced with a projection to an infinite-dimensional sub-space whose von Neumann dimension is not larger than one.

2. This raises interesting question. Could infinite integers constructible from infinite primes correspond to these infinite dimensions so that prime p would appear as a factor of this kind of infinite integer? One can say that for inclusions of hyperfinite factors the ratio of dimensions for including and included factors is quantum dimension which is algebraic number expressible in terms of quantum phase $q = exp(i2\pi/n)$. Could n correspond to the integer ratio $n = n_f/n_i$ for the integers characterizing the sub-algebra of super-symplectic algebra acting as gauge transformations?

7.3.4   Generalizing The Notion Of P-Adic Space-Time Surface

The notion of p-adic manifold [K122] is an attempt to formulate p-adic space-time surfaces identified as preferred extremal of p-adic variants of p-adic field equations as cognitive charts of real space-time sheets. Here the essential point is that p-adic variants of field equations make sense: this is due to the fact that induced metric and induced gauge fields make sense (differential geometry exists p-adically unlike global geometry involving notions of lengths, area, etc does not exist: in particular the notion of angle and conformal invariance make sense).

The second key element is finite resolution so that p-adic chart map is not unique. Same applies to the real counterpart of p-adic extremal and having representation as space-time correlate for an intention realized as action.

The discretization of the entire space-time surface proposed in the formulation of p-adic manifold concept [K122] looks too naïve an approach. It is plausible that one has an abstraction hierarchy for discretizations at various abstraction levels.

1. The simplest discretization would occur at space-time level only at partonic 2-surfaces in terms of string ends identified as algebraic points in the extension of p-adics used. For the boundaries of string world sheets at the orbits of partonic 2-surface one would have discretization for the parameters defining the boundary curve. By field equations this curve is actually a segment of light-like geodesic line and characterized by initial light-like 8-velocity, which should be therefore a number in algebraic extension of rationals. The string world sheets should have similar parameterization in terms of algebraic numbers.

   By conformal invariance the finite-dimensional conformal moduli spaces and topological invariants would characterize string world sheets and partonic 2-surfaces. The p-adic variant of Teichmueller parameters was indeed introduced in p-adic mass calculations and corresponds to the dominating contribution to the particle mass [K52, K23].

2. What might be called co-dimension 2 rule for discretization suggests itself. Partonic 2-surface would be replaced with the ends of fermion lines at it or equivalently: with the ends of space-like strings connecting partonic 2-surfaces at it. 3-D partonic orbit would be replaced with the fermion lines at it. 4-D space-time surface would be replaced with 2-D string world sheets. Number theoretically this would mean that one has always commutative tangent space. Physically the condition that em charge is well-defined for the spinor modes would demand co-dimension 2 rule.

3. This rule would reduce the real-p-adic correspondence at space-time level to construction of real and p-adic space-time surfaces as pairs to that for string world sheets and partonic 2-surfaces determining algebraically the corresponding space-time surfaces as preferred extremals of Kähler action. Strong form of holography indeed leads to the vision that these geometric objects can be extended to 4-D space-time surface representing preferred extremals.

4. In accordance with the generalization of AdS/CFT correspondence to TGD framework cognitive representations for physics would involve only partonic 2-surfaces and string world sheets. This would tell more about cognition rather than Universe. The 2-D objects in question would be in the intersection of reality and p-adicities and define cognitive representations of 4-D physics. Both classical and quantum physics would be adelic.

5. Space-time surfaces would not be unique but possess a degeneracy corresponding to a sub-algebra of the super-symplectic algebra isomorphic to it and acting as conformal gauge symmetries giving rise to n conformal gauge invariance classes. The conformal weights for the sub-algebra would be n-multiples of those for the entire algebra and n would correspond to the effective Planck constant $h_{eff}/h = n$. The hierarchy of quantum criticalities labelled by n would correspond to a hierarchy of cognitive resolutions defining measurement resolutions.

    Clearly, very many big ideas behind TGD and TGD inspired theory of consciousness would have this picture as a Boolean intersection.

7.3.5   Number Theoretic Universality For Cognitive Representations

Number theoretic universality is one of the key principles of quantum TGD [K66]. In the following this principle is discussed in the light of the newest results about quantum TGD.

1. By number theoretic universality p-adic zero energy states should be formally similar to their real counterparts for option B. For option A the states between which real–p-adic transitions are highly probable would be similar. The states would have as basic building bricks the elements of the Yangian of the super-symplectic algebra associated with these strings which one can hope to be algebraically universal.

2. Finite measurement resolution demands that all scattering amplitudes representing zero energy states involve discretization. In purely p-adic context this is unavoidable because the notion of integral is highly problematic. Residue integral is p-adically well-defined if one can deal with π.

   p-Adic integral can be defined as the algebraic continuation of real integral made possible by the notion of p-adic manifold and this works at least in the real–p-adic intersection. String world sheets would belong to the intersection if they are cognitive representations as the interpretation of fermions as correlates of Boolean cognition suggests. In this case there are excellent hopes that all real integrals can be continued to various p-adic sectors (which can involve algebraic extensions of p-adic number fields). Quantum TGD would be adelic. There are of course potential problems with transcendentals like powers of π.

3. Discrete Fourier analysis allows to define integration in angle degrees of freedom represented in terms of algebraic extension involving roots of unity. In purely p-adic context the notion of angle does not make sense but trigonometric functions make sense: the reason is that only the local aspect of geometry generalize characterized by metric generalize. The global aspects such as line length involving integral do not. One can however introduce algebraic extensions of p-adic numbers containing roots of unity and this gives rise to a realistic notion of trigonometric function. One can also define the counterpart of integration as discrete Fourier analysis in discretized angle degrees of freedom.

4. Maybe the 2-dimensionality of cognition has something to do with the fact that quaternions and octonions do not have p-adic counterpart (the p-adic norm squared of quaternion/octonion can vanish). I have earlier proposed that life and cognitive representations resides in real-p-adic intersection. Stringy description of TGD could be seen as number theoretically universal cognitive representation of 4-D physics. The best that the limitations of cognition allow to obtain. This hypothesis would also guarantee that various conserved quantal charges make sense both in real and p-adic sense as p-adic mass calculations demand.

7.3.6   Why P-Adic Intentionality Does Not Reduce To Quantum Randomness?

The basic argument against quantal free will is that quantum non-determinism is basically randomness of a particular kind so that one can apply statistical determinism to predict the behavior for an ensemble of systems. The crucial question is whether also intentionality in the proposed sense reduces to randomness so that statistical determinism applies. One can imagine several mutually consistent approaches to the problem.

1. The notion of randomness is based on the notion of probability, and it could happen that the notion of probability simply does not make sense at all for a system exhibiting an intentional behavior or that the probabilities do not exist in the real sense but only as p-adic probabilities. Thus abnormal statistics might serve as a signature of an intentional system.

2. Intentionality involves free will and unpredictability in short time scales but predictability in long time scales. This could serve as a signature of an intentional system. Quantum-classical correspondence states that the dynamics of space-time surface mimics quantum dynamics and therefore also the dynamics of consciousness and intentionality. If so the behavioral patterns of an intentional system characterized by p-adic prime p should obey p-adic topology, which is a strong and testable prediction.

3. Zero Energy Ontology and the notion of negentropic entanglement provide a further perspective to the problem. Intentionality means goal directed behavior. NMP implies that the increase of negentropy is the universal goal. Universe builds negentropic entanglement servings as kind of Akashic records. One could therefore say that it is NMP that intends and wants. The outcome of the state function reduction at the opposite boundary of CD is forced by NMP and the plan for making it and the will to do do it should characterize the contents of consciousness associated with the self defined by a sequences of state function reductions at given boundary of CD. NMP also implies that the outcome of state function reduction is not random since entanglement negentropy is preserved or even increases. Of course, negentropic entanglement can be transferred between different systems.

p-Adic topology for time series as a signature of intentionality

Intentional behavior means that there is unpredictability in short time scales but predictability in long time scales because system can realize its long term plans and use its partially free will to cope with the changing challenges of the everyday life.

   p-Adic topology could realize this idea.

1. The rational values of real and p-adic embedding space coordinates correspond to the same points of the generalized embedding space (essentially union of real and p-adic embedding spaces for various values of p with common rational points identified).

2. The points, which are p-adically close to each other can have arbitrarily long real distance since the points x and $x + kp^n$, $k \in \{0, p-1\}$, become arbitrarily near to each other p-adically and arbitrarily far way in real sense as n increases for the p-adic topology characterized by prime p.

   Thus p-adic long range fractal correlations could simply result from p-adic continuity. The local unpredictability would be mimicked by a discontinuous behavior in the real topology resulting from the fact that time values close to each other in the real sense are far from each other in p-adic sense.

   p-Adic non-determinism means that integration constants of p-adic differential equations having by definition vanishing derivatives, are functions of the pinary cutoffs x_N defined as $x = \sum_k x_k p^k \rightarrow x_N = \sum_{k<N} x_k p^k$ of the arguments of the function. Since the rational values of real and p-adic coordinates correspond to same points of embedding space, this means that p-adic non-determinism realizes intentionality by fixing the solution of field equations at a finite number of points below some real time (length) scale defined by N. The choice of these pseudo constants would characterize p-adic intentionality, the future plan of the system relatively stable against

quantum jumps and the range of intentional action would be finite, which could explain why the young person in the geometry youth now cannot make choices affecting dramatically the geometric now decades later.

There is an analogous non-determinism also in the real sector due to the dramatic failure of the complete non-determinism of the basic action principle determining the dynamics of space-time surfaces. This non-determinism justifies the characterization of the real space-time sheets by a p-adic primes.

Consider now a situation in which some observables of might -be intentional system are measured as a function of time. Suppose that measurements are carried out at moments $t_n = n\Delta T$, $\Delta T = T/N_m$, where T is the duration of the experiment and N_m is the number of measurements.

1. With respect to the real topology the behavior of the system would look random in short time scales with violent discontinuities independently how precise the time resolution is made: fluctuations would actually become more violent with the improving time resolution.

2. p-Adic fractality would predict long range correlations over arbitrarily long time scales p^n in this kind of situation. Time values t and $t + rp^k \Delta T$ would be near to each other p-adically so that the values of the observables measured at these time values would be near to each other. Long range temporal correlations would thus quantify the ideas that will is not completely free and that intentionality implies an approximate predictability in long time scales. The fact that p-adic pseudo constants allow intentional free will only below some time and length scales, justifies the idea that our life is in long time scales determined by what might be called fate although we can make freely decisions in short time scales. The stability of the p-adic pseudo constants and pinary cutoff N in quantum jumps would also mean that the realization of p-adic intentions occurring subjectively now in my geometric childhood would not have dramatic implications in the geometric now.

3. p-Adic fractality would also mean that similar behavioral time patterns could repeat themselves as temporally scaled-up versions. Person would react in a similar manner in different time scales, say in stressing situation lasting for few minutes or many years. What is used to call as personality might have something to do with these fractal behavioral patterns. There is indeed statistical evidence for the possibility to predict much about the life cycle of a person from the behavioral patterns in childhood. The child who wants all now tends to become an adult who does the same. Some aspects of personality would perhaps represent something not invariant under time translations but under p-adic time scalings.

How statistical behavior could exhibit intentionality?

Consider an ensemble of consisting of N_m measurements of some observables of a system during a fixed time interval T occurring at equally spaced moments of time $t_n = n \times \Delta T$, $\Delta T = T/N_m$. Classify the measurements by some equivalence relation so that there are I possible outcomes and estimate the probabilities for the outcomes as rational numbers $p_i = n_i/N_m$, $\sum n_i = N_m$. When N_m becomes large one should obtain estimates for the probabilities of various instances labelled by $i = 1, ..., I$. The standard frequency interpretation of probability theory relies on the assumption is that these estimates converge in real topology so that the estimates $p(i, N_m + k) = n_i/N_m + k$, $k << N_m$ and $p(i, N_m) = n_i/N_m$ do not differ much for large values of N_m.

It is however quite possible that $p(N_m)$ converges in some p-adic topology which would mean that in the real topology the estimates would fluctuate wildly without any convergence, in a typically fractal manner. The estimates for probabilities would however converge p-adically in which case the system would be intentional and characterized by some p-adic prime p. The quantum-classical correspondence suggests that the sequence of N_m measurements performed for an intentional system during time interval T can be modelled as a sequence of measurements performed for a p-adic space-time sheet serving as its correlate. With this assumption one can immediately conclude that the estimates for the probabilities do not converge since various observables are continuous functions with respect to p-adic rather than real topology and ΔT does not approach zero at the limit $N_m \to \infty$ but fluctuates wildly. Only for N_m and $N_m + kp^n$ p-adic continuity guarantees that probabilities estimated in this manner are near each other.

It must be emphasized that the notion of p-adic probability based on frequency interpretation satisfies the Kolmogorov axioms as demonstrated by [A10] [A10]. The notion of resolution $\Delta T = T/N_m$ defining what $N_m \to \infty$ limit really means is an absolutely essential additional element. If one defines $N_m \to N_m + 1$ as an addition of one additional measurement to existing sequence of measurements, the frequencies convergence to ordinary real probabilities with a given resolution since only one of the numbers n_i changes in $N_m \to N_m + 1$. The notion of resolution makes sense also in spatial degrees of freedom.

The notion of resolution is unavoidable already in quantum field theories in order to reduce degrees of freedom which are not directly experimentally detectable since the that measurement resolution is always finite. The notion of renormalization group realizes mathematically the notion of finite resolution [B17]. Thus resolution dependent statistics is not anything new. What is new is p-adicity and the long range correlations reducing to the p-adic continuity because of different concept of nearness. Note also that p-adically small structures have real sizes which are astrophysical so that cognition is naturally an astrophysical phenomenon in accordance with the notions of magnetic body and ME.

These considerations suggests how one could try to demonstrate p-adic intentionality experimentally.

1. One might hope of demonstrating that intentional systems behave apparently randomly in short time scales but that there are long range temporal correlations in time scales $t_n = p^n \Delta T$, $\Delta T = T/N_m$. Wild fluctuation of the probability estimates as function of N_m is a direct signature of intentionality. The approximate invariance of the frequencies under the transformations $N_m \to N_m + p^n \Delta T$ in turn allow to identify the value p. This approach could be used to prove the presence of the p-adic intentionality even at the molecular level or at level of say solar and planetary magnetospheres by studying the temporal behavior of the fluctuations of magnetic fields. For instance, it is known that solar magnetic field has what might be called memory [E3], which should not be there if it were really random. For tornadoes the presence of short range chaos and long range order in at at least spatial degrees of freedom is obvious. Period doubling in the systems approaching chaos could be a signature for the appearance of 2-adic intentionality in increasingly longer time scales. Also $1/f$ noise, not really understood in standard physics framework, might be related to intentionality.

2. One could also test the number theoretic information measures suggested by the p-adic approach using preferred resolutions defined by $N_m = kp^n$. Number theoretic information measures make sense for rational valued probabilities, and are obtained from Shannon entropy by replacing ordinary logarithm with the p-adic logarithm $Log_p(x) = log(|x|_p) = log(p^k) = klog(p)$ to get $S_p = -\sum_n p_n Log_p(p_n)$. The number theoretic entropies can have also negative values in which case one can say that the ensemble contains genuine information.

How the p-adic primes involved with intentionality and ordinary physics are related?

In real physics the p-adic primes involved are very large, for instance, $p = 2^{127} - 1$ for electron. These large primes however labels real space-time sheets and characterize their fractality and *effective* p-adic topology. p-Adic length scale hypothesis in its basic form predicts that primary and n-ary length/time scales correspond to powers of $\sqrt{2}$ of the fundamental p-adic length/time scales so that 2-adic fractality would indeed be realized in this sense. Besides the basic units for time and length also their integer multiples can take the role of the basic unit, this of course in accordance with the very notion of fractality.

Small primes would characterize p-adic space-time sheets serving as correlates of intentions. It seems that only relatively small values p, $p = 2$ being the simplest guess, are realized as far as intentionality is considered. The octaves in music realize 2-adic fractality and it might not be an accident that binary mathematics is mathematics of computation.

7.4 Some Other Aspects Of Consciousness In Relation To Time

The new view about time implies has quite far reaching implications. The notion of 4-dimensional body is the basic concept involved. One can understand long term memories as communications with the geometric past. Sensory perceptions can be seen as memories of magnetic body about the state of the material body in a time scale of a fraction of second. Also some other unexpected symmetries are predicted. Long term memory and precognition seem to be aspects of one and a same phenomenon. The same applies to psychokinesis and retro PK. In fact, both sensory perception, motor action, and memory can be seen as being based on the same mechanism if one accepts that personal magnetic body corresponds to "me". Libet's findings about active and passive aspects of consciousness provide empirical support for the notion of magnetic body.

7.4.1 Passive And Active Aspects Of Consciousness

The division of the aspects of conscious experience to active and passive ones is not so obvious as one might think. Sensory experiencing is more like building a piece of artwork than passive receival of the sensory input and active processes like healing could be rather passive receival of negative energy MEs from the patient so that the healee gets in this manner only metabolic energy and does the healing herself. It is also far from obvious whether precognition is passive experiencing of the geometric future or psychokinesis actively affecting it.

The fundamental identification for the active and passive aspects could be in terms of terms of the arrow of time for the sub-self in question. Sequences of state function reduction at the opposite boundaries of sub-CD would correspond to sensory perception and motor action respectively. Which is which would depend on the arrow of time for the CD containing the sub-CD.

A precise theoretical dichotomy, at least apparently analogous to active-passive dichotomy, however exists if one accepts that MEs provide the basic mechanism of remote viewing and intentional action. Negative energy MEs can induce mere entanglement making sharing of mental images possible. This would naturally correspond to the passive aspects of consciousness as far as the receiver of negative energy MEs is considered. The generation of negative energy MEs makes possible remote metabolism at the end of system generating the negative energy ME. The receiver of the negative energy ME, say precognizer would be the passive counterpart whereas its sender, say an area of left cortex suffering from under-nutrition as might be in the case of synesthesia, would be the active counterpart. One must be however cautious here. It is not at all clear whether one can talk about sender/receiver of the negative energy ME since entanglement is completely symmetric process. In the sequel it is assumed that the notion of sucking of negative energy does not make sense.

Low frequency MEs can also contain also high frequency MEs inside them and positive energy MEs of this kind are especially natural for the realization of active aspects of consciousness. Positive energy MEs could directly provide energy to the receiver. They can also induce bridges along which various particles leak between space-time sheets so that basic metabolic activities are induced and controlled remotely.

7.4.2 Sensory Perception, Motor Action, And Time

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

hierarchy of some organization and CNS as the lowest level ultimately realizing the desire of the big boss.

Sensory organs as seats of qualia

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

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking [K39].

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

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

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

How motor action differs from sensory perception?

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

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

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

7.4.3   Long Term Memories And Time

TGD based model of long term memory requires no storage of memories of past to the brain of the geometric now. The memories are in the geometric past as dynamical self organization patterns and subject to changes.

1. In the case of active memory recall the desire to remember is communicated to the geometric past by sharing and fusion of mental images made possible by entanglement. In the case of episodal memories also the memory recall would result in this manner. For non-episodal memories the memory would be communicated from the geometric past using classical communications.

2. In the case of episodal memories active precisely targeted memory recall might be difficult since the entanglement with a correct mental image seems to require good luck. In principle it is possible to select the distance T to the geometric past where the memory comes from by selecting the fundamental frequency of ME. There are huge amounts of information, which is useless unless the person is an artist. Ironically, the loss of cognitive abilities would be compensated by episodal memories providing mental powers making an idiot a genius able to tell whether a given number is prime and to perform extremely complex calculations. A mild variant of the idiot savant phenomenon can be induced artificially by trascranial magnetic stimulation even in ordinary persons [J98]. The miraculous memory feats of synesthetes and idiot savants, and also sensory memories and strange abilities induced by electric and transcranial magnetic stimulation could involve the entanglement of the stimulated brain areas rather than that of magnetic body with sensory representations with brain areas taking the role of sucker of positive energy. In this kind of situation the starving magnetic body could send negative energy sensory MEs to a more distant geometric past and experience episodal memories instead of the sensory input.

3. Classically communicated memories are symbolic and thus the amount of information is minimized. They are also reliable since it is enough for the brain of the geometric past to share the desire to remember. If the desire is communicated to a wide temporal range in geometric past, some self of the geometric past is able to communicate the answer. Context sensitivity is the drawback of this memory mode. Memes defined as sequences of memes defined by sequences of 21 DNA triplets might define what might be called universal language helping to overcome the context sensitivity [K41].

4. Brains could also generate automatically classical signals about often needed declarative memories to the geometric past at various lengths of magnetic flux tubes. The memory recall would require only the tuning to receive the classical signal. This would require an organization of brain analogous to sensory areas so that a particular neuron group is tuned to receive signals from a particular distance to geometric past. One can also imagine a situation in which the communication of the memory from the past occurs as repeated communications over shorter time interval, somewhat like ordinary communications using radio stations receiving and re-sending the message. For instance, classical communications could circulate around the magnetic loops associated with the personal magnetic body or that of Earth's magnetic field much like neural signals in neural circuits. This would make the memory retrieval more reliable. The automatic classical communications could be also involved with the communications by active memory recall. The extreme situation would be the transfer of information from the geometric past like a news about some event in a population via communications between individuals. This mechanism would also establish the memory representation along the entire life span.

Do declarative memories and intentional action involve communications with geometric past?

Communications with geometric past using time mirror mechanism (see **Fig. `http://tgdtheory.fi/appfigures/timemirror.jpg`** or **Fig.** 24 in the appendix of this book) in which phase conjugate photons propagating to the geometric past are reflected back as ordinary photons (typically

dark photons with energies above thermal threshold) make possible realization of declarative memories in the brain of the geometric past [K85].

This mechanism makes also possible realization of intentional actions as a process proceeding from longer to shorter time scales and inducing the desired action already in geometric past. This kind of realization would make living systems extremely flexible and able to react instantaneously to the changes in the environment. This model explains Libet's puzzling finding that neural activity seems to precede volition [J34].

Also a mechanism of remote metabolism ("quantum credit card") based on sending of negative energy signals to geometric past becomes possible [K46]: this signal could also serve as a mere control signal inducing much larger positive energy flow from the geometric past. For instance, population inverted system in the geometric past could allow this kind of mechanism. Remote metabolism could also have technological implications.

Episodal memories as time-like entanglement

Time-like entanglement explains episodal memories as sharing of mental images with the brain of geometric past [K85]. An essential element is the notion of magnetic body which serves as an intentional agent "looking" the brain of geometric past by allowing phase conjugate dark photons with negative energies to reflect from it as ordinary photons. The findings of Libet about time delays related to the passive aspects of consciousness [J70] support the view that the part of the magnetic body corresponding to EEG time scale has same size scale as Earth's magnetosphere. The unavoidable conclusion would be that our field/magnetic bodies contain layers with astrophysical sizes.

p-Adic length scale hierarchy and number theoretically preferred hierarchy of values of Planck constants, when combined with the condition that the frequencies f of photons involved with the communications in time scale T satisfy the condition $f \sim 1/T$ and have energies above thermal energy, lead to rather stringent predictions for the time scales of long term memory. The model for the hierarchy of EEGs relies on the assumption that these time scales come as powers $n = 2^{11k}$, $k = 0, 1, 2,$, and predicts that the time scale corresponding to the duration of human life cycle is ~ 50 years and corresponds to $k = 7$ (amusingly, this corresponds to the highest level in chakra hierarchy).

Basic model for memory recall

For the time-mirror model of long term memory the ULF dark MEs must be generated both at the personal magnetic body and in the brain.

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

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

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

Higher levels of dark matter hierarchy provide neat quantitative view about self hierarchy and its evolution. For instance, EEG time scales corresponds to $k = 4$ level of hierarchy and a time scale of.1 seconds [K32], and EEG frequencies correspond at this level dark photon energies above the

thermal threshold so that thermal noise is not a problem anymore. Various levels of dark matter hierarchy would naturally correspond to higher levels in 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]. $k = 7$ would correspond to a duration of moment of conscious of order human lifetime which suggests that $k = 7$ corresponds to the highest dark matter level relevant to our consciousness whereas higher levels would in general correspond to transpersonal consciousness. $k = 5$ would correspond to time scale of short term memories measured in minutes and $k = 6$ to a time scale of memories measured in days.

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 [K51, 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.

How to achieve precisely time-targeted communication to and from geometric past?

Negative energy MEs are ideal candidates for sending a signal to the geometric past and inducing entanglement and sharing of the mental image representing the desire to remember. The magnetic flux tubes of the personal magnetic body with sizes measured in light years in turn can act as wave guides along which the negative energy curvilinear MEs propagate along or are parallel to. Also negative energy em MEs are possible since negative energy MEs interact very weakly with the external world in any case. Also the positive energy MEs sent to the direction of the geometric future as a response and representing classically communicated declarative memories would propagate along magnetic flux tubes. The same magnetic flux tube could be used for both communications.

One can consider several variants about how long terms memories are realized as communications between geometric now and geometric past.

1. Mirror model

The original idea was that MEs could be reflected at the ends or kinks of a magnetic flux tube serving as kind of mirrors. The outcome was the mirror model of long term memory in which the signal from the geometric past represented by ME is reflected at the end of the magnetic flux tube of astrophysical size. In the similar manner also the negative energy ME would be reflected. The model was still based on the idea that "me" is the physical body or brain. The basic objections are that there is no convincing identification of the mirrors and there is no guarantee that the mirrored ME returns to the original brain.

2. Loop model

One can also consider the possibility that closed magnetic flux tubes associated with the personal magnetic body could function as wave guides for curvilinear MEs, so that MEs would automatically return to the brain if they propagate while attached to the boundary of a closed magnetic flux tube. Also this model is still based on idea that the size of the personal magnetic body is not much larger than Earth's size so that one can idealize "me" as brain, at least in the length scale defined by the time span of the long term memories. Furthermore, despite the fundamental similarity between motor action, sensory perception, and memory, the mechanism of long term memory would differ from the mechanism of motor action and sensory perception. A further serious objection is that MEs parallel to the closed magnetic flux tubes and representing closed topological light rays might not be allowed as solutions of the field equations.

3. Brain and body as time like mirror

If one takes completely seriously idea about "me" as the magnetic body with size at least of order light lifetime which can be regarded as single quantum coherent structure, one ends up to a

variant of the model a). First of all, the whole magnetic body becomes the experiencer and classical communications need not be spatially precisely targeted. Secondly, brain and body serve as time like mirrors in the sense space-like reflection is replaced with both spatial and temporal reflection. Negative energy ME characterized by frequency and wave vector is replaced with time reflected positive energy ME: $(-E, -k) \rightarrow (E, k)$ in the reflection. Ideal reflection changes only the sign of the normal component of 3-momentum. If this is the case also now then also the magnitude of energy would be conserved so that the classically communicated memory would be automatically communicated to a correct temporal position in the geometric future.

If the transverse area S of flux tube codes for the temporal distance T to the geometric past by its transverse area ($T \propto S$) and thus by cyclotron frequency scale, the mechanism of long term memory becomes precisely identical with that of sensory perception and motor action. The desire to remember is communicated quantally from the magnetic body to brain along flux tube, and the reply arrives as a classical communication along same flux tube at the fundamental frequency and the reply communicated classically generates cyclotron transitions at the receiver's end at a correct temporal distance in future. In light of the fractality of consciousness, this model is certainly the unique one and is certainly consistent with the field equations.

The memory mental image communicated classically should reach the temporal position of the 4-D brain, which communicated the desire to remember. High precision communication is not absolutely necessary although it is favored by metabolic considerations: it is enough that the memory is communicated to a time interval containing the temporal position wherefrom the desire to remember was communicated. Memory could even diffuse like an interesting news in a 4-D society formed by mental images in brains at different times.

If MEs are amplified by Alfven wave resonance (closed magnetic flux tubes or flux tubes with ends), the wave length of ME should correspond to the length of the magnetic flux tube involved. If negative and positive energy MEs are associated with same magnetic flux tubes and the thickness of the magnetic flux tube varies as $S \propto L$, cyclotron transitions occur automatically at a correct temporal and spatial position of the flux tube and the sender of the memory recall receives the answer. In this case however memory is communicated to some time interval in geometric future.

If temporally selective communication is required, the frequency associated with ME must correspond to the same time value for the negative and positive energy MEs involved. A relative precision of $\Delta f / f \simeq 10^{-9}$ is required if the time span of the memory is 10 years and precision about.1 seconds (sensory memories). Of course, the needed precision could be much lower already because the time span of short term memories is of the order of minute. The active loss of memories could result from the refusal or inability of the "mes" of the geometric past to communicate memories or of the "me" of now to generate memory recalls. Later a model of time like reflection which could conserve the frequency with this precision will be discussed.

Second solution to the problem is to have several copies of the memory mental image so that the probability to hit one of them is high. Very probably brain applies this trick. This would explain why the standard model for long term memories seems to work reasonably well.

4. Variants of the time-mirror model

One can consider several variants of the time-mirror model.

1. For the simplest model the MEs involved are mor or less linear structures. For classical communications with light velocity the lengths $L = cT$ of the flux tubes would be measured in light years for a typical time span T of long term memory. If the memory recall originates simultaneously from various points of the magnetic body, the reply to the memory recall is received simultaneously by different part of the personal magnetic body in the approximation that the response at the biological body is instantaneous (so that also the received response emerges instantaneously). For EEG phase velocities L would be of the order of the size of the magnetic body of Earth for typical values of T so that the declarative memory could be communicated also to the magnetic Mother Gaia responsible for the third person aspects of the memory.

2. What is intriguing that for a typical EEG phase velocity v the distance $L_B = vT$ travelled during T corresponds to a wave length $\lambda = L_B = c/f_{high}$ of EEG wave propagating with light velocity. This brings strongly in mind the scaling law of homeopathy and its generalizations

[K42], and suggests that the boundary ME corresponds to EEG wave with EEG phase velocity v. This numerical coincidence encourages to consider also time like reflection in which energy is not conserved. The scaling law of homeopathy suggests that low frequency negative energy ME could transform in the reflection to high frequency positive energy ME:

$$f_{low} \rightarrow f_{high} \quad .$$

This transformation could be interpreted in terms of the Alfven resonance condition $f_{high} = c/L_B$ for a ME propagating in the flux loop of length L_B (recall however the objection against closed topological light rays).

3. Positive energy EEG MEs could propagate with light velocity along the closed loops of personal magnetic body of Earth's magnetic field and return again and again to brain very much like neural signals circulate in neural circuits. This would provide a way to refresh often needed memories. The main theme of [K50] was indeed the fractal correspondence between the structures of the brain and magnetosphere.

4. Fractality suggests that magnetic loops of all possible sizes are involved with classical communications by boundary MEs, even the magnetic loops of the material body serving as templates for neural circuits. The requirement that frequencies are identical for these fractally scaled magnetic circuits could be seen as an entrainment phenomenon. This would predict ultra-slow neural signals serving as correlates for the classical communications of long term memories at brain level. It is indeed known that Ca_{++} have extremely wide velocity spectrum [A34].

The model based on W MEs as induces of motor actions explains these velocities explains these velocities differently. Classical W field depends on the light like longitudinal coordinate and single transversal coordinate. One expects that the maxima for the intensity of W field are the loci around which physiological effects concentrate. These maxima in general propagate in the transversal direction. This velocity could correspond to the velocity of the physiological wave.

7.4.4 Remote Mental Interactions And Time

If the notion of magnetic body is taken completely seriously, sooner or later comes the realization that not only motor action, sensory perception, and memory, but also various forms of remote mental interactions could be based on essentially the same mechanism. Motor action and memory recall certainly involve the active aspect but so does sensory perception via direction of attention and selection between percepts.

Magnetic bodies are the intentional agents, and accompany even "non-living" targets. The intention of the magnetic body to achieve something is transformed first to a negative energy ME representing the communication of the desire to achieve something to the geometric past by sharing of mental images. Already the sharing of mental images might be enough, as In the case of remote viewing of the geometric past, in special case long term memory. Then the receiver of the negative energy ME, be it lower level magnetic body or material body, tries to realize the desire and generates classical signals. These signals could be also positive energy MEs and could propagate back to the magnetic body as in case of declarative memory recall. They could also propagate to another magnetic body, which would mean that mind-mind interactions are involved.

This unified view means that the distinction between active and passive aspects of remote mental interactions is far from trivial, and it is not so easy to tell where the boundary line between precognition and psychokinesis is. The first realization along these lines was that precognition and long term memory are different aspects of the same phenomenon. Then came the idea that also PK and retro PK could be seen as different aspects of the same phenomenon if PK can be regarded a generalized motor action in which target becomes effectively part of the body of the psychokinesist.

A possible view about remote viewing

The basic question is whether negative energy MEs are always generated actively by the system in the geometric future or whether also active sucking of the negative energy from the geometric

future is possible. The simplest assumption is that the sucking of negative energy is not a sensible concept. The motivation comes from the fact that it seems to be impossible to distinguish between sucking and passive receival of the negative energy since the entangled systems are in a completely symmetric position.

1. Active and passive aspects

Whether one can regard remote viewing as active or passive process depends on whether it is geometric past or future which is viewed.

1. If geometric future is viewed, the task of the remote viewer is to tune to the "correct wave length" in order to be able to receive the negative energy ME from the geometric future. This requires that remove viewer tries to get rid of mental images competing for the metabolic resources and tend to mask the viewed mental image. The initiative is possessed by the system in the geometric future sending the negative energy ME. The reaction of the remote viewer realized as classical communications could give rise to PK effect in the target. If the time-mirror mechanism based on induced phase transition is involved also with remote viewing, the reaction of remote viewer would be automatic so that some kind of PK effect would be unavoidable.

   One cannot completely exclude the possibility of time reversed classical communications. In ordinary classical communications the high frequency positive energy MEs absorbed by the receiver kicks it to a higher energy state wherefrom it returns to the ground state spontaneously. A system receiving high frequency negative energy MEs inside low frequency negative energy ME can drop to a lower energy state only if the magnitude of the energy is below thermal energy or if the system is analogous to population inverted laser. In the latter case the receiver would not however return spontaneously to the original state unless their is a feed of energy to the system.

2. If the geometric past is viewed, the process is active process and completely analogous to long term memory recall except that negative energy MEs generated by the remote viewer are not received by the brain of the viewer but some other system. Note that now also classical communications are possible and would be analogous declarative memories. These communications might be possible if the target is living system and be based on memetic code using the common vocabulary defined by common memes [K41].

2. Sharing of mental images

Since remote viewing by the sharing of mental images does not involve classical communications at all so that one cannot characterize the process in terms of bit currents. There are indeed arguments that if the field patterns of EEG waves were responsible for the remote viewing realized as classical communications, the bit rates required would not be high enough since the frequency defines an upper bound for the bit rate.

Sharing of mental images does not pose any obvious upper bound for the amount of conscious information transferred. Measures for the amount of information contained by mental image could be provided by the number theoretical information measures predicted by TGD approach [K56, K64].

What would be communicated would be more like impressions instead of messages consisting of symbol sequences. The message, say visual perception, would contain huge amounts of irrelevant information. Of course, the mental images could be also cognitive or symbolic representation, say internal speech. The translation of these impressions to language involves cognition and analytic thinking and can lead to misinterpretations. The reports about telepathic communications suggest that mental images transferred in telepathic communications are fragmented more like sensory and emotional impressions and often what might be regarded as separate "features" of the perceptive field rather than complete percepts. If sensory organs are the seats of the sensory representations, telepathy should thus involve entanglement of the viewer with the brain of the sender containing the symbolic representations. Fragmentation would reflect that fact that brain does for sensory input same as catabolism makes for food.

It is known that the entropy gradients associated with the target correlate with the probability that target is remote viewed [J112]. In TGD framework this can explained as a basic

characteristic of conscious experience [K39]. All gradients, also spatial gradients, such as textures of visual field or gradients of illumination at particular wave length, are transformed to subjecto-temporal gradients and only changes are perceived in accordance with quantum jump as moment of consciousness identification. In TGD Universe the intensities of emotions are proportional to the gradients of entropies associated with various quantum number and zero mode increments and only objects generating strong enough emotional response catch the attention. Targets with low entropy gradients do not generate intense mental images in any perceiver (not necessarily human!), and thus do not generate remote perception by a sharing of mental images.

3. Remote viewing is not only viewer-target phenomenon

Remote viewing does not seem to be only a viewer-target phenomenon but involves many-brained magnetospheric selves receiving information from the brains involved with the typical experiment whose protocol is such that viewer does not know the location of the target. In particular, the ability of the remote viewer to view target about which he knows only coordinates having no significance as such to him but for someone involved with the protocol supports this view [J87]. Also the reported healings induced by prayer groups and meditation groups whose members do not know the healees and even where they are, support the same conclusion [J57]. Thus remote viewing as well as healing might involve multiple entanglement. For instance, healer would be entangled with higher level self in turn entangled with the healee. Fractality suggests that one could apply the wisdom about brain functioning to the modelling of the multi-brained selves. The notion of associations might make sense for instance. The analogy with brain encourages to think that also classical communications by positive energy MEs might be involved and make possible feedback and thus PK.

An interesting practical question is how to characterize the strength of the entanglement by negative energy MEs. The lifetime of the resulting bound state is one such measure. One could guess that this time scale is of the order of the relevant p-adic time scale. Somewhat paradoxically but in consistency with Uncertainty Principle, the duration would be the longer, the weaker the binding energy would be. Second measure is the number of MEs involved. If collective multi-brained selves are involved the number of brains involved and having information about target would be a significant factor.

Sharing of mental images as the basic mechanism of remote viewing

Sharing of mental images does not require neither target nor receiver to be able to communicate symbolically. Therefore the target and receiver could be any living system: animal, plant, even bacterium. In TGD Universe one cannot exclude even "non-living" systems as targets and even sharers of mental images. The remote viewing of non-living targets is indeed possible and in this case either mental images of target or some system perceiving target are shared.

Support for the extreme generality of the sharing of the mental images as a basic mechanism of remote viewing comes the fascinating experimental discoveries made by Cleve Backster [J24, J41]. These findings have led Backster to introduce the notion of primary perception, which seems to have a natural identification as sharing of mental images.

1. Plants, eggs, and even bacteria are able to have primary perceptions. Backster tells in the interview that even yoghurt got wild when he took a chicken out of refrigerator and began pulling off strips of meat. Plants respond electrically to strong negative emotions and to the violence or death suffered by other living organisms. That primary perception correlates with the strength of emotions conforms with the view that entropy gradients with respect to subjective time, which are indeed identifiable as emotions, measure the strength of perception.

2. Distance does not seem to matter much. Sperm separated by a large distance from its donor reacted when the donor inhaled amyl nitrate. White cells were found to remotely react to the emotions of their donors. Same was found to apply to plants and their owners.

3. Plants and even bacteria seem to have a defence mechanism resembling shock. If bacteria share the mental images of suffering organisms by receiving negative energy MEs sent by them, the shock could be interpreted as resulting from the depletion of positive energy resources (all excited states of population inverted many-sheeted lasers decay to the ground state) or be a mechanism preventing this depletion.

An interesting question is whether humans have lost this ability or is this reaction usually unconscious at our level of self hierarchy and whether human skin could exhibit GSR to say death of other life-forms.

Precognition and memory as different aspects of the same phenomenon?

It is tempting to see precognition and long term memory as different aspects of the same phenomenon involving sharing of the mental image resulting as fusion of mental images by time-like entanglement induced by negative energy ME.

1. This identification would explain why precognition is a rare instance whereas memories would pop up more or less spontaneously. The reason is that precognition means giving energy to the future self whereas memory means receiving it. During wake-up period brain has to utilize its metabolic energy to build sensory representations, to plan and realize motor actions, and cognize. Therefore not much energy is not available unless these activities are silenced. This kind of silencing is indeed a prerequisite for precognition [J87].

2. Sleep state is for metabolic reasons ideal for precognition. During sleep state it is however the larger self resulting as a fusion of brain with some other self which precognizes, so that these precognitions are usually not remembered. It should be however possible to precognize during dreams, especially so during lucid dreaming. The problem is that dreams are forgotten very rapidly unless they are documented immediately. The classic work "Experiment with time" of Dunne provides strong support for the prediction that dreams can be precognitive [J91]. Also Joe McMoneagle has told in his book about height ened precognitive abilities during lucid dreaming [J87]. Probably almost anyone has had dreams which develop logically to the ringing of the alarm clock.

3. In this picture the one who remembers, that is generates negative energy ME, is a natural candidate for the active participant in the process. Therefore precognizer can only calm his/her mind and try to "tune at the same wave length" in order to entangle with the self of geometric future and try to eliminate the mental images that would mask the precognized one and compete for metabolic resources. The tuning to the same wave length has quite literal meaning since the fundamental frequency of ME determined by its temporal duration characterizes what might be called the extension of the memory field. There is indeed evidence for the notion of memory field [J125]. If memory and precognition are aspects of the same phenomenon then also the notion of precognitive field makes sense.

PK and retro PK as essentially same phenomenon?

The ideas that PK is just motor action with target taking the role of the motor organs and motor action involves negative energy W ME leads to a new view about PK and retro PK.

1. Ordinary motor actions are initiated by higher level selves by sucking negative energy from motor organs and the process proceeds upwards in CNS to the direction of geometric past wherefrom classical response comes from. In the case of PK this would mean that psychokinesis would be initiated by psychokinesists by sucking energy from the target by sending negative energy MEs to the target. If this picture is correct, all motor actions, in particular PK, would be by definition retro PK since the reaction would occur in the geometric past always and only the time scale of the time lapse would distinguish between PK and retro PK.

2. One can of course imagine also a situation in which positive energy W MEs are generated and exotically ionize and entangle part of brain with a system located in the geometric future. Certainly this mechanism is not the one favored by the life in jungle. It is also far from obvious whether magnetic body has the needed metabolic energy resources to generate positive energy W MEs.

   In the case of non-living targets one can imagine that PK able person is able to transfer the metabolic energy of his own biological body to the target, perhaps by sucking it first to his own magnetic body and sending then to the target. Target could also generate negative

energy MEs send most naturally to motor organs or perhaps skin of the psychokinesist. This could induce the flow of various particles to say atomic space-time sheets, where they can induce dissipative effects. This and the universality of metabolism based on zero point kinetic energies forces to consider quite seriously the possibility that the magnetic body of almost any system can be a conscious experiencer or an intentional agent.

3. Not all targets are optimal. Targets should allow the generation of dark plasmoids giving rise to dark plasma oscillations. Capacitor like systems near di-electric breakdown would be optimal in this respect and this kind of systems has been used in PK experiments (this is discussed in [K82]. Targets made of organic material are also favored. If all PK is actually retro PK, PK is possible only if the target is able to provide or receive from some source the metabolic energy needed. Organic or living targets would be optimal but one might expect that living systems have developed immune systems in order to avoid of becoming possessed by alien magnetic bodies. There are indeed reports about PK effects on films which have gelatin as one component [I56]: I have discussed a model for these effects in [K42].

4. MEs can also play a role of mere control function by acting as bridges along which particles can flow between various space-time sheets but not accelerating the charges. The flow of particles between say magnetic flux tubes and atomic space-time-sheets induces a recoil effect and the explanation for the report of Modanese and [H8] [H7] about a new kind of radiation which induces motion of material particles without giving them appreciable energy, supports the view that this recoil effect can induce macroscopic motion. Also the model for the PK effects induced by Russian psychokinesists in charged objects at table near the critical potential inducing discharge leads to the idea that the flow of ions between space-time sheets inducing recoil effects is responsible for PK effect [K82]. Psychokinesist would provide the energy needed for the control of motion but that part of the momentum could come from (say) magnetic flux tubes carrying the ionic supra currents.

5. The idea about long term memory and precognition as different aspects of the same phenomenon does not generalize as such. Psychokinesist would perform (retro) PK to the target while living target could communicate sensory data as a reaction to the motor action coded into Josephson radiation giving rise to generalized EEGs. Hence remote sensing could appear as one aspect of PK and make possible controlled OK in the case that direct sensory input from the target is not available.

In the famous chicken-robot [J132] experiments chicken was imprinted to a robot with the consequence that the robots motion in room coded earlier to a random number sequence changed so that the robot tended to stay near chicken. In this case one could say that chicken performed retro PK in the computer program responsible for generating the random number sequence or sequence itself by generating negative energy MEs. The resulting PK effect on chicken was at the level of chicken brain and provided for chicken metabolic energy. Perhaps the interaction between child and parents involves a similar transfer of energy.

From remote viewing to quantum remote sensing?

Ordinary remote sensing technology is limited by the finite velocity of light making it impossible to remote sense actively objects that are too faraway. Time mirror mechanism (see **Fig. ??**) not only makes it possible to survive utilizing.3-.5 seconds old sensory data but also suggest a technology of active remote sensing based on time reflection at the studied object and thus involving no time lapse, and making possible remote sensing of arbitrarily distant, even astrophysical, objects.

A phase conjugate laser wave would travel to the geometric past and time-reflect back as an ordinary laser wave from an object containing population inverted many-sheeted laser mirrors. If negative energy ME is able to draw some critical number of particles to the ground state, a phase transition to the ground state occurs since the rate for the transition is proportional to the number of particles already existing in the ground state. The only additional condition is the presence of the many-sheeted population reversal. This condition could be satisfied for living matter at least.

Dela-Warr camera [J55] might be based on this mechanism. Even more science-fictively and a little bit of tongue in cheek, one can consider also the possibility of communicating with the

civilizations of the geometric future by using population inverted lasers. Send to the geometric future classical k-bit signals (k harmonics of the fundamental) at p-adic frequencies $f(n,k)$ to tell that we have discovered p-adic cognitive codes, and wait whether the population inverted lasers at these frequencies return to the ground state with an abnormally high rate! One can easily imagine simple codes for communication. For instance, for p-adic length scales corresponding to visible wave lengths the typical number of bits would be 163.

In the technological context remote metabolism would translate to a remote utilization of energy stores making un-necessary the costly transport of the fuel. Only negative energy signal of critical intensity would be required to generate amplified positive energy signal from the geometric past providing the energy instantaneously and over long distances. For instance, the need to carry large amounts of fuel and the limitations posed by the maximal classical signal velocity are the basic problems of the space technology. The technological variant of the remote metabolism might provide at least a partial solution to these problems.

7.4.5   Some Paradoxes Solved By The New View About Time

In the sequel some paradoxes of modern physics and philosophy of mind related closely to the notion of time, are discussed.

Paradoxes related to quantum physics

The basic paradox is the conflict between the non-determinism of the state function reduction and the determinism of the Schrödinger equation. At a more general level this paradox is the conflict between the subjectively experienced actuality of the free will and the determinism of the objective world. The resolution of this paradox in TGD context is already discussed.

In the context of the deterministic physics, theoretician encounters three rather unpleasant paradoxes.

1. The determinism implies that the unique objective reality corresponds to a single solution of the field equations. The first question is "What determines the initial conditions, say at the moment of the big bang?". The attempt to answer this question leads necessarily outside the physical theory: one possibility is to postulate anthropic principle. In TGD objective reality changes at each quantum jump and the localization in zero modes and Negentropy Maximization Principle imply a genuine p-adic evolution: therefore the recent objective reality is indeed an outcome of conscious selections.

2. The second paradox encountered by a theoretician is that in principle it is not possible to test a deterministic theory since only single solution of the field equations is realized and a genuine testing would require the comparison of the time developments for various initial data. In practice this problem can be circumvented by assuming the existence of identical sub-systems having very weak interactions with the external world but in principle the problem remains unsolved. In TGD framework the hopping in the space of quantum histories makes possible the conscious comparison of the "solutions of field equations".

3. A further paradox relates to the dualism between theories and reality. Sooner or later theoretician is forced to ask about in what sense the theories exists. In TGD framework there is no need to postulate any further reality behind the theory. Quantum histories/ WCW spinor fields are what exists, model of reality is the reality. The hopping around in the space of these mathematical structures gives rise to the experiences of the pain and the concepts of toe and stone.

The famous Einstein-Bohr debate was related with the question whether God plays dice or not. In TGD context both were correct in their own ways. Quantum histories are indeed deterministic but God can replace the old quantum history with a new one: perhaps one should not however call this act dice playing but simply an act of free will. Einstein was also an advocate of local realism: this led to Einstein-Podolski-Rosen paradox created by the possibility of quantum entanglement between distant system. In TGD framework local realism holds true at the level of the infinite-dimensional WCW but not at the level of space-time since point like particles are replaced with 3-surfaces.

The phenomenon of dissipation is paradoxical from the point of view of standard physics. It is generally accepted that the fundamental laws of classical physics are reversible whereas everyday reality is manifestly irreversible. Thus the situation is rather schizophrenic. Two worlds, the reversible and extremely beautiful world of the fundamental physics and the irreversible and mathematically rather ugly "real" world, seem to exist simultaneously. The quantum jumps between quantum histories concept solves the paradox and one can understand the dissipative world as an effective description forming an "almost" -envelope for the sequence of reversible worlds (time developments).

Paradoxes related to the theories of consciousness

Chalmers describes in his book "Conscious Mind" [J48] several paradoxes related to the materialistic and dualistic theories of mind. A common denominator for these problems is the assumption that consciousness is a property of a physical state: hence these paradoxes disappear in TGD context. These paradoxes are encountered also in the quantum theories of consciousness identifying consciousness as a property of a macroscopic quantum state, say Bose Einstein condensate.

In the materialistic theories of mind, postulating a unique objective reality, consciousness is an epiphenomenon and free will is necessarily a peculiar illusion and one can always ask why the consciousness is needed at all. Nothing changes in the physical reality if consciousness is dropped away. It is also very difficult to understand how the contents of consciousness are determined by the state of the material world.

In the dualistic theories postulating a unique objective reality (say the theory of Chalmers [J48]), the problems are related to the coupling between matter and mind. The basic problem of the dualistic theories is what Chalmers calls hard problem: how the physical processes in the brain give rise to conscious experience? If the laws of the physics determine the behavior of the system completely then one ends up immediately either with a complete separation of the mind and matter so that our conscious experience tells nothing about the material world or with materialism and epiphenomenalism. One can also consider a non-trivial coupling between matter and "mind like" fields but assuming a deterministic physics one ends up with a situation in in which the mind fields are effectively just additional physical fields and consciousness is again redundant.

In TGD framework, which could be called tripartistic, hard problem and other problems of the dualistic theories disappear since there is no need to assign consciousness to quantum history. Moment of consciousness as quantum jump between quantum histories hypothesis allows even to define measures for the information contents of the conscious experience despite the fact that one cannot write explicit formulas for the contents of conscious experience.

Logical paradoxes and concept of time

Many logical paradoxes could be resolved if one assumes that there are two times: geometric and subjective and that the space-time surface providing linguistic representations changes quantum jump by quantum jump. In particular, during the conscious argument leading to the logical paradox!

The objections of Uri Fidelman [J147] against the Platonic vision about reality involve the paradoxes of the cyclic cosmology (one might think that Turing machine in cyclic cosmology might be able to "know" whether it has halted immediately after starting and thus be much more powerful than ordinary Turing machine). Basic paradox is that in cyclic cosmology allowing time travel one can imagine a psychopathic son who murders his mother.

It is interesting to consider this paradox as resulting from identification of the identification of subjective time with geometric time, which I see only as an approximation. In TGD the counterpart of time travel would be sequence of quantum jumps changing the entire classical history quantum jump by quantum jump and inducing the shift of the space-time region, where the contents of consciousness of time traveller are concentrated, to the geometric past. No paradoxes result since space-time is not a fixed arena of dynamics but changes in each quantum jump.

As a second example one can take the second objection of Uri Fidelman [J147] against Penrose's program known as Berry's paradox.

Non-formalizable theory cannot provide a model of the physical world which includes the brain's cognitive function, since such a model must be lingual, written or spoken. However, such

a model implies the following paradox of Berry: Let n be the smallest number which cannot be defined by an English sentence having less than, say, a hundred letters. This number exists, since the number of all possible combinations of a hundred letters is finite. Nevertheless, it has just now been defined by a sentence comprising less than a hundred letters.

Berry's paradox could be understood when the piece of text is seen as inducing a sequence of quantum jumps in which the space-time region at which the argument is represented symbolically changes. For the initial space-time region representing my cognitive state there is indeed smallest number n which cannot be defined by using less than one hundred words (using the English in that space-time!). After reading the statement quantum history is replaced by a new, more complex one in which this this number can be defined by using less than one hundred words since a new reflective level of cognitive consciousness has emerged and is represented at space-time level.

This example encourages to think the possibility of replacing the idea of a fixed axiomatic system with a living and dynamically evolving system becoming conscious of new axioms from which new theorems can grow. Mathematician would not be anymore an outsider but and active participator affecting the mathematical system he is studying. For instance, when paradoxical statement represented symbolically becomes conscious in quantum jump sequence, also the context in which it was originally stated changes. This dynamical view about mathematical system could allow to solve antinomies.

7.4.6   Comparison With The Approach Of Barbour

The comparison of TGD based view about time with that of Barbour might help to understand what distinguishes TGD view from quantum general relativistic view. Barbour has proposed in his book [J81] that time is illusion. Barbour is a proponent of canonically quantized general relativity, where the canonical quantization rules eliminate time completely from the formulation. This reflects that fact that the dynamical arena is the space of 3-geometries rather than 4-geometries. This is also the situation in the super-space approach of Wheeler, which served as an inspirer of the WCW geometry approach in TGD framework. Barbour's conclusion that time is illusion is certainly counter-intuitive but perfectly logical if one identifies time as geometric time and takes canonically quantized general relativity completely seriously.

There are of course objections against this conclusion. General coordinate invariance is a four-dimensional symmetry and the notion of space-time is crucial in all practical applications of general relativity: therefore the disappearance of time from quantum theory tells that something has gone wrong. Indeed, Schrödinger equation and canonical quantizations were derived originally for non-relativistic systems so that the application of the formalism in general relativity might lead to astray. Secondly, the mathematical formalism resulting exists only formally since the naïve generalization of non-linear field equations to infinite-dimensional context fails.

Accepting for a moment the absence of geometric time, one can ask whether the experienced time could have a place in Barbour's universe. If one accepts the notion of quantum jump sequence also the space of 3-geometries, one would indeed have subjective time. In the transition to TGD Universe space-times become 4-surfaces and the geometric time would emerge automatically. The fundamental deviation from the canonical quantization is that the fundamental variational principle means something more than the extremization of the action defining the theory. This led to the notion of preferred extremal as analog for Bohr orbit.

Zero energy ontology (ZEO) was a great step of progress in the development of TGD. Now pairs of space-like 3-surfaces at the boundaries of causal diamond become the basic objects. It is important to notice that preferred extremal property itself in ZEO is un-necessary unless one requires Bohr orbit property: the reason is that for given pair of 3-surfaces at boundaries CD the space-time surface would be unique for deterministic dynamics. In the case of non-deterministic dynamics situation can change but this seems to relate to hierarchy of Planck constants bringing in new degrees of freedom related to the non-determinism and to super-conformal symmetries acting as gauge symmetries. Bohr orbit property would be space-time correlate for the correlations of the positive and negative energy states at the ends of CD and non-triviality of quantum dynamics so that preferred extremal property would be another name for Bohr orbit property. Therefore it seems reasonable to assume that the notion of preferred extremal indeed makes sense and is needed.

After several guesses what the preferred extremals might be, it became clear that the formulation of the theory in terms of the modified Dirac equation requires the existence of infinite number of deformations of the space-time surface with vanishing second variation of Kähler action. This is nothing but classical correlate for quantum criticality. The interpretation in terms of conformal symmetries is highly attractive and suggests that most of the conserved charges vanish.

Besides allowing to get rid of the infinities of the local quantum field theories, preferred extremal property implies generalized Bohr rules and assigns to given 3-surface (counterpart of 3-geometry) a unique space-time surface. This however requires generalization of the notion of 3-surface since standard form of determinism fails for Kähler action, Even this is not enough for having the psychological time: the localization of conscious experience requires classical non-determinism (which becomes determinism if 3-surfaces are generalized to sequences of 3-surfaces with time like separations). As found, also p-adic physics as physics of intentionality is required to understand the emergence of the psychological time.

7.5   Cosmology Of Consciousness And Four-Dimensional Brain

The paradigm of 4-dimensional brain is the most important consequence of the Grand Scenario. The non-determinism of the Kähler action (non-determinism is understood here in the conventional sense of the word) is the quintessential, purely TGD based element of the Grand Scenario: without there would not be any evolution, the contents of conscious experience would be diffused around entire quantum histories and there would be no systems with strongly time-localized contents of consciousness. A second key element is p-adic nondeterminism making possible intentionality and cognition.

7.5.1   Cosmology Of Consciousness

Cosmology of consciousness scenario is inspired by the notion of infinite self hierarchy and by the quantum-classical correspondence principle stating that the fractal structure of the many-sheeted space-time should directly reflect the general structure for the cosmology of consciousness. For instance, the p-adic evolution of consciousness should have its counterpart at space-time level: indeed, there are good reasons to believe that 4-surfaces have decomposition into regions obeying real or finite-p p-adic topology just like WCW has decomposition into real regions and regions D_P labelled by infinite primes characterizing the appropriate functions space topology. Fractality suggests that there are conscious universes within conscious universes and that the experiences of universes involve kind of abstractions about the experiences of the sub-universes they contain. Summation hypothesis for the experiences of selves indeed states just this.

Each self corresponds geometrically to its own subset of space-time sheets, separate conscious cosmology. Mind like space-time sheets are bounded in time direction since they belong inside CDs. p-Adic length scale L_p gives a first guess for the typical duration $T_p = L_p/c$ of the space-time sheet. Even human body could correspond to mind like space-time sheet: time duration would be of order of lifetime. Note however that the visible body might be only tip of iceberg, and it indeed seems that our magnetic body could have size for which light life is natural unit of size. Since selves contain sub-selves with various values of psychological time, the experiences are actually multi-time experiences with respect to both geometric and subjective time. The most natural identification of the psychological time is kind of center of mass coordinate associated with the sensory selves.

If quantum entanglement in the direction of time is a relatively rare phenomenon (it is completely absent in standard theories), entangled mind like space-time sheets correspond to nearly the same value of time so that our conscious experience gets dominant contribution from time values around the mean value of the time coordinate for our space-time sheet of finite duration. Entanglement in time direction gives rise to multi-snapshot experiences which would resemble vivid long term memories. The interpretation as genuine memories is however not correct. Rather, multi-time experiences with contents coming from geometric past and recent are in question.

The conclusion would be that the entire 4-dimensional space-time is a living system in TGD universe: both the geometric future and past are living and participate in each moment of consciousness. Each moment of consciousness decomposes into infinite number of sub-moments

of consciousness of selves in the self hierarchy with the values of psychological time varying from zero to infinity. The value of our own psychological time of roughly 10^{11} years is just an accident. Entire civilizations can live in different geometric times without knowing anything about each other unless they happen to have entanglement in time direction. If they have, the resulting experiences could be interpreted as memories, dreams, religious or mystic experiences or simply as hallucinations. The inhabitants of sufficiently but not sufficiently advanced sub-cosmologies tend to believe that they are the only conscious beings in the Universe, construct their own cosmology and try desperately to understand why the value of cosmological time happens to be what it is and, to certain degree quite correctly, conclude that Anthropic Principle is the only explanation.

The civilizations of past could still exist and participate to each quantum jump. Also the civilizations of future coexist consciously with us. The hierarchy of selves implies that selves have increasingly longer geometric and subjective memories. The hypothesis about infinite primes implies a hierarchy of literally infinite values of psychological time and God like conscious beings with infinitely long geometric and subjective memories is possible if infinite primes. At the top of the hierarchy is the entire universe having infinitely long geometric and subjective memories and integrating all experiences at the lower levels of the hierarchy in single abstracted experience. Note that this picture gives hopes to understand how universe is able to construct theory about itself. Notice also that any theory of consciousness should be able to predict its own discovery and the infinite hierarchy of selves gives good hopes in this respect.

7.5.2   Communications In Four-Dimensional Society

The idea about four-dimensional society makes sense only if communication between members of this society is possible. It would be even better if communication could occur in "real subjective time". This seems to be possible in principle as the following arguments show.

Communication method

A simple model for real time communication between societies of the geometric future and past is based on the possibility of space-time sheets of negative time orientation having negative energy density. It seems natural to assume that at least classical signals propagate from geometric future to geometric past along these space-time sheets. As suggested in [K19, K68] "massless extremals" could make possible coherent motion of living systems. It seems that they could make possible also "real subjective time" communications in four-dimensional society.

1. Signals to the geometric future propagate along space-time sheets of positive time orientation. These space-time sheets can correspond to ordinary material space-time sheets but also almost vacuum space-time sheets can be considered. In particular, so called "massless extremals" [K68] are possible.

2. Signals to the geometric past propagate along space-time sheets of negative time orientation. Negative energy massless extremals are the optimal choice as far as classical communication is involved. The reason is that signal propagates with maximal signal velocity and consists of Fourier components with same momentum direction so that the shape of pulse is preserved. Polarization direction at a given point of the massless extremal is constant and depends on the transversal coordinates only. Solution involves two arbitrary functions and linear superposition of parallel Fourier components with identical polarization directions is possible. Therefore all possible pulse shapes are possible.

3. What happens in the communication is following. Sender performs quantum jump in which massless extremal of positive/negative energy is generated representing signal propagating to geometric future/past. Some standardized alphabet formed by the pulse forms for massless extremals: two basic pulse shapes identifiable as binary digits is the simplest choice. Receiver interacts with the massless extremal purely classically to receive the message and generates a massless extremal propagating to geometric past/future as a reply. The difference between sender and receiver is that sender performs quantum jump whereas receiver just acts purely classically to receive the message.

4. The communication is on-line "real subjective time" communication. There is no need to wait for next billion years for reply and members of cultures separated by billions of light years can have real time chat about their family problems! Also communication with effective signal velocity larger than light velocity becomes possible by using a "radio mast" in the geometric future able to send past-directed signals: the mast receives a signal from the geometric past and sends it to the second receiver in the geometric past.

Anomalies related to spinning astrophysical objects as empirical support for the idea

The proposed communication method could be regarded as mere wild science fiction unless there were some empirical support for the possibility of communication from geometric future to geometric past. In the articles [H11, H6] various anomalies related to spinning objects are reviewed. These anomalies are discussed in [K112]. There are also anomalies related to spinning astrophysical objects. Kozyrev [H5] has conducted astronomical observations using a receiving system of a new type. These observations have been replicated later by other groups [H4]. These anomalies give also support for the possibility of the signal propagation backwards in time.

1. When a telescope was directed at a certain star, the detector positioned within the telescope registered the incoming signal even if the main mirror of the telescope was shielded by metal screens. This indicated that electromagnetic waves were accompanied by some waves not shielded by the metal screens.

2. When the telescope was directed to the true position, the signal became stronger. As if there had been almost instantaneous propagation of signal with velocity billions times greater than the velocity of light!

3. When the telescope was directed to a position symmetrical with respect to the visible position, again signal was detected: the imaginative interpretation was that the signal came from future position of the star!

   Leaving aside the objections of a typical sceptic and the question whether the effect is real or not, one can ask whether the concepts of many-sheeted space-time concept and classical Z^0 field could somehow give rise to this kind of effect in strong conflict with the conventional wisdom.

1. Propagating photons (extremely tiny 3-surface glued to macroscopic space-time sheet) affect the space-time sheet and could generate propagating classical Z^0 field causing the effect in the detector. Of course, one cannot exclude the possibility of negative energy photons although the experimental arrangement eliminating the ordinary photons should eliminate also these.

2. The strong signal from the true position could have explanation in terms of a coherent classical Z^0 field of astronomical size. This kind of coherence is forced by the imbeddability requirement and was coined as topological field quantization in [K47]. One can intuitively understand it as follows. In TGD elementary particle is replaced with 3-surface, which can have arbitrarily large size and absolution minimization of Kähler action forces 3-surface to behave coherently like single particle (in case that it does not so, it decomposes into disjoint components!). The results of Kozyrev are not the only evidence for this kind of behavior. Total eclipses of the Sun by the Moon reach maximum eclipse about 40 seconds before Sun's and Moon's gravitational forces on Earth align [H10]. If gravity is a propagating force, this 3-body test implies that gravity propagates at least 20 times faster than light. The result is consistent with the assumption that the acceleration of Earth is towards the true instantaneous direction of the Sun now, rather than being parallel to the direction of the arriving solar photons now. The TGD based explanation is that the changes of the classical gravitational field are not propagating effects but that the classical gravitational field behaves like single coherent whole (it could of course contain also small propagating part).

3. The signal in the symmetric position could indeed come from geometric future. An attractive possibility is that classical Z^0 field propagated along space-time sheet with negative time orientation: for negative time orientation the propagation is expected to occur backwards in time.

There are also reports about the anomalies related to rotated magnetic systems in laboratory scale and these effects are under intensive study (for instance in Faraday Lab in Russia). The TGD based explanation of the anomalies reported in [H9] is developed in [K112]. The model involves in an essential manner the generation of both negative energy space-time sheets and many particle states with negative single particle energies residing at these sheets and some of the observed strange effects involved support the generation of the negative energy particles. The model allows to seriously consider the possibility that even ordinary ions and atoms could have negative energy counterparts.

7.5.3   The Paradigm Of Four-Dimensional Brain

The cosmology of consciousness implies that each conscious experience decomposes into separate sub-experiences with the values of the psychological time varying from zero to infinity. Furthermore, the experiences are in general multitime experiences both with respect to both geometric and subjective time. This picture forces the paradigm of 4-dimensional brain having profound consequences concerning the understanding of the brain functioning.

The difficult problems related to the understanding of conscious memory recall could trivialize. No separate mechanisms of memory storage or retrieval are needed and the difficult problems related to the interpretation of the stored memories are circumvented. There are two basic types of memories: geometric and subjective memories. Geometric memories provide as simulation for what happened and will happen provided no quantum jumps occur and has occurred and subjective memories tell what actually occurred. Actual memories are indeed known to be creative reconstructions of past and hence it seems that geometric memories are an essential part of construction. The comparison of expectations and actuality made possible by the two memory types gives rise to the emotions involving comparison aspect.

Subjective memory corresponds to immediate short term memory and the only possible identification of the *genuine* long term memories is as subjective memories at the higher level of self hierarchy, where the time span of subjective memory is longer. One possibility is periodic wake-up of sub-selves representing mental images and giving in this manner rise to long term memories: this requires some kind of periodic neural activity giving rise to the same sub-self periodically. Of course, it is not at all obvious whether long term memories are genuine! It is indeed known that long term memories are a result of a creative process and are not reliable. This would suggest that long term memories are actually geometric memories and are reasonably reliable because our geometric past is rather stable under quantum jumping. Of course, we do not usually test the reliability of our long term memories but take them as granted. The notion of mind like space-time sheet allows multitime experiences containing simultaneous contributions from both geometric present and past and the memories of, say, childhood could be genuine multitime experiences.

The "averaging" associated with the subjective memory implies that volition cannot correspond to the quantum jump occurring in the measurement of the density matrix. Rather, volitional activities must correspond to a localization in zero modes, most naturally selections between degenerate maxima of Kähler function. Besides volition associated with the motor activities, also the focusing of attention and even the selection of premises of logical thought very probably involve this kind of selection. The most probable function of the motor nerve pulses is the generation of multi-furcations in an initial value sensitive system between which the choice occurs. Various motor programs correspond to various branches of the multi-furcation. Just as sensory experience, motor activity is predicted to be a top-down self cascade of quantum jumps starting from the level of the entire body. Each selection of the space-time branch creates self inside which subsystems perform quantum jumps as long as self is awake and these quantum jumps in turn lead to even smaller sub-selves: in this manner a precise and flexible coordination and control of the movement involving volition at all length scales becomes possible whereas in the standard neuroscience picture body would act like a robot with fixed motor programs.

7.5.4   Geometric And Subjective Memories

TGD predicts two kinds of memories corresponding to two different time developments. There is deterministic (in generalized sense) geometric time development and the non-deterministic subjective time development by quantum jumps. The memories with respect to subjective time are

about previous conscious experiences and "real" whereas geometric "memories" are prophecies giving simulation of geometric past and future assuming that quantum jumps do not alter the macroscopic properties of the space-time surface.

A good visualization is following: each quantum jump represents particular geometric memory whereas the heap of these memories gives rise to subjective memory. The comparison between expectations and reality is obviously a central part of mentality and the heap structure of conscious experience implies that this comparison is a basic function of conscious mind not reducible to anything simpler. It is well-known that our memories involve a lot of construction and are more like stories consistent with what we actually have experienced than actual documents of what happened. This suggests that geometric memories, possibly constrained by subjective memories, give rise to the "story" about past.

7.5.5   Memories With Respect To Geometric Time As Simulations

Geometric memories are about both future and past and are predictions/simulations for what would happen if no further quantum jumps would occur and what would have happened if no quantum jumps had occurred in past. Geometric memories are also about past: we continually make guesses about the sequences of events which could have led to some event and this is nothing but predicting the geometric past. Of course, geometric memories are simulations rather than real memories. Geometric "memories" are real in the classical limit, when the effect of quantum jumps becomes negligible. In classical physics geometric memory is all that is needed to make predictions of past and future. We can indeed predict rather reliably what will happen in the solar system during the next decade. Also the computational approach to mind assumes only geometric memories. p-Adic geometric memories about future give rise to intentionality often regarded as a basic characteristic of conscious mind: beliefs, expectations, plans, etc. can be understood in terms of the p-adic geometric memory of future.

Intentionality manifests itself in many ways: as expectations of future, planning, goals, desires, fears, imagination, disappointments, etc.. The basic element of mentality is the comparison between the expectations of future and what actually occurred. In TGD framework this tension between potential and actual can be understood. The temporal extension of the mind like space-time sheet makes possible expectations of what happens in the future assuming that no quantum jumps occur or at least that quantum jumps do not change the macroscopic space-time. Single quantum jump contains information about this kind of expectations. Subjective memory in turn tells what happened actually. Therefore it seems natural, and this is the only possibility given the fact that it is not possible to know anything about future quantum jumps, to assume that all aspects of intentionality are made possible the predictions of the expected geometric future and past provided by the mind like space-time sheets.

What is nice is that subjective memory makes it possible to compare the expectations with what really occurred since subjective memory is kind of heap of predictions of future arranged with respect to the value of the psychological time. The origin of at least some emotions, which often involve a comparison of what happened and what was expected to happen, is perhaps here. It is quite well possible that all comparisons must be realized as comparisons of the subjective and geometric time developments (it could be that self is also able to compare its sub-selves).

The possibility of this comparison perhaps provides a solution to the paradox raised by the innocent question "How do I know that the me of today is the same as the me of the yesterday? How do I even know that I existed yesterday?". The solution might be simple: mind like space-time sheets have extension which can be much longer than the duration of the subjective memory. Therefore subjective memories contain information about the geometric me of the yesterday and geometric me of today and since these me's resemble each other quite a lot, the conclusion is that also the yesterday's me was a conscious self living in this same body. It is however quite possible that temporal entanglement with higher selves still remembering my past wake-up states is also involved and realized as a formation of join along boundaries bonds/magnetic flux tubes between the mind like space-time sheets of my self and of higher level self. Higher level self could also communicate directly the subjective memories about my existence to me.

7.5.6   Are Long Term Memories Geometric Or Subjective Memories?

The answer to the question whether long term memories are geometric memories and thus only simulations or genuine subjective memories of higher level self somehow communicated to us, is not obvious.

Long term memories as geometric memories?

Geometric memories realized as multitime experiences involving mind like space-time sheets located around several moments of the geometric time, provide the simplest realization for the long term memories.

1. The model solves the basic difficulties of the neural net models of long term memory. In the neural net models long term memories are represented by synaptic strengths. The problem is that the learning of new memories destroys old memories. In particular, the stability of the childhood memories is difficult to understand. It is also hard to understand how brain knows that the experience represents memory. One cannot avoid the difficulty by saying that novelty detection tells that experience occurs for the first time since the notion of novelty does not make sense if conscious experience contains only information from single moment of geometric time.

2. TGD model is consistent with neural net models and actually generalizes them. Neural net in the spirit of TGD corresponds to brain as system moving in spin glass energy landscape. Self-organization by quantum jumps leads the system to a bottom of an energy valley representing memory. This model is consistent with the fact that there is no upper bound for autobiographical memory. One can also understand how learning occurs. The repetition of an experience means that energy valley becomes a canyon in time direction so that mind like space-time sheets in the geometric past have a large probability to end up to the region representing memory. In particular, reverberating nerve pulse patterns are ideal for representing cognitive long term memories.

3. Highly emotional experiences generate deep valleys and increase the probability of the system of the geometric past to stay at the bottom of valley. This explains why childhood experiences are so stable. In fact, one could identify primitive emotions of pleasure and pain as related to the motion in the spin glass energy landscape. Pleasure and pain could even directly correlate with the sign of the increment of the Kähler function in the hopping motion in the spin glass energy landscape. Note that primitive pleasure and pain are are very much like sensory experiences and one could regard them as sensory experiences of brain about its own motion in spin glass energy landscape. This leads to the generalization of the notions of sensory experience and motor action to include the motion in spin glass energy landscape and to a considerably new insight about the meaning of the brain architecture.

   There are also perinatal experiences, memories about previous lives and transpersonal experiences having natural explanation in terms of geometric memory realized as multitime experiences associated with mind like space-time sheets located at different values of the geometric time.
   Transpersonal experiences suggests that self is dynamical: if prenatal experiences, memories about previous lives and transpersonal experiences are really what they seem to be, the geometric time extension of self should dramatically increase during these experiences.

Long term memories as subjective memories of higher level self?

The natural identification of the immediate short term memory as subjective memory predicts that the life time of a human sensory self cannot be much longer than .1 seconds, the duration of psychological moment of time. Our long term memories correspond to much longer time interval and cannot thus correspond to our subjective memories. Entire hierarchy of subjective memories is however predicted and a possible model for *genuine* long term memories (whose existence is questionable) is as resulting from temporary entanglement with selves belonging to the higher level of the hierarchy. Also this identification is consistent with the fact that there seems to be no upper bound on autobiographical memory.

Quantum-classical correspondence principle suggests that entanglement could correspond geometrically to temporary flux tubes between the mind like space-time sheets of self and higher level self. Summation hypothesis implies that our genuine long term memories would be sums over a large number of wake-up periods of self in the subjective past of the self. Therefore one could perhaps understand how ageing self gains gradually wisdom from experience: also the identification of the long term memories as geometric memories explains this. It would seem that our self must be able to shift the hierarchy level in order to remember details on one hand and to form abstractions on the other hand and that the detailed memories about the wake-up periods of self are unavoidably lost.

There are however serious counter arguments against this identification.

1. It is not at all clear why the experiences of the higher level selves during entangled state could be ours! For instance, during sleep without dreams entanglement with some higher level self should occur and we do not remember anything about this. Trance is a second example of this: subject person does not remember anything about the trance state.

2. The averaging involved with the temporal binding means that the subjective memories of the higher level selves cannot possess the details of our long term memories.

3. It is not obvious how to understand learning and the role of emotions in learning.

The entanglement with the higher level self is not necessary to have genuine long term memories. One could consider also the possibility that higher level self could somehow communicate the long term memories to the lower level selves. One function of sleep might be the generation of the entanglement with higher selves making in turn possible the communication of genuine memories of subjective past to our mind. This communication could realize these memories as thoughts about the experiences of past realized as nerve pulse patterns regenerating these thoughts. The lack of a precise realization of this mechanism makes the realization of the long term memories as geometric memories much more attractive option.

Long term memories as a communication between now and geometric past

The basic challenge is to identify concrete mechanisms of long term memory recall. According to the idea of magnetic sensory canvas discussed in [K83], the positions of objects of perceptive field are coded by the frequency scale of the magnetic transitions occurring at the magnetic flux tube structures having size of wave lengths associated with EEG frequencies. The slowly varying thickness of the magnetic flux tube codes for the position of the object of the perceptive field.

This encourages to consider the possibility that also the temporal position of the object of perceptive field could be coded in this manner. There are however two difficulties involved:

1. Since the time scales are of order life time T , the needed frequency resolution is $\Delta f/f \sim \Delta T/T$, if the time resolution is ΔT. This requires frequency resolutions of order $\Delta f/f \sim 10^{-8}$ at least and this kind of resolution is certainly not achievable in the neuronal circuits.

2. If ELF MEs (massless extremals) are involved it is difficult to understand how one could circumvent the fact that the ME represents geometrically a light ray escaping from the system. This ray should be reflected somewhere. Kind of mirror would be required. Magnetic flux tubes could serve as this kind of mirror and allow the radiation to travel in zigzag curve in space-time to geometric past.

There is however a much more elegant mechanism of long term memory recall based on MEs. First, of all what makes MEs so interesting from the point of view of long term memories, is that light like selves has a temporal extension, which can be arbitrary long in given rest system. Secondly, the pairs of MEs resulting when ME reflects from some structure such as magnetic flux tube structure serving as a mirror, provide a TGD based model of long term memories relying on the idea that long term memory recall involves a "question" sent to the geometric past as a classical signal reflected back to brain in a magnetic mirror, and a subsequent quantum entanglement in which the selves of the geometric past and now as well as ME selves entangle to single self so that the self of the geometric now can share the experience of the self of the geometric past.

What is so elegant in this mechanism is that there is no necessity of sending the information as a classical signal, only the time like entanglement is needed. In this case the MEs would have a length of order lifetime so that long term memories would be astrophysical phenomena involving magnetic flux tube structures and MEs. The temporal location T of the memory (or rather, shared conscious event) of the geometric past would be coded by the length L of ME: $L = cT/2$. The TGD based notion of time indeed allows geometric time scales of order lifetime to be involved with subjective experiences in psychological time scale of a fraction of second. Certainly this mechanism is completely out of question in standard physics.

7.6   Time Delays Of Consciousness

TGD based concept of time has rather dramatic implications and it would be important to show that the new time concept indeed solves conceptual problems and anomalies. One should also device experiments to test the new time concept. Dissipation is the black sheep in the family of theoretical physics and quantum jump between quantum histories concept explains dissipation in elegant manner. Quantum jumps between quantum histories concept together with the notion of self explains also the peculiar time delays of consciousness revealed in the experiments relating to the active and passive roles of consciousness [J70, J34] and described by Penrose in his book [J130]. It is also possible to explain the causal anomalies revealed by the experiments of Radin and Bierman [J36, J37, J56]. TGD predicts "tribar effect" as a general signature for the quantum jump between quantum histories concept.

7.6.1   Dissipation As Evidence For Consciousness

TGD based picture about time relies crucially on the notion that quantum jumps occur between quantum histories, objective realities. This hypothesis obviously means giving up the materialistic idea about single objective reality behind our experiences. It took quite long time to realize that our everyday experiences reveals directly the occurrence of quantum jumps between quantum histories! The phenomenon of dissipation is paradoxical from the point of view of standard physics. It is generally believed that fundamental laws of classical physics are reversible whereas everyday reality is manifestly irreversible. This leads to a rather schizophrenic situation. Two worlds, the reversible and extremely beautiful world of fundamental physics and the irreversible and the mathematically horribly ugly "real" world, seem to exist simultaneously. Quantum jumps between quantum histories concept solves the paradox and one can understand dissipative world as an effective description forming "almost" envelope for the sequence of reversible worlds (understood as entire time evolutions).

Dissipation can be also regarded as a direct evidence for the presence of the self hierarchy. One can imagine quite spectacular tests for the idea. NMP predicts that self can be in two modes of consciousness: quantum jumps reduce either matter-mind like entanglement or reduced matter+mind-matter+mind type entanglement leading to an unentangled subsystem giving rise to two new self candidates (sub-system and its complement inside self). The first mode corresponds to "whole-body" consciousness and in this mode matter-mind like dissipation in short length scales should be completely absent. The lowered dissipation should reflect itself as lowered metabolism. The measurement of cell level dissipation occurred during meditative states could provide a test for this picture. TGD explanation for the phenomenon of synesthesia [J126] discussed in [K89] relies on the hypothesis that left brain or considerable parts of it get quantum entangled and spends part of time in "whole-body consciousness". Indeed, synesthesia can involve lowering of left brain metabolism by as much 18 per cent [J126]: this should lead to paralysis if standard wisdom about brain functioning would hold true!

7.6.2   Strange Time Delays Of Consciousness: Experiments Related To The Active Role Of Consciousness

Libet has carried out classical experiments about active and passive aspects of consciousness [J70, J34]. It has gradually become clear that these experiments can be interpreted as a support for the identification of "me" as the personal magnetic body.The first class of experiments [J139, J34]

is related to the active role of consciousness. For example, the human subject moves his hand at free will. What happens is that neurophysiological processes (changes in EEG, readiness potential) start $T_1 = .35 - .45$ seconds before the conscious decision to move the hand whereas the awareness about the decision to move the hand comes $T_2 = .2 - .1$ seconds before the hand movement. Decision seems to be followed by the action rather than action by decision! This is in apparent accordance with the point of view that consciousness is indeed a passive spectator and the act of free will is pure illusion. What is interesting from the p-adic point of view, is that the most plausible estimates for the time delays involved are $T_1 \simeq .45$ seconds and $T_2 = .1$ seconds [J139]. T_1 is very near to the p-adic time scale $T(6, 43) = .4$ seconds and T_2 to the fundamental p-adic time scale $T(2, 127)$ defining the duration of the memetic codon.

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

The geometric past changes in quantum jump

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

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

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

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

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

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

This view about motor action means that it proceeds from long length scales to short ones whereas in the standard neuroscience view motor motor action would be planned and initiated in the brain and proceed to the level of motor organs, from short to long length scales. This certainly seems to be the case if one looks only the classical communications (say nerve pulse patterns). The extreme coherence of and synchrony of motor activities is however in conflict with this picture: neuronal communications are simply too slow to achieve the synchrony. This has been emphasized by Mae-Wan Ho [I46]. Since quantum communications proceed backwards in geometric time, classical signalling such as nerve pulses from brain to motor organs are actually reactions to the initiation of the motor action from the magnetic body.

7.6.3 Strange Time Delays Of Consciousness: Experiments Related To The Passive Role Of Consciousness

Libet's experiments [J70] about the strange time delays related to the passive aspects of consciousness have served as a continual source of inspiration and headache. Every time I read again about

these experiments, I feel equally confused and must start explanations from scratch.

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

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

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

Communications from brain to magnetic body

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

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

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

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

Libet's findings

Libet's experiments [J70] about the strange time delays related to the passive aspects of consciousness serve as a continual source of inspiration and headache. Every time one reads again about these experiments, one feels equally confused and must start explanations from scratch. The following explanation is based on the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths [K83].

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

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

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

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

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

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

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

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

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

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

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

7.6.4 The Experiment Of Radin And Bierman As Evidence For Quantum Jump Between Quantum Histories Concept

The experiments of Radin [J56] and the later experiments by Radin and Bierman [J36, J37] gave evidence for anomalous unconscious emotional responses preceding their cause. Radin monitored the sympathetic and parasympathetic behavior of the autonomic nervous system with skin conductance, heart rate and fingertip blood volume measurements. Subjects were asked to look at a computer monitor and press a button to start a trial. Button press caused the display of a blank screen for five seconds, then a randomly selected calm or emotional picture was shown for three seconds, and this was followed by ten seconds of a blank screen. In three studies, Radin found significant differences in autonomic physiology, most notably skin conductance, *preceding* the exposure of emotional vs. calm pictures. Radin examined a number of possible normal explanations for the result and concluded that they did not apply.

Radin and Bierman interpreted the result of the experiment as evidence for a reversal of the arrow of time. The constancy of the arrow of psychological time is by no means obvious in TGD Universe and one of the basic challenges of TGD inspired theory of consciousness is to understand how the (probably statistical) arrow of psychological time emerges. Moment of consciousness as quantum jump between quantum histories concept provides however an elegant explanation of the effect without any need to assume the reversal of the arrow of psychological time. What is important that one can also avoid the poorly defined concept of effects propagating backwards in time, which is needed in explanations based on quantum state as time=constant snapshot concept.

Consider now the TGD based explanation. In quantum jump deterministic quantum history is replaced with a new one: this means that, not only the future, but also the *past* changes. Therefore, if the mean galvanic skin response of the subject person provides a faithful representation for some aspects of subject person's deterministic quantum history, the entire time record about skin response must change to a new one in any quantum jump. If subject person experiences a highly emotional stimulus, the moment of consciousness is expected to be more intensive than for calm stimulus in the sense that the non-determinism associated with the quantum jump is expected to cause observable effects in a larger space-time volume of the quantum history (represented to a good approximation as quantum average space-time surface geometrically). Therefore also the change of the quantum past is expected to be more dramatic as it indeed seems to be according to the results of the experiment.

At first it might seem that there are no means to test whether the past has changed at the moment of consciousness. The experimental arrangement of Bierman and Radin, although certainly not originally planned to test quantum jumps between histories concept, circumvents in an ingenious manner this difficulty by comparing the skin responses associated with calm and emotional trials. Standard physics, which is based on assumption that there is no signal propagation backwards in time, predicts that the average skin responses before the stimulus should be identical for calm and emotional trials. This is not the case so that the results of the experiments indeed support TGD based world view.

One can in fact imagine even more dramatic test based on a modification of Radin-Bierman experiment. In quantum-mind discussion group Stan Klein [J139] suggested a modification of Radin-Bierman experiment [J36, J37, J56] providing a test for Stapp's and Sarfatti's theories of consciousness [J79, J1]. One could perhaps consider the following further modification of Radin-Bierman experiment so that it would simultaneously discriminate between Stapp's and Sarfatti's theories and TGD.

1. It might be possible for computer to perform a comparison of the response with average

calm and emotional responses *before* the subject person A sees the picture and, depending on whether the response is nearer to calm or emotional average response, to print C or E to a computer screen such that the printing result is seen by person B *before* A sees the picture.

2. The theories explaining phenomenon in terms of effects propagating backwards in time (say Sarfatti's theory [J1]) would predict that computer record and the sequence of letters remembered by B are identical and contain both C: s and E: s. According to [J139] Stapp's theory would predict that both computer record and B's memories contain only C: s.

3. TGD predicts that B would *see* only C: s. The concept of subjective memory implies that B also *remembers* of seing only C: s whereas computer records would contain both C: s and E: s. This would provide dramatic support for quantum jump between quantum histories concept and for the notion of subjective memory.

In TGD framework one can also consider an alternative explanation for the result of Radin-Bierman experiment. If this explanation is correct, the report of B is consistent with the computer record just as in Sarfatti's theory. The argument goes as follows.

1. Given moment of consciousness contains several irreducible sub-experiences besides the experience corresponding to the "real I", which presumably corresponds to "I" able to communicate using language and possessing long term memories. These "I": s are usually collectively identified as subconscious mind. The phenomenon of blind sight and related phenomena [J26] give support for the idea that there is second "I", most naturally at the same level of self hierarchy. One can even imagine entire population of selves at some lower level of self hierarchy giving rise to "Zombi within us" or shortly Z. In the latter case the response of Z is dictated by statistical determinism at the level of ensemble. Deterministic response has definite value in fight for survival.

2. The values of the psychological times associated with these various "I": s need not be same in given quantum jump. Suppose that Z has psychological time slightly larger than the psychological time of the ordinary "I" so that Z sees the state of the world at time $t + \Delta t$ whereas "the real I" sees it at time t in given quantum jump. The order of magnitude for Δt is roughly one second. Assume further that Z is able to assign emotional content to the picture. If the decision about what picture is shown is purely mechanical involving no quantum jump (and hence only effectively random) then Z can perceive the picture before the ordinary "I" perceives it with the result that galvanic response is created. Galvanic response is deterministic in case that Z is an entire population of "I": s.

Some remarks about the model are in order.

1. The criticism against this kind of model is that Z is perhaps not able to assign any emotional content to the pictures. The experiments supporting the existence of Z mildly suggest that Z sees the things "as they are" (for instance Z cannot be fooled by visual illusions) which in turn suggests that emotional response is perhaps not involved.

2. Z could also receive the information about the picture by precognition in principle made possible by the diffuse contribution to the contents of conscious experience coming from entire initial and final quantum histories. If this is the mechanism, one can however wonder why the "real" I is not capable to same so that also "real" "I" would have *conscious experience* about the nature of the picture before seeing it.

3. In case of Kornhuber experiments similar explanation would lead to the veto model: the conscious decision to raise index finger is preceded by the conscious decision of Z to raise it and the "real I" can decide whether to allow various neural processes to continue or not.

4. In principle (probably only in principle) one could test the model by allowing the selection of the figure to be shown to A be determined by a quantum jump rather than by deterministic process. If this quantum jump occurs only very short time before A sees the picture, response should disappear.

An effect resembling Radin-Bierman effect might occur in much more concrete situation. There is a legend about the ability of the short distance runners to anticipate the shot of the starting pistol and start already before the gun shot. Perhaps this really occurs but in the following sense. When short distance runners hear the shot they perform a quantum jump to a new history. For obvious reasons they might have developed a skill to jump to a quantum history at which they started before the gun shot. Whether this effect occurs could be tested by using video camera or some more sophisticated arrangement (gun shot can be accompanied or even replaced by light signal to make the timing precise). What could happen is that the man with the gun honestly claims that the runner started after the shot whereas videocamera tells that runner started before the shot. This effect deserves the nickname "tribar effect" (tribar is the famous non-existing triangle like structure formed from three bars): in its various forms the effect could provide very general hard evidence for TGD based view about space-time.

Notice that the paradox of ping pong game described in the book of Penrose [J130] can be resolved in quantum jumps between quantum histories picture. The problem is that the time delays of consciousness are so long that no conscious action seems to be possible in ping pong game. The resolution is simple. The players can quite well miss the ball time on the old history but perform a jump to a new history: on this history they do not miss the ball thanks to the rapid deterministic reflex action.

7.7   Good And Evil, Life And Death

In principle the proposed conceptual framework allows already now a consideration of the basic questions relating to concepts like Good and Evil and Life and Death. Of course, too many uncertainties are involved to allow any definite conclusions, and one could also regard the speculations as outputs of the babbling period necessarily accompanying the development of the linguistic and conceptual apparatus making ultimately possible to discuss these questions more seriously.

Even the most hard boiled materialistic sceptic mentions ethics and moral when suffering personal injustice. Is there actual justification for moral laws? Are they only social conventions or is there some hard core involved? Is there some basic ethical principle telling what deeds are good and what deeds are bad?

Second group of questions relates to life and biological death. How should on define life? What happens in the biological death? Is self preserved in the biological death in some form? Is there something deserving to be called soul? Are reincarnations possible? Are we perhaps responsible for our deeds even after our biological death? Could the law of Karma be consistent with physics? Is liberation from the cycle of Karma possible?

In the sequel these questions are discussed from the point of view of TGD inspired theory of consciousness. It must be emphasized that the discussion represents various points of view rather than being a final summary. Also mutually conflicting points of view are considered. The cosmology of consciousness, the concept of self having space-time sheet and causal diamond as its correlates, the vision about the fundamental role of negentropic entanglement, and the hierarchy of Planck constants identified as hierarchy of dark matters and of quantum critical systems, provide the building blocks needed to make guesses about what biological death could mean from subjective point of view.

7.7.1   Life And Death

There are rather important steps of progress occurred during that last years (I am doing this updating 2015), which allow a more serious consideration of the notions of life and death in TGD framework.

1. NMP and the notion negentropic entanglement imply that state function reductions do not only destroy entanglement but can also create negentropic entanglement for which the density matrix is projector to a higher-dimensional sub-space of state space. This changes completely the standard rather gloomy view about evolution as approach to maximal entropy. Also now second law holds but for the ensemble entropy which is single particle quantity whereas entanglement entropy characterizes a system with at least two particles. The stable correlation between system and complement becomes information carrier.

A possible interpretation is as an abstraction: the pairs of stase in the superposition are instances of the abstraction, concept, or rule. I have christened the negentropic resources as Akashic records. In this view Universe is a gigantic library, which grows all the time. It is not a priori clear whether the information coded to negentropic entanglement is conscious.

The original idea that interaction free measurement generalizes so that it applies to deduce information about negentropic entanglement turned out to be wrong. Negentropic entanglement must be experienced directly. Interaction free measurement can be however used to read memories represented in terms of bits. For interaction free measurement Elizur-Weizman bomb tester is an excellent representation (see `http://tinyurl.com/y9zenssv`) involves state function reduction. The outcome of interaction free measurement now tells whether the bomb can act as quantum measurement apparatus or not (is it active or not) and at idealized limit the state of bomb is not changed (it does not explode).

The only option consistent with the recent formulation of quantum measurement theory in ZEO and based on NMP is that negentropic entanglement is directly experienced as a rule or concept during state function reduction sequences at the same boundary of CD so that no measurement is needed. This option is the only possible one in the recent formulation.

2. TGD Universe is quantum critical. This statement has now an elegant formulation as a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of various conformal algebras associated with TGD acting as gauge symmetries, and labeled by effective Planck constants $h_{eff} = n \times h$. The levels of the hierarchy have interpretation in terms of dark matter. The most important algebra of this kind is super-symplectic algebra. The phase transitions increasing $n = h_{eff}/h$ correspond to scalings $n \to m \times n$ for some integer m and criticality is reduced so that these phase transitions should occur spontaneously. Living systems can be seen as systems trying to stay at the existing criticality. This requires metabolic energy and homeostasis serves this purposed. Eastern philosophies talk about Karma's cycle and the need to preserve ego preventing the spontaneously occurring extension of consciousness.

One can argue that this view about life as a battle against enlightenment is rather cynical. The attempt to stay at quantum criticality should have some deep positive meaning. Maybe the jumping forth and back between criticalities is what gives life its positive meaning and helps to build Akashic records by generating negentropic entanglement. Maybe living systems could be seen as kind of publishing producing systematically replicas of Akashic records could be the deep rationale behind life.

3. ZEO allows a precise identification of self as a sequence of state function reductions at the same boundary of CD. This allows also to understand how the experience about flow of time and arrow of time emerge. One can also formulate precisely the life-time of the system in geometric sense as the increase of the average distances between the tips in the superposition of CDs associated with self. The life-time in subjective sense can be identified as the number of quantum jumps at passive boundary of CD.

The first state function at the opposite boundary of CD means the death of self and rebirth of self at the opposite boundary. NMP forces this first state function reduction and when it occurs for sub-self higher level self interprets it as an act of volition.

4. NMP has become central principle of TGD inspired theory of consciousness. Quite generally, NMP replaces quantum randomness with intentional evolution: Universe has a goal and this is to increase negentropic resources. The analogs of slee-wake-up cycles in which self and its shadow wake up would be realized in all scales. Can one interpret also human life cycle as on example about this kind of cycles.

The basic questions seem to be following ones.

1. Is me the self defined by my biological body? In this case biological death would mean re-incarnation of me at opposite boundary of CD and life lived in opposite direction of time. Or does my biological body corresponds to my subs-elf/mental image. Me could in this case correspond to my magnetic body or field body having possibly astrophysical size. The death

of my biological body would replaced the mental image about biological body with time reversed mental image.

2. A further interesting question is whether there is a continuity of conscious experience in the re-incarnation of self at opposite boundary of CD. We remember something about our dreams. Does this new self have memories about the earlier life?

3. Also NMP raises questions. Can self perform bad deeds or does NMP automatically imply possible deeds increase the negentropic resources. In thermodynamics thermodynamical fluctuations can break second law in some short enough time scales. NMP has structure very similar to second law. Could it be that bad deeds are analogous to thermodynamical fluctuations: possible but present only in short time scales?

Or is the only remaining non-predictability related to the ordinary state function reductions in which outcome is non-deterministic and random. But how can one see the deeds of Hitler as creation of negentropy? His deeds produced a lot of suffering but did they teach for humanity something very importan: Do not do like Hitler?

Perhaps the only reasonable option is that NMP allows but does not force state function reduction to a density matrix which is a higher-dimensional projector. Self can select whether it performs a reduction to this or a lower-dimensional space or even to a ray of Hilbert space. This allows also bad deeds and the optimistic view would be that these bad deeds are analogous to thermodynamical fluctuations.

What is Death

One can interpret ageing in two senses. The ageing with respect to geometric time and the ageing with respect to the subjective time. Before discussing ageing in the sense of geometric time one must specify what one means with geometric time and what one believes its relationship to subjective time to be.

1. There are two geometric times corresponding to the times assignable to space-time surface and embedding space and by general coordinate each of these times can be identified in various number of ways.

2. Geometric time increases in discrete steps and corresponds to sub-sequent scalings of CD size defined by the distance between its tips by integer. One could call this geometric time associated with particle CD/self personal geometric time. Each self/CD defines its own embedding space time and the increase of the proper time distance between the tips of CD is the natural choice for the definition of the age of self. There is also time associated with space-time surfaces. Both time coordinates can be chosen in many ways but symmetry conditions favor certain choices.

3. Subjective time corresponds to the number of the state function reductions already occurred at the passive boundary since the first one. The ratio of subjective age to geometric age measures the number of conscious experiences per geometric time and the larger this number is the longer of the subjectively experience time is.

4. Ageing itself with the biological and spiritual aspects that we know could be seen in two ways. Biological ageing which corresponds to $h_{eff}/h = 1$ sector consisting of ordinary visible matter and second law which follows also from TGD. Variants of second law are expected also for other values of h_{eff}/h corresponding to dark matter and be a manifestation of the non-determinism of state function reduction at ensemble level. Spiritual ageing would correspond to the gradual increase h_{eff}/h and quite literally leading to the increase of the scope of consciousness. The increase would be due to giving up in the fight against spontaneous increase of criticality to keep h_{eff}/h unchanged and allowing the transition to criticality at longer length scales. Eastern thinking would translate this to ego attachment.

There must of course be some point in fighting against the spontaneous increase of h_{eff} and there is. The longer the lifetime of self is, the wiser the sub-selves representing mental images can become by repeated re-incarnations. Ageing means getting wiser! By favoring the generation of negentropic mental images, self can live longer.

5. The challenge is to understand in more detail how biological death as the first state function reduction at the opposite boundary of CD is forced by NMP. This relates to the growth of entropy at the lowest and also other levels by the challenge is to understand the details. The increase of the total negentropy of CD by generation of negentropic mental images can postpone the biological death.

   Could it be that a cascade of state function reductions proceeding down to shorter scales from the level of CD cannot anymore produce negentropic entanglement and after that NMP forces the biological death. Since h_{eff} can increase in the first reduction to the opposite boundary of CD, NMP forces this reduction to eventually occur. An interesting question already posed is whether the integer multiples of the original size of CD correspond to especially critical moments for the biological death.

   There is present an entropy growth due to the randomness of state function reduction leading to a thermalization or the ensemble of mental images. This would correspond to second law, which still hold true for ensemble entropy. NMP predicts that the negentropy of conscious experience tends to increase and the biological death is only a transformation to some new form of existence. The dark matter hierarchy with levels labeled by the values of Planck constants has become a key element of TGD inspired theory of consciousness and one can imagine that during ageing these levels of existence begin gradually dominate consciousness.

   What interests us mostly is obviously the subjective ageing and biological death. What dying person might experience? Is there a continuity of subjective experience or does suffering end with a loss of consciousness. What follows after biological death? How our deeds affect what happens in biological death and to the experiences after the biological death? Here are some possible answers.

1. If biological body corresponds only a mental images of the magnetic body, the only thing that happens in biological death could be that the contribution of biological body to the contents of consciousness disappears so that other contributions usually masked to a high degree by sensory input and motor activities become into full light of consciousness. In fact biological body and magnetic body are 4-dimensional and there are good reasons to expect that it continues to contribute to the consciousness of some self- not necessarily the self which possessed the body. The question is however about what this particular self that I have experiences in biological death and after it.

2. The notion of negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig.** 21 in the appendix of this book) allows to consider an answer to what might happen in biological death from the point of subjective time. Depending on the choices of self which has the dying person as sub-self, dying person generates bound state entropic entanglement with a loss of consciousness or negentropic entanglement accompanied by an expansion of consciousness. What option the higher level self chooses depends on the probability of the size of the contribution of the state with negentropic entanglement.

3. If the dying person has a strong negentropic entanglement with external world, it tends to be preserved in quantum jumps and only a small entropic contribution is present and there is only a small probability to lose consciousness. Another manner to see this is that a sub-self having very entropic sub-selves (mental images) is experienced by self as something unpleasant and by generalized NMP self might want to get rid of this kind of mental image. This would reduce the chances of experiencing an expansion of consciousness. Perhaps death could be seen as the price for sins.

4. One could also argue that although consciousness might be lost it might be not be in any manner different from sleep. It could be gained back in wake-up but as something different from ordinary wake-up consciousness and determined by the 4-D biological and magnetic bodies and the deceased could remember his former life by still existing 4-D body. The notion of electromagnetic body, when combined with the view about psychological time, allows to consider a general answer to these questions. Magnetic body probably survives the biological death, and since it serves as the sensory canvas, there are all reasons to expect that subjective consciousness continues after the biological death. The contents of consciousness

would be determined by the 4-dimensional physical and electromagnetic bodies and the dominating contribution creating the illusion about reality as a time=constant snapshot would be absent. Kind of timeless consciousness would be in question in accordance with the life review experiences associated with NDEs.

5. One can also ask what might be the physical correlate of self after the biological death. The self associated with the biological body should re-incarnated at the opposite boundary of CD associated with it and defined kind of "shadow me". The 4-D space-time sheet representing self very probably does not disappear in biological death and the 4-D character of the perceptive field suggests that this 4-D body continues to exist as a conscious entity and the sub-CDs of the geometric past representing mental images still exist. Only at the future boundary of CD the flow of 4-D biological body ceases but the sub-CDs representing existing mental images float to the direction of geometric past in the river of time and remain consciousness.

Ageing from the point of view of second law

In standard quantum theory framework not allowing negentropic entanglement self could be regarded as a statistical ensemble of mental images defined by the unentangled final states of the quantum jumps. Since the size of this ensemble increases quantum jump by quantum jump, the approach of this ensemble to thermal equilibrium is unavoidable although living matter has probably invented ways to fight against the second law of thermodynamics. Thus ageing of self means dissipation.

The hierarchy of Planck constants and negentropic entanglement mean deviations from this picture.

1. For higher levels of dark matter hierarchy the dissipation rate is expected to be slower: the naïve expectation is that the rate is inversely proportional to Planck constant.

2. Negentropic entanglement means second exception to the rule and for given CD second law can be broken in time scales shorter than the time scale characterizing CD [K56].

Each p-adic length scale defines its characteristic dissipation rates. In case of a self decomposing into sub-selves the rate of dissipation is sum over the real dissipation rates associated with the nested system formed by the self, its sub-selves, their sub-selves, etc.... The dissipation associated with states of whole-body consciousness can be anomalously small since only negentropic mental images are absent and if there is only one such mental image (or no mental images at all) there is no generation of ensemble entropy. A possible test for this is the study of total rate of metabolism during meditation.

Dissipation causes the ageing of self: getting old at least at the level of biological body would be the price for having self. More concretely, the entropies associated with various distributions of quantum number and zero mode increments increase during ageing so that mental images are gradually blurred. Note that also our self which defines a mental image of a higher level self is blurred. Also biological death, or at least death experience, seems to be unavoidable fate of self.

Ageing and death from the point of NMP

The possility of negentropic entanglement allows to see ageing from different point of view if NMP is taken as the analog of second law holding in the realm of subjective existence.

1. Ageing as an entropic process could be seen also as a process analogous to the process of getting drowsy and falling asleep but in much longer time scales. Bodily sub-self would not remember anything about these periods in the case that the entanglement was entropic. Also sleep could represent a similar conscious state without bodily mental image and the impossibility to remember anything about this period of consciousness might be simply due to the fact that one can remember something about sleep state only in sleep state. The periods during which negentropic entanglement prevails would be experienced as enlightenment like experiences. During ageing bodily sub-self would spend more and more time near the critical line at which this kind of phase transition occurs.

2. Ageing could be seen as a process of personal growth generating negentropic entanglement. The negentropic entanglements generated with larger selves would give rise to larger selves and the metaphor "awakening" would thus be much more than a metaphor. Time-like negentropic entanglement would mean longer time span of attention. Person would spend more and more time in extended state of consciousness and in death finally leave the confines of the biological body. Note that person need not, and probably doesn't, remember anything about the periods of entanglement in which the local topology of self changes. This would make possible the evolution of selves continuing after death to higher levels of conscious existence.

This picture is rather optimistic: one must also consider the possibility that the evolution of self is not always a continuous personal growth! The fact that the individual development of most people seems to be a process of continual abstraction suggests that biological death is only one step in the process of abstractions and that our self consciously experiences the final transition to higher level of existence in biological death.

Why childhood memories are recalled so intensely?

The first manner to see ageing is as a subjective experience: as ageing with respect to subjective time. Our self contains sub-selves representing our memories, sensory input from the geometric now and future plans. At the old age it often happens that childhood memories begin to dominate whereas the recall of more recent memories is gradually lost. Of course, the contribution of future plans becomes also gradually negligible. This suggests that the contents of consciousness for our self can suffer a gradual transformation such that the childhood begins to dominate: of course, this need not happen always. That the childhood dominates is not easy to understand if the memories of the past are stored in the geometric now as assumed in the standard brain science. In TGD framework the very fact that the childhood consciousness is very intense and un-conceptual, explains the dominance of the episodal memories of childhood.

Who is the subjective experiencer in this kind of situation? Is it the old person with vivid memories or a child with some very diffuse ideas about future? The view about psychological time would suggest that the general experience gradually becomes some kind of a 4-dimensional life review such that the very intense childhood memories dominate but that the person in the psychological now is still the only one who can transform intentions to actions effectively whereas the 4-D body of the past is more or less frozen.

Death as disappearance of the mental image representing the biological body?

If one takes seriously the following two assumptions behind the TGD based model of quantum control and coordinate based on the symbiosis of MEs, magnetic flux tube structures, and matter at the atomic space-time sheets, one ends up with rather concrete view about what happens after the biological death. The ultimate sensory representations are realized on the sensory canvas provided by magnetic flux tube structures of similar size, so that we have magnetic body providing sensory representation of the biological body and external world [K83]. Our magnetic self very probably survives in the biological death by the conservation of the magnetic flux.

In this picture the body of after-life body would consists of the magnetic body plus MEs possibly surviving the death of the biological body. The only difference as compared to the life before death would be that the sensory and cognitive mental images representing the biological body (sub-selves) would disappear and the attention of our self would be directed to something else. Possibly to the entire time span of 4-D biological body since sensory input and motor actions at the upper boundary of peresonal CD are absent. Near death experiences indeed support this view [K19]. In this picture re-incarnation is possible and even plausible and means only that the magnetic flux tube structure representing our bodily self turns its attention to some other biological body and uses it as a sensory and motor organ. This new biological body could be plant, animal, human, or perhaps something else. In this picture the metaphor about biological body as a cloth becomes very concrete.

Since self has an extension with respect to geometric time, it has memories about its earlier history and one could perhaps identify the continuation of self after the death as that self which has the memories of self with respect to geometric time before death. In this extended state of

consciousness self could experience the subjective past of the space-time sheet of self and associate it with self's recent mind-like space-time sheet.

Near death experiences

Near death experiences provide a testing ground for the general ideas about what might happen in the physical death. Experiences resembling near death experiences can be produced now in controlled manner in laboratory circumstances for people well and alive and irrespective of their belief structure subject persons tell about light tunnels and meeting of deceased relatives [J30] . These experiences have been found to be therapeutic and are indeed used as therapy to cure severe psychic traumas. Therefore the materialistic explanation as a hallucination associated with dying brain seems to be excluded. Near death experiences involve experiences like being in light tunnel, seeing beautiful and rich landscapes and meeting dead relatives. Also out-of-body experiences are involved. The model of NDEs are discussed in detail in [K82] and here only some brief comments are represented.

The proposed picture about physical death allows a lot of room to interpret these experiences. For instance, OBEs allow two explanations.

1. The first explanation is based on the fact that in TGD based model of sensory representations the magnetic sensory canvas far outside body basically sees the brain in ELF light. This light usually comes from brain and provides a sensory representation for the external world. TGD predicts also a mechanism producing background ELF radiation from the entire body at magnetic transition frequencies and this background would make possible to see the body 3-dimensionally from outside when the sensory input is absent and does not mask this weak contribution. NDE OBEs might correspond to this kind of vision reported also by yogis.

2. The experience looking one's body from outside could mean that some higher level self corresponding to slow EEG waves and higher em selves formed physically by the personnel of hospital in the hospital room begins to dominate. This self could perhaps see patient's body with the combined eyes of the hospital personnel. Indeed, since the sensory input from the biological body ceases, the illusory identification of "me" with the biological body ceases and attention can be directed to this higher level sensory input.

Geometrically the em bodies of our dead relatives would exist in the geometric past and now, perhaps already in a re-incarnated form. This allows several explanation for the experience of meeting dead or living relatives. A very concrete model would be based on electromagnetic bridges formed by magnetic mirrors and connecting us with our relatives and friends. This would make possible for us to see them in ELF light just like we would see ourselves.

The experience about meeting deceased relatives could be also understood as a special kind of geometric memory. Generation of the long term memory means classically looking to a magnetic mirror at classical level and seing the me of the past in the mirror. It is however possible to see someone else in the mirror since the magnetic flux tube from the mirror could continue to the body of the deceased relative of friend instead of my body. In the usual states of consciousness the sensory input from the psychological now dominates and this contribution is masked. In near death experiences sensory input from the geometric now is diminished and the transpersonal background contribution becomes unmasked.

What after biological death?

Biological death could mean the loss of sub-self representing body image and involve extension of the physical self: this would explain out of body experiences and near death experiences (person near death looking his body from outside). In fact, an attractive hypothesis, motivated by the quantum model of brain, is that the topological field quanta associated with photons generated by EEG currents having size of order Earth by Uncertainty Principle, could correspond to selves in our personal self hierarchy. Also magnetic flux tube structures associated with body and brain could have similar sizes and serve as a magnetic body [K83]. In biological death these ELF selves could continue to oscillate as Schumann resonances in the wave cavity between Earth's surface and ionosphere interacting with magnetic flux tube structures!

If one believes that even cell sized structures have their own CDs then the primary p-adic length scale defined by the size scale of a large neuron (10^{-4} meters) would correspond to a time scale of the order of the age of the Universe! It seems implausible that these CDs could disappear totally although zero energy ontology in principle allows it.

Biological body is accompanied by magnetic body and radiation body which provide representation for the physical (or better to say, material) body. The latter consists of radiation selves (massless extremals representing topologically rays of light) representing classically the ELF radiation fields generated by EEG currents, one is led to ask what happens for these em selves in biological death. Some of them correspond to resonant frequencies of the em fields in the 80 km thick wave cavity between Earth surface and ionosphere known as Schumann frequencies and one can consider the possibility that that something which might be called soul remains after the biological death and is represented as Schumann resonances.

The most plausible hypothesis is that both ULF MEs and magnetic flux tube structures remaining after physical death together with the 4-dimensional body of geometric past define our self after the biological death. This leads to the following speculative vision about consciousness after the biological death.

1. The transformation of intentions to actions ceases in the biological death so that the dominating contribution of the psychological now to the experience disappears and conscious experience becomes kind of four-dimensional life review in which also the contributions from other bodies (say deceased relatives) appear as unmasked.

2. The geometric past, or rather experiences about it, can be gradually refined but no big changes are possible, so that a totally new life based on different decisions does not seem to be possible. The assumption about totally new life would also lead to paradoxes. On the other hand, the instability of the long term memories suggests that the memories about the past life could be edited. The conscious experience contains also the contribution of the magnetic body continuing to exist.

3. The surviving magnetic body could attach to some new organism which it begins to use as a sensory and motor organ. The re-incarnation would have the memories of the past life as an unconscious background masked strongly by the sensory input and coming clearly conscious only in some altered states of consciousness. The reports about children remembering they previous life could be understood in this conceptual framework. This of course makes one wonder whether young children could remember their past lives. Perhaps someone should ask!

4. ZEO inspired view about state function reduction suggests more concrete view. The new self is generated at the previously active boundary of CD assignable to the biological body and the new life is lived in reversed direction.

Does soul exist in some sense?

An open question is what happens for the space-time sheet (or CD) assignable to self after biological death.

1. Could this space-time sheet or CD be called soul? Does this soul continue drift in light-cone and get attached to some new material system. Or can it disappear in quantum jump? This would not be a reincarnation in the usual sense of the word. The re-incarnation in the usual sense if the word would mean that one has memories about the life of someone whose has lived in past. In TGD Universe this is quite possible since the mechanisms of remote mental interactions are basically the same as the interaction mechanisms making possible for the magnetic body to control the biological body receive information from it.

   "Ontogeny recapitulates phylogeny" principle suggests that the evolution of an individual is image for the evolution of the entire universe. Biological death would be only a metamorphosis to some new form of existence, perhaps as topologically quantized classical fields associated with the biological body. Magnetic flux tube structures having sizes measured in scale of light lifetime are especially promising candidates for the components of electromagnetic body

surviving in the death of what is usually identified as the biological body. Some experimental facts lead to rather precise ideas about the geometric representation of our selves and also suggest that our existence continues in electromagnetic form after death [K19].

3. An attractive identification of "soul" would be as negentropic entanglement resources - Akashic records - serving also as a quantum correlate of love and other positive atributes of consciousness. Could this negentropic entanglement become conscious (be read) in repeated state function reductions or is the counterpart of interaction free quantum measurement require for this to happen?

Indirect support for the survival of space-time sheets carrying associated with negentropic entanglement/large h_{eff} after death comes from rather unexpected direction.

1. The phenomenon of phantom DNA suggesting that dark space-time sheets associated with DNA remain in the chamber which contained DNA: in the experiments of Poponin [I69] the signature of phantom DNA is its interaction with laser light at visible frequencies. Phantom DNA would be represented by mind-like space-time sheets with size of at least the wavelength of visible light (10^{-7} meters). The em selves remaining after our death would have consirably larger size! One can however consider the possibility that some detectable interaction between ELF frequency em fields and "phantom brain" ("em soul") could be possible and make it possible to prove experimentally the presence of em soul!

2. The claimed successes of homeopathy (for phantom DNA and homeopathy see [K123] and [K42]). could also have explanation in terms of the mind-like space-time sheets. Homeopathic drugs are fabricated by a repeated dilution of the active drug so that the concentration of the drug in solution becomes extremely low. The method of fabrication could however imply that final product contains quite many mind-like space-time sheets of the drug molecules. These mind-like space-time sheets might be able to affect the sickness since the mind-like space-time sheets provide a cognitive representation for drug and this mimicry could "cheat" the patient to cure. The law of similarities could have something to do with the mechanism involved.

   More concretely, a given quantum transition frequency characterizing the medicine would be represented as ME with length equal to the wavelength associated with the transition frequency. The electromagnetic body of the molecule could be mimicked by liquid crystal water blobs producing similar transition frequencies and thus containing similar MEs in their electromagnetic bodies. The effect of the medicine would be mediated by the electromagnetic body so that the "fake" medicine could indeed cure.

Some support for the extension of self in death is provided by near death experiences (NDEs). For instance, looking one's body from outside could mean that self is entangled with a larger self formed by the personnel of hospital in the hospital room and sees patient's body with the eyes of the personnel. This experience could be understood as experience of, say self representing hospital room: in this experience the visual experiences of persons in the hospital room would fuse to the experience experienced by patient entangled with the hospital room. Meeting one's relatives and elders could mean entanglement with a larger self formed by the selves of dead and living relatives. This larger self could experience the abstracted experiences of dead and living relatives. Also the ability of subjects of surgical operations to occasionally remember about events occurred during unconscious state, supports this view. Magnetic flux tube structures are the most plausible candidates for the "body" remaining in physical death: this point is discussed in more detail in [K19].

Is it possible to get into contact with deceased?

There is a lot of anecdotal evidence consistent with life after death. Near-death experiences are not the only manner to get convinced for life after death. So called eye-movement de-sensitization and reprocessing (EMDR) discovered by Francine Shapiro [J30, J72] induces what could be interpreted as after-death communications.

1. The experiences of subject persons can be induced by this therapy in highly reliable manner: according to [J30] 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.

2. 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.

3. 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 could involve communication with the recent selves of the deceased ones located possibly in the geometric recent or past and represented by magnetic flux tube structure and MEs interacting with them.

7.7.2 Good And Evil

The vision about life as something in the intersection of real and p-adic worlds together with the notion of negentropic entanglement gives hopes for understanding the quantum correlates of evolution and even ethics. The basic principle would be that good deeds generate negentropic entanglement and Negentropy Maximization Principle - perhaps suitably generalized from its original form- would define the basic principle of ethics.

Quantum ethics very briefly

The proposal is that the basic ethical principle is that good deeds help evolution to occur. This proposal can be criticized. Evolution should correspond to the increase of negentropic entanglement. NMP in trong forces it and in weak form allows it.

1. If strong form of NMP prevails, one can worry that TGD Universe does not allow Evil at all, perhaps not even genuine free will! No-one wants Evil but Evil seems to be present in this world.

2. Could one weaken NMP so that it does not force but only allows to make a reduction to a final state characterized by density matrix which is projection operator? Self would choose whether to perform a projection to some sub-space of this subspace, say 1-D ray as in ordinary state function reduction. NMP would be like Christian God allowing the sinner to choose between Good and Evil. The final entanglement negentropy would be measure for the goodness of the deed. This is so if entanglement negentropy is a correlate for love. Deeds which are done with love would be good. Reduction of entanglement would in turn mean loneliness and separation.

3. Or could could think that the definition of good deed is as a selection between deeds, which correspond to the same maximal increase of negentropy so that NMP cannot tell what happens. For instance the density matrix operator is direct sum of projection operators of same dimension but varying coefficients and there is a selection between these. It is difficult to imagine what the criterion for a good deed could be in this case. And how self can know what is the good deed and what is the bad deed.

Good deeds would support evolution. There are many ways to interpret evolution in TGD Universe.

1. p-Adic evolution would mean a gradual increase of the p-adic primes characterizing individual partonic 2-surfaces and therefore their size. The identification of p-adic space-time sheets as representations for cognitions gives additional concreteness to this vision. The earlier proposal that p-adic–real-phase transitions correspond to realization of intentions and

formations of cognitions seems however to be wrong. Instead, adelic view that both real and p-adic sectors are present simultaneously and that fermions at string world sheets correspond to the intersection of realities and p-adicities seems more realistic.

The inclusion of phases $q = exp(i2\pi/n)$ in the algebraic extension of p-adics allows to define the notion of angle in p-adic context but only with a finite resolution since only finite number of angles are represented as phases for a given value of n. The increase of the integers n could be interpreted as the emergence of higher algebraic extensions of p-adic numbers in the intersection of the real and p-adic worlds. These observations suggest that all three views about evolution are closely related.

2. The hierarchy of Planck constants suggests evolution as the gradual increase of the Planck constant characterizing p-adic space-time sheet (or partonic 2-surface for the minimal option). The original vision about this evolution was as a migration to the pages of the book like structure defined by the generalized embedding space and has therefore quite concrete geometric meaning. It implies longer time scales of long term memory and planned action and macroscopic quantum coherence in longer scales.

   The new view is in terms of first quantum jumps to the opposite boundary of CD leading to the death of self and its re-incarnation at the opposite boundary.

3. The vision about life as something in the intersection of real and p-adic words allows to see evolution information theoretically as the increase of number entanglement negentropy implying entanglement in increasing length scales. This option is equivalent with the second view and consistent with the first one if the effective p-adic topology characterizes the real partonic 2-surfaces in the intersection of p-adic and real worlds.

The third kind of evolution would mean also the evolution of spiritual consciousness if the proposed interpretation is correct. In each quantum jump U-process generates a superposition of states in which any sub-system can have both real and algebraic entanglement with the external world. If state function reduction process involves also the choice of the type of entanglement it could be interpreted as a choice between good and evil. The hedonistic complete freedom resulting as the entanglement entropy is reduced to zero on one hand, and the negentropic entanglement implying correlations with the external world and meaning giving up the maximal freedom on the other hand. The selfish option means separation and loneliness. The second option means expansion of consciousness - a fusion to the ocean of consciousness as described by spiritual practices.

In this framework one could understand the physics correlates of ethics and moral. The ethics is simple: evolution of consciousness to higher levels is a good thing. Anything which tends to reduce consciousness represents violence and is a bad thing. Moral rules are related to the relationship between individual and society and presumably develop via self-organization process and are by no means unique. Moral rules however tend to optimize evolution. As blind normative rules they can however become a source of violence identified as any action which reduces the level of consciousness. There is an entire hierarchy of selves and every self has the selfish desire to survive and moral rules develop as a kind of compromise and evolve all the time. ZEO leads to the notion that I have christened cosmology of consciousness. It forces to extend the concept of society to four-dimensional society.

There is an entire hierarchy of selves and every self has the selfish desire to survive and moral rules develop as a kind of compromise and evolve all the time. The newest progress in this evolution is brought by the cosmology of consciousness, which forces to extend the concept of society to four-dimensional society! The decisions of "me now" affect both my past and future and time like quantum entanglement makes possible conscious communication in time direction by sharing conscious experiences. One can therefore speak of genuinely four-dimensional society. Besides my next-door neighbors I had better to take into account also my nearest neighbors in past and future (the nearest ones being perhaps copies of me!). If I make wrong decisions those copies of me in future and past will suffer the most. Perhaps my personal hell and paradise are here and are created mostly by me.

What could the quantum correlates of moral be?

We make moral choices all the time. Some deeds are good, some deeds are bad. In the world of materialist there are no moral choices, the deeds are not good or bad, there are just physical events. I am not a materialist so that I cannot avoid questions such as how do the moral rules emerge and how some deeds become good and some deeds bad. Negentropic entanglement is the obvious first guess if one wants to understand emergence of moral.

1. One can start from ordinary quantum entanglement. It corresponds to a superposition of pairs of states. Second state corresponds to the internal state of the self and second state to a state of external world or biological body of self. In negentropic quantum entanglement each is replaced with a pair of sub-spaces of state spaces of self and external world. The dimension of the sub-space depends on the which pair is in question. In state function reduction one of these pairs is selected and deed is done. How to make some of these deeds good and some bad?

2. Obviously the value of $h_{eff}/h = n$ gives the criterion in the case that weak form of NMP holds true. Recall that weak form of NMP allows only the possibility to generate negentropic entanglement but does not force it. NMP is like God allowing the possibility to do good but not forcing good deeds.

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

   For the maximal dimension of this sub-space the negentropy gain is maximal. This deed would be good and by the proposed criterion the negentropic entanglement corresponds to love or more neutrally, positively colored conscious experience. Interestingly, there are $2^n - 1$ possible choices which is almost the dimension of Boolean algebra consisting of n independent bits. The excluded option corresponds to 0-dimensional sub-space - empty set in set theoretic realization of Boolean algebra. This could relate directly to fermionic oscillator operators defining basis of Boolean algebra- here Fock vacuum would be the excluded state. The deed in this sense would be a choice of how loving the attention towards system of external world is.

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

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

   One can make further questions.

1. Could the moral rules of society be represented as this kind of entanglement patterns between its members? Here one of course has entire fractal hierarchy of societies corresponding different length scales. Attention and magnetic flux tubes serving as its correlates is the basic element also in TGD inspired quantum biology already at the level of bio-molecules and even elementary particles. The value of $h_{eff}/h = n$ associated with the magnetic flux

tube connecting members of the pair, would serve as a measure for the ethical value of maximally good deed. Dark phases of matter would correspond to good: usually darkness is associated with bad!

2. These moral rules seem to be universal. There are however also moral rules or should one talk about rules of survival, which are based on negative emotions such as fear. Moral rules as rules of desired behavior are often tailored for the purposes of power holder. How this kind of moral rules could develop? Maybe they cannot be realized in terms of negentropic entanglement. Maybe the superposition of the allowed alternatives for the deed contains only the alternatives allowed by the power holder and the superposition in question corresponds to ordinary entanglement for which the signature is simple: the probabilities of various options are different. This forces the self to choose just one option from the options that power holder accepts. These rules do not allow the generation of loving relationship.

Moral rules seem to be generated by society, up-bringing, culture, civilization. How the moral rules develop? One can try to formulate and answer in terms of quantum physical correlates.

1. Basically the rules should be generated in the state function reductions which correspond to volitional action which corresponds to the first state function reduction to the earlier active boundary of CD. Old self dies and new self is born at the opposite boundary of CD and the arrow of time associated with CD changes.

2. The repeated sequences of state function reductions can generate negentropic entanglement during the quantum evolutions between them. This time evolution would be the analog for the time evolution defined by Hamiltonian - that is energy - associated with ordinary time translation whereas the first state function reduction at the opposite boundary inducing scaling of h_{eff} and CD would be accompanied by time evolution defined by conformal scaling generator L_0.

   Note that the state at passive boundary does not change during the sequence of repeated state function reductions. These repeated reductions however change the parts of zero energy states associated with the new active boundary and generate also negentropic entanglement. As the self dies the moral choices can made if the weak form of NMP is true.

3. Who makes the moral choices? It looks of course very weird that self would apply free will only at the moment of its death or birth! The situation is saved by the fact that self has also sub-selves, which correspond to sub-CDs and represent mental images of self. We know that mental images die as also we do some day and are born again (as also we do some day) and these mental images can generate negentropic resources within CD of self.

   One can argue that these mental images do not decide about whether to do maximally ethical choice at the moment of death. The decision must be made by a self at higher level. It is me who decides about the fate of my mental images - to some degree also after their death! I can choose the how negentropic the quantum entanglement characterizing the relationship of my mental image and the world outside it. I realize, that the misused idea of positive thinking seems to unavoidably creep in! I have however no intention to make money with it!

4. It is difficult to avoid an association with the basic myth of Christianity about the death of God's Son which is said to mean that sins of sinners are forgiven. How could one make sense of this? Or is the Freudian interpretation the only possible explanation? If negentropy increases as self dies, the paradox begins to disappear. God was self and his Son was his mental image, whose death increased the negentropic resources of the Universe and made it better. We are Gods of our mental images and we are mental images of higher level Gods.

Do positively colored emotions allow a representation of Boolean logic?

Weak form of NMP allows the state function reduction to occur in $2^n - 1$ ways corresponding to subspaces of the sub-space defined by n-dimensional projector if the density matrix is n-dimensional projector (the outcome corresponding to 0-dimensional subspace and is excluded). If the probability for the outcome of state function reduction is same for all values of the dimension $1 \leq m \leq n$,

the probability distribution for outcome is given by binomial distribution $B(n, p)$ for $p = 1/2$ (head and tail are equally probable) and given by $p(m) = b(n, m) \times 2^{-n} = (n!/m!(n - m)!) \times 2^{-n}$. This gives for the average dimesion $E(m) = n/2$ so that the negentropy would increase on the average. The world would become gradually better. Note that one assumes that there is some preferred basis for the states and these numbers apply when this basis is given.

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

1. There should be a mapping of k-dimensional subspaces of n-dimensional space to the fermionic representation of Boolean algebra

2. Could one speak about a hierarchies of codes of cognition based on the assignment of different degrees of "feeling good" to the Boolean statements? If one assumes that the n:th bit is always 1, all independent statements except one correspond at least two non-vanishing bits and corresponds to negentropic entanglement. Only of statement (only last bit equal to 1) would correspond 1 bit and to state function reduction reducing the entanglement completely (brings in mind the fruit in the tree of Good and Bad Knowlege!).

3. A given hierarchy of breakings of super-symplectic symmetry corresponds to a hierarchy of integers $n_{i+1} = \prod_{k \leq i} m_k$. The codons of the first code would consist of sequences of m_1 bits. The codons of the second code consists of m_2 codons of the first code and so on. One would have a hierarchy in which codons of previous level become the letters of the code words at the next level of the hierarchy.

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

1. The hierarchy starting from $M_2 = 3$ contains the Mersenne primes $3, 7, 127, 2^{127} - 1$ and Hilbert conjectured that all these integers are primes. These numbers are almost dimensions of Boolean algebras with $n = 2, 3, 7, 127$ bits. The maximal Boolean sub-algebras have $m = n - 1 = 1, 2, 6, 126$ bits.

2. The observation that $m = 6$ gives 64 elements led to the proposal that it corresponds to a Boolean algebraic assignable to genetic code and that the sub-algebra represents maximal number of independent statements defining analogs of axioms. The remaining elements would correspond to negations of these statements. I also proposed that the Boolean algebra with $m = 126 = 6 \times 21$ bits (21 pieces consisting of 6 bits) corresponds to what I called memetic code obviously realizable as sequences of 21 DNA codons with stop codons included. Emotions and information are closely related and peptides are regarded as both information molecules and molecules of emotion.

3. This hierarchy of codes would have the additional property that the Boolean algebra at $n + 1$:th level can be regarded as the set of statements about statements of the previous level. One would have a hierarchy representing thoughts about thoughts about.... It should be emphasized that there is no need to assume that the Hilbert's conjecture is true.

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

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

10 nmandsize 2.5 μm of cell nucleus!) follow from the proposed connection between emotions and Boolean cognition.

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

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

Some questions

There are still many questions that are waiting for more detailed answer. These questions are also a good manner to detect logical inconsistencies.

1. What is the size of CD characterizing self? For electron it would be at least of the order of Earth size. During the lifetime of CD the size of CD increases and the order of magnitude is measured in light-life time for us. This would allow to understand our usual deeds affecting the environment in terms of our subselves and their entanglement with the external world which is actually our internal world, at least if magnetic bodies are considered.

2. Can one assume that the dynamics inside CD is independent from what happens outside CD. Can one say that the boundaries of CD define the ends of space-time or does space-time continue outside them. Do the boundaries of CD define boundaries for 4-D spotlight of attention or for one particular reality? Does the answer to this question have any relevance if everything physically testable is formulated in term physics of string world sheets associated with space-time surfaces inside CD?

   Note that the (average) size of CDs (, which could be in superposition but need not if every repeated state function reduction is followed by a localization in the moduli space of CDs) increases during the life cycle of self. This makes possible generation of negentropic entanglement between more and more distant systems. I have written about the possibility that ZEO could make possible interaction with distant civilizations [K55]. The possibility of having communications in both time directions would allow to circumvent the barrier due to the finite light-velocity, and gravitational quantum coherence in cosmic scales would make possible negentropic entanglement.

3. How selves interact? CDs as spot-lights of attention should overlap in order that the interaction is possible. Formation of flux tubes makes possible quantum entanglement. The string world sheets carrying fermions also essential correlates of entanglement and the possibly entanglement is between fermions associated with partonic 2-surfaces. The string world sheets define the intersection of real and p-adic worlds, where cognition and life resides.

How the law of Karma could be realized?

The existence of self hierarchy means that our deeds are remembered also after our death at higher level of self hierarchy although only as an abstracted summary. Also the shadow me which is born

at the opposite boundary of my personal CD remembers my deeds like a person remembers his dreams just after wake-up.

One can therefore ask whether the law of Karma or something akin to it might be implied by basic principles of consciousness theory.

First of all, self has two life strategies: be a sinner or saint. Sinner is selfish and minimizes the dependence on the environment be avoiding negentropic entanglement. Saint does the opposite and develops love towards surrounding world.

1. Self can fight for the metabolic energy feed giving rise to the self-organization of self. This strategy works as long as self is a young, brisk and arrogant sinner. Sinners are not desirable mental images from the point of view of higher level self since they induce a lot of entropic mental images (pain). This strategy is also in conflict with the possible goal of the higher level self to achieve fusion of its own mental images.

2. Self can attempt to share mental images by quantum entangling its sub-selves with the sub-selves of other, possibly, higher level selves. This mechanism gives rise to quantum metabolism and expanded states of consciousness, favors the generation of social structures, and means fusion of mental images from the point of view of higher level self. The cognitive mental images of the saintlike self are highly negentropic and favored by p-adic NMP.

On basis of these findings the policy for higher level selves looks obvious: try to get rid of the unpleasant mental images represented by sinners. Higher level self could apply this policy for purely selfish reasons: too bad sinners might affect like a poison to the moral level of the higher level self and, since the law of Karma is universal, could eventually lead to the decline of the higher level self to a lower level of the hierarchy: the world would seem to be a tough place also after death!

What "liberation" might mean?

The strong analogies with eastern spirituality encourage to ask whether the TGD inspired quantum counterpart for the concept of liberation might make sense.

1. Quantum-classical correspondence suggests that the endless evolution at the level of the entire universe corresponds to endless evolution at the level of individual so that the notion of liberation would make sense only as kind of transformation to a higher level of consciousness.

2. In the real context selves having only single mental image or no mental images at all are in state of "oneness" and experience no divisions and separations since the analysis process represented by state function reductions and self measurements is absent. This kind of state realized at the level of field body is a possible candidate for enlightened state. Certainly it cannot last forever.

3. Liberation experience might also relate to the experience of "cosmic consciousness". Most naturally a generation of negentropic entanglement fusing self to a self at higher level of self hierarchy. The fear about the loss of consciousness is what gives self an ego, since ego is something which can be lost. This can happen via the generation of entropic bound state entanglement with some other system. This can happen for any subsystem of Universe but not for the entire Universe enjoying an eternal state of consciousness. The state of cosmic consciousness thus means being a self without ego. The counterpart for this would be negentropic entanglement. Leaving aside the question whether we are able to experience ideal cosmic consciousness, one can consider the possibility that even human beings could achieve a state of consciousness in which the loss of consciousness is highly un-probable and that this loss of ego is synonymous with the experience of liberation.

The term "cosmic consciousness" looks somewhat pompous notion to anyone identifying himself with his suffering biological body and it would be certainly very difficult to sell this concept to a neuroscientist. The notion of magnetic body, the hierarchy of Planck constants, and the identification of quantum gravitational bound states in terms of astroscopic quantum coherence assignable to gravitational Planck constant, allow to take this notion seriously. In ZEO the arrow

of geometric time can change so that finite light velocity does not prevent instantaneous communications over cosmic distances so that communications with life forms in distant galaxies become possible. I have considered a concrete model for what might be involved in [K55].

7.7.3   About God Theory Of Bernard Haisch

I have found that the best manner to learn about TGD is to read books about other theories, and after many years at the border of basic survival I now have opportunity to do this thanks to some generous people making this possible.

Just now I have been reading Bernard Haisch's book "The God theory" (see `http://tinyurl.com/yaa94c64`) [J33]. Haisch himself is an astrophysicist who might have become priest. The book discusses the possibility of spirituality consistent with physics. It also discusses Zero Point Energy (ZPE) hypothesis and the idea that inertia might emerge from vacuum fluctuations of various fields.

I agree in many respects with Haisch's vision about possibility to build bridge between fundamental physics and spirituality. The new view about spirituality requires that a lot of horrendous stuff of religions (such as eternal purgatory, the sadistic God of Old Testament killing his own son, blind belief in dogmas, etc...) is thrown away. Where I disagree with Haisch is the notion of ZPE but think that I understand why he wants ZPE. In TGD all that can be done using ZPE can be replaced with zero energy ontology (ZEO) to achieve the possibility of re-creation without breaking of conservation laws: without ability go generate new sub-Universes God would be rather powerless creature. I also disagree with the idea that inertia follows from zero point fields although again I understand the underlying motivations of the proposal as relating to a genuine problem of General Relativity. This problem also inspired TGD.

Haisch lists three questions usually regarded as highly non-scientific. Is there really a God? What am I? What is my destiny? As I started to build theory of consciousness, these questions began to make more and more sense also to me. One must be however ready to give up some dogmas such as God as a sage with white hair and long beard, the idea that we are nothing but our neurophysiology generating a brief flash of light in infinite darkness, and the belief that heat death dictated by second law is the eventual fate of the universe as whole.

Putting Haisch in box

When thinkers happen to encounter genuine thinking they want to classify it in order to feel safe. For safety reason some of us also debunk the new idea. The first classification is philosophical. I use three boxes for this purpose (safety reasons). The first box has label "monism". It contains two smaller boxes. "Materialist" contains thinkers accepting only third person view as an acceptable - objective - view about the world. I close to "Idealist" those thinkers who accept only the first person view as fundamental. Most of my colleagues are happy to live in the box "Materialist". The second box has label "Dualist" and contains thinkers accepting both first and third person views - also this box decomposes to smaller boxes depending on how closely the first and third person views are assumed to be related: if the correspondence is exactly 1-1 then the view reduces to materialism. To the third box - "Miscellaneous" - I put the others and live also myself in this box.

Haisch perfoms the classification himself and completely voluntarily chooses the box "Idealist". Hence consciousness is fundamental form of existence for him. In TGD framework both first and third person perspectives are tolerated: consciousness is however in quantum jump between quantum superpositions of objective realities identified as zero energy states and does not define another world as it does in dualistic theories. As a matter fact, in TGD several ontological levels are accepted: geometric existence at space-time and embedding space levels in real and various p-adic versions, existence as zero energy states identified as spinor fields of world of classical worlds (WCW)) and subjective existence as quantum jumps.

Universe as God

Haisch postulates God as an infinite intelligence. We are God's eyes and ears through which God experiences her (no reference to gender here) own creation. Haisch's God is not the Newtonian

clock-smith who creates deterministic universe and then forgets it completely. This God is free to create universes with he chooses freely using her infinite intelligence. This God is also somehow outside the realm of space-time.

The possibility of universes with different laws of physics inside each of them brings in mind inflationary cosmology, multiverse, and the landscape of M-theory. Haisch indeed takes inflationary scenario and multiverse idea rather seriously and also talks about superstrings. The landscape of string theory is catastrophe from the point of view of physics but would fit with the idea about God who can freely decide about the laws of physics in the limits of mathematical consistency. But what mathematical consistency means? Have M-theorists really thought about this?

What about TGD? In TGD framework nothing prevents from calling conscious selves gods since free will is genuine and the essence of creation. Thus God is replaced with an infinite hierarchy of god like entities. Nothing prevents from calling the entire Universe as God, which is re-creating itself in every quantum jump. This God has us as mental images or to be more precise: as mental images of mental images of..... of its mental images. The sequence could be rather long)!

Concerning the laws of physics the situation in TGD framework. The surprising outcome already from the geometrization of loop spaces is that geometry of the infinite-dimensional world of classical worlds (WCW) is expected to be unique if it consists of 4-D surfaces of some higher-dimensional space. This comes from mere mathematical existence requiring the WCW metric to have infinite-dimensional group of isometries (generalization of various conformal symmetries of super string models). This means that also physics is unique just from its existence. As a matter fact, in TGD there is no need to assume any physical existence behind mathematical existence since consciousness is in quantum jumps. Space-time dimension and the choice embedding space are forced by very general mathematical conditions closely related to the structure of classical number fields. Four-dimensional Minkowski space and space-time dimension four are forced by the condition of maximal symmetries needed for the existences of WCW geometry.

Inflation in TGD framework is replaced with quantum criticality making the Universe maximally sensitive perceiver and motor instrument. Quantum criticality means absence of scales (or actually discrete hierarchy of them) and the flatness of 3-space (dimensional curvature scalar vanishes) is the correlate of quantum criticality in cosmology. The inflaton field producing via its decay matter is in TGD framework replaced with monopole magnetic fluxes assignable to magnetic flux quanta which near Big Bang correspond to what I call cosmic strings. The decay of magnetic energy of flux quanta to particles produces matter and radiation. The basic difference to string landscape is that standard model symmetries apply in all these sub-cosmologies although there are dynamical parameters distinguishing between them. Hence TGD is highly predictive theory. Even God must bow to the laws of mathematics. TGD space-time is many-sheeted and one has Russian doll cosmology natural also in inflationary scenarios.

In superstring theory the landscape problem forces to assume anthropic principle: the fact that we exist becomes the basic guide line when we try to identify the particular universe in which we happen to live. In TGD framework the evolution implied by Negentropy Maximization Principle (NMP, [K56]) stating that the conscious information gained in quantum jump is maximal, implies evolution. Evolution gradually fine tunes the values of various parameters so that they generate maximal intelligence. This implies that our existence indeed fixes the values of various parameter very precisely. Of course there are some parameters such as Kähler coupling strength (analogous to critical temperature), whose possible values are dictated by quantum criticality. Note that NMP challenges second law as a universal law - at least a generalization is required in ZEO - and it is now clear that the recent view about universe neglects completely the huge negentropy sources associated with the negentropic entanglement assignable to magnetic flux tubes carrying dark matter. In human scale these resources - "Akashic records" - give rise to memories and plans of future, ideas, ...

The purpose of lifes

Haisch adopts the vision about endless sequence of reincarnations as a kind of "life-school" in which one transcends life by life to higher levels of consciousness - to upper class in school (and sometime to same or even to lower one).

This vision could have rather concrete realization in TGD framework. In the average sense the average size scale for personal causal diamonds (CDs) in their quantum superposition grows in a

given quantum jump, and a biological death now and then does not stop this process. New sub-CDs also pop up and mean creation of new small sub-Universes which began to evolve. Asymptotically the size of the personal CD approaches infinity - asymptotic Universe, asymptotic Godness!

Biological death would not mean the end of consciousness, only a transformation to a new level: perhaps higher, perhaps same, or maybe even lower. This depending on the Karma - the law of action and reaction at spiritual level as Haisch puts it - that we have gathered by our deeds. By doing bad deeds reduce our level of consciousness guaranteeing the return to a lower level in hierarchy. This has quite concrete quantum physical correlate: reduction of the effective Planck constants reducing the quantal size scales of the magnetic flux tubes connecting as as bridges of attention to the rest of the world and reducing thus quantum coherence lengths and times characterizing us. It also reduces our long range goals from those dictated by a mission to short range goals dictated by opportunism.

What could happen in biological death?

"What is my fate?" is one of the questions of Haisch. A more concrete formulation for this question is "What happens to the magnetic body in biological death?". TGD framework provides the tools for a glass pearl game around this question.

It would not be too surprising if at least some upper layers of this onion-like structure were preserved. NMP might guarantee the approximate conservation of the entire magnetic body since its braiding serves as a correlate for negentropic entanglement (see **Fig.** http://tgdtheory.fi/appfigures/cat.jpg or **Fig. ??** in the appendix of this book) defining "Akashic records", a kind of cumulative collective wisdom having as a counterpart Sheldrake's morphic fields defining among other things also species memory.

What it means that in 4-D sense (contents of consciousness are from 4-D embedding space region: either boundary of CD in given scale) also our biological body still exists as sub-CD of the larger CD we continue to exist subjectively? Only the sensory input and motor output conscious-to-us has ceased in biological death.

Does my biological body continue its life in reversed direction of embedding space geometric time? The answer is negative if one relies on the assumption that the arrow of embedding space time changes and the folded bath towel argument for the arrow of 4-D time defined by thermodynamical entropy holds true: my body would continue becoming older than it was at the moment of death. Not very plausible or desirable scenario!

NMP requires that negentropic entanglement is generated at the moment of biological death and adds to existing negentropic entanglement defining "Akashic records" about previous life conserved in good approximation. What I painfully learned during my lifetime is not waste! Attention is directed to some target generates negentropic entanglement. It has braiding of magnetic flux tubes connecting the attending system to the attenfed one. Reconnection is the mechanism for building flux tube bridges between the systems.

Tibetan book of dead supports what NMP suggests: I direct my attention somewhere else from my biological body which has become rather uninteresting. The new target of attention could be some new brisk young life form not yet caught the attention (almost anywhere in planet or even elsewhere but inside my personal CD: my magnetic body is big with size scale of - as I hope - about one hundred light years at least!). My new life would proceed in opposite direction of embedding space time (recall that two subsequent quantum jumps create zero energy states with opposite arrows of embedding space geometric time). Maybe I remember the teachings of Tibetan book of dead and manage to direct my attention to a higher level in self hierarchy, larger CD, representing perhaps a collective level of consciousness.

If one takes fractality seriously, the death of civilizations and cultures could be a process analogous to biological death. It is difficult to avoid the feeling that this is something which could happen in not so distant future. If this process corresponds to quantum jump, NMP tells that negentropy is generated but does not exclude the possibility of a catastrophe in which even entire species suffers extinction and some of our relatives, maybe bonobos, take the lead. The transition could also lead to a new higher level of consciousness with the prevailing materialistic world view being replaced with a new one? The individuals who have become aware about the need for a new world view and about what it might be could serve as seeds of the quantum phase transition.

ZPE or ZEO?

Laws of physics and conservation laws are the basic problem of Haisch and all those who want free will in the existing ontology of physics. Haisch is also a physicist so that the problem becomes even more difficult to circumvent! How God can re-create the reality without breaking the well-established conservation laws? Or are these laws just rules of game that God has chosen to obey in this particular part of multiverse? But would this lead to mere quantum randomness and does statistical determinism mean a loss of genuine free will?

If I have guessed correctly, Haisch hopes that ZPE could help God over this problem but to my opinion ZPE is mathematically hopelessly ill-defined and reflects the mathematical problems of quantum field theory rather than reality.

In TGD framework ZPE is effectively replaced with ZEO - zero energy ontology instead of zero point energy. Zero energy states have vanishing total quantum numbers so that re-creation can be carried out without breaking conservation laws and standard laws of physics remain true. One can assign to the positive (say) energy part of zero energy state conserved energy and other quantum numbers and positive and negative energy parts correspond to initial and final state of physical event in the usual positive energy ontology: no states - just events! Therefore there is room also for God in TGD Universe. Together with re-creation as quantum jump one obtains maximal free will: any zero energy state can be created or vacuum in principle.

A possible test for ZEO would be creation of zero energy states apparently breaking conservation laws in the framework of positive energy ontology. In cosmology the non-conservation of gravitational energy indeed takes place and can be understood in terms of ZEO: the energy and other quantum numbers are conserved only in scale which correspond to spotlight of consciousness defined by one particular causal diamond (CD). Therefore also the consistency of Poincare invariance of TGD with cosmology requires ZEO.

Does the replacement of personal CD with a larger one in quantum jump (perhaps increasing the effective value of Planck constant) involve also generation of smaller sub-CDs representing mental images. Are our mental images these tiny Universes that we create?

How to a new sub-Universe this in laboratory? Quantum physicists would perhaps speak about generating long lived enough quantum fluctuations creating matter from vacuum. I remember having seen a popular article about a planned experiment in which very intense laser beams would generate particle pairs from vacuum. Of course, the probability for generating CD containing matter might be very small but maybe for some selected CDs this might not be the case!

The origin of inertia

Haisch and Rueda claim of having derived inertia appearing as a mass parameter in Newton's equations from vacuum energy (see `http://tinyurl.com/yafx6aew`). The basic idea behind the derivation does not however make much sense to me. Here is the condensed form of argument.

If one assumes that the quarks and electrons in such an object scatter this radiation, the semi-classical techniques of stochastic electrodynamics show that there will result a reaction force on that accelerating object having the form $f_r = \mu a$, where the μ parameter quantifies the strength of the scattering process. In order to maintain the state of acceleration, a motive force f must continuously be applied to balance this reaction force f_r. Applying Newton's third law to the region of contact between the agent and the object, $f = f_r$, we thus immediately arrive at $f = \mu a$, which is identical to Newton's equation of motion.

I confess that I have do not have a slightest idea what this statement might mean. The standard wisdom is that particle to which no forces are applied does not suffer acceleration. Now it would suffer acceleration although net force vanishes: $f + f_r = 0$.

The standard view is that in special relativity Poincare invariance combined with Noether's theorem allows to assign to any system conserved four-momentum and angular momentum. Given a variational principle coupling particles to fields one obtains automatically the analog of Newton's equations stating that the momentum lost/gained by fields is gained/lost by particles. Therefore in special relativity based theories there are no problems.

In general relativity situation however changes.

1. First of all, space-time becomes curved and the symmetries behind Poincare invariance are lost. One cannot use Noether's theorem to deduce expressions for conserved quantities:

this is especially catastrophic outcome in quantum theory where the conserved quantities interpreted as operators play fundamental role. This was indeed the basic motivation of TGD: by replacing abstract space-time with a 4-D surface in higher-D space possessing the symmetries of empty Minkowski space, one does not loose the classical conservation laws.

2. There is also another, closely related problem. In Newtonian approach to gravity gravitation accelerating test particle experiences a genuine force. In general relativity test particle however suffers no acceleration nor force. There seems to be now manner for how these pictures could be consistent. Maybe Haisch and Rueda were thinking about this aspect when they made their attempt to derive inertia from vacuum energy in general relativistic context.

TGD provides a neat solution also to this problem. At 4-D space-time level the orbit of neutral test particle is indeed a geodesic line and 4-D acceleration vanishes. At 8-D embedding space level the orbit of test particle is not a geodesic line anymore and it experiences genuine 8-D acceleration, whose M^4 part defines the Newtonian force. The CP_2 part of the force is also present can be neglected since the scale of CP_2 is so small (about 10^4 Planck lengths).

Chapter 8

About the Nature of Time

8.1 Introduction

The notion of time remains one of the most problematic concepts of physics. In classical physics the different properties of the time of Newton's equations and thermodynamical time are puzzling. In special relativity and general relativity the notion of simultaneity becomes a problematic concept and challenges the naive Newtonian view about time flow as a motion of 3-D time=constant snapshot of 4-D space-time. The replacement of time=constant 3-surface with past directed light-cone assignable to the world-line of observer resolves this problem. In general relativity the problem is that past light-cones need make sense only locally. In quantum measurement theory the localization of the state function reduction process into a finite space-time volume is in conflict with the determinism of Schrödinger equation. In biology the presence of self-organization processes like self assembly challenge second law of thermodynamics in short time scales. In neuroscience the finding of Libet suggesting that neural activity seems to precede conscious decision forces to give up the notion of free will or the naive identification of experienced and geometrical time.

In this chapter I will consider a new view about time based on Topological Geometrodynamics [K118], which can be regarded as an attempt to unify fundamental interactions assuming that space-times are representable as 4-dimensional surfaces of certain higher-dimensional space-time $H = M^4 \times CP_2$ (M^4 denotes 4-D Minkowski space and CP_2 complex projective space of 2 complex dimensions) fixed by the requirement that the theory explains standard model symmetries and provides a geometrization of classical gauge fields and gravitational fields.

The construction of quantum TGD leads to a radical revision of space-time concept (many-sheeted space-time and topological field quantization), and forces also to generalize the original view about embedding space. p-Adic physics as physics of cognition is part of TGD inspired theory of consciousness and the need to fuse real and p-adic physics to single coherent whole forces to revise the notions of number and space-time: the outcome seems to be what one could call adelic space-time [K116]. Reals and p-adic number fields together with their extensions are glued together to form a larger structure and same applies to space-time and embedding space. It has been also necessary to replace the standard positive energy ontology with what I call zero energy ontology. These generalizations are of special importance in TGD inspired theory of consciousness and of quantum biology.

There are several first principle approaches to quantum TGD and following gives only a very concise summary of them.

1. Generalization of Einstein's program of geometrizing classical physics so that quantum theory can be seen as a theory of *classical* spinor fields in the world of classical worlds (WCW) consisting of light-like 3-surfaces and possessing Kähler geometry [K26, K121]. By general coordinate invariance (GCI) classical physics becomes an exact part of quantum theory in a well-defined sense. A geometrization of Fermi statistics is obtained, and the Clifford algebra associated with the spinors of WCW can be regarded as a direct sum of von Neumann algebras known as hyper-finite factors of type II_1 (HFFs) closely related to quantum groups and non-commutative geometry.

2. Quantum TGD as almost topological field theory (TQFT) with fundamental objects identified as light-like 3-surfaces and having generalized super-conformal symmetries as symmetries [K25, K24] : the notion of braid is the basic building block of this approach.

3. There are two kinds of conformal symmetries corresponding to the boundary of light-cone of Minkowski space and light-like 3-surfaces, and these symmetries alone dictate to high degree the physics. Quite recently it turned that also a symplectic analog of conformal field theory emerges naturally in TGD framework (super-symplectic symmetries) and this led to a concrete proposal for how to construct n-point functions needed to calculate M-matrix [K110].

   There are two new elements [K110]. The first one is the generalization of twistors from 4-dimensional to 8-dimensional context made possible by the octonion structure of embedding space. $H = M^4 \times CP_2$ has completely unique twistorial properties. Second new element is actually a revival of the old idea that scattering amplitudes are representations for sequences of algebraic operations - product and co-product defining fundamental 3-vertices - connecting two sets of algebraic objects. The algebraic objects are elements of the Yangian associated with super-symplectic algebra realizes as Noether charges assignable to strings connecting partonic 2-surfaces. Universe would be performing quantum algebraic manipulations.

4. Physics as a generalized number theory involves three different threads corresponding to need fuse real and various p-adic physics to single coherent whole by using a generalization of number concept obtained by gluing reals and various p-adic number fields and their extensions together along rationals and common algebraics [K103] ; the observation that standard model symmetries and dynamics of quantum and classical TGD are to high degree dictated by classical number fields [K104] ; and the ideas inspired by the notion of infinite prime [K102].

5. The identification of WCW Clifford algebra elements as hyper-octonion (subspace of complexified octonions spanned by real unit and octonionic imaginary units multiplied by the commuting additional imaginary unit) valued conformal fields having values in HFF provides a justification for the concept of number theoretic braid needed both in the fusion of real and p-adic physics and in TGD as almost TQFT approach.

   What number theoretic braid is has remained unclear. Now it is however clear that string world sheets belong in a well-defined sense to the intersection of reality and various p-adicities defining adelic embedding space and space-time as its surface. Number theoretic braids identified as boundaries of string world sheets would be very simple: they would consist of segments which are light-like geodesics of embedding space. Whether they can be braided without consisting of this kind of pieces remains unclear.

   Discretization is not so simple as one might think: the problem is that standard discretization defines only 0-dimensional objects consisting of points. What I call co-dimension two rule tells how the discretization is achieved for higher-dimensional objects. Partonic 2-surfaces are mapped to a discrete set of points- the ends of string boundaries carrying fermion number, their 3-D light-like orbits are replaced with the boundaries of string world sheets whose defining parameters are algebraic numbers, space-time surfaces in turn are replaced by string world sheets whose parameters are again algebraic numbers. Thus discretizations defined abstraction hierarchy. This brings in mind category theoretical construct of n-objects with $n = 1, 2, 3$ giving three hierarchy levels. Remarkably the hierarchy ends at the third step and string world sheets are the highest dimensional objects that can reside in the intersection of realities and p-adicities.

6. The hierarchy of Planck constants $h_{eff}/h = n$ realizing quantum criticality [K36] in terms of infinite number dark matter phases suggests a generalization of the notion of embedding space by replacing it with a book like structure having as its pages singular coverings and factor spaces of H and allowing to realize geometric correlates for the choice of quantization axis in quantum measurement: the particles at different pages of this book are "relatively dark" since they do not possess local interaction vertices which means a radically new way to interpret dark matter. It has turned out that this generalization is only an auxiliary tool. The proper notion is space-time surface with a structure of n-dimensional covering and the sheets of covering are due to the non-determinism of Kähler action. There are n

conformal equivalence classes of space-time surfaces connecting the space-like surfaces at opposite boundaries of causal diamond (CD). One allows not only space-time surface with one such sheet but also those consisting of several sheets and this should lead to charge fractionization.

There is infinite fractal hierarchy of breakings of super-symplectic symmetry having structure of conformal symmetry: the elements of the sub-algebra have conformal weights are n-ples of those for the full algebra act as gauge symmetries so that it is isomorphic to the entire algebra. There is infinite number of inclusion series for these algebras such that n_i divides n_{i+1} and they correspond to reduction of criticality. Therefore TGD Universe is like a hill at the top of hill at the top of hill....The phase transitions increasing h_{eff} and generating dark matter occur spontaneously. Living systems however tend to stay at criticality defined by particular h_{eff} and the phase transition changing it can be said to mean death of self and its re-incarnation at opposite boundary of CD. In the phase transition some gauge degrees of freedom transform to physical ones. The interpretation is as improvement of measurement resolution. Basically this measurement resolution is cognitive and derives from number theoretic constraints and reflects the character of algebraic extension of p-adic numbers.

7. Zero energy ontology and the notion of finite measurement resolution formulated in terms of inclusions of HFFs fix quantum dynamics highly in terms of Connes tensor product allowing to interpret quantum theory as a square root of thermodynamics [K118, K24]: finite measurement resolution has number theoretic braid as its space-time correlate so that various approaches to TGD are closely related. The hierarchies of super-symplectic symmetry breakings define hierarchies of inclusions for HFFs.

8. Quantum theory of consciousness as a generalization of quantum measurement theory to include observer to the theory [L8].

    The article series about TGD and its applications to biology and consciousness [?, K113] , [L8, L7, L4, L6, L5, L3] gives an overall view about quantum TGD. In the following I will concentrate only on the aspects of quantum TGD relevant for the notion of time. I will first describe zero energy ontology and p-adicization program and after that consider the problem of time.
    The TGD based vision about how the arrow of geometric time is by no means fully developed and final. I will describe also the approaches which look now partially wrong.

1. What seems clear now is the decisive role of ZEO and hierarchy of CDs, and the fact that the quantum arrow of geometric time is coded into the structure of zero energy states to a high extent. The still questionable but attractively simple hypothesis is that U matrix connects two basis with opposite quantum arrows of geometric time: is this assumption really consistent with what we know about the arrow of time? If this is the case, the question is how the relatively well-defined quantum arrow of geometric time implies the experienced arrow of geometric time. Should one assume the arrow of geometric time separately as a basic property of the state function reduction cascade or more economically- does it follow from the arrow of time for zero energy states?

2. The first idea was that state function reductions occur alternately at the two boundaries of CD. If the reduction occurs at given boundary is immediately followed by a reduction at the opposite boundary, the arrow of time alternates: this does not conform with intuitive expectations: for instance, this would imply that there are two selves assignable to the opposite boundaries!

3. Zero energy states are however de-localized in the moduli space CDs (size of CD plus discrete subgroup of Lorentz group defining boosts of CD leaving second tip invariant). One has quantum superposition of CDs with difference scales but with fixed upper or lower boundary belonging to the same light-cone boundary after state function reduction.

    In standard quantum measurement theory the repetition of state function reduction does not change the state but now it would give rise to the experienced flow of time. Zeno effect indeed requires that state function reductions can occur repeatedly at the same boundary.

In these reductions the wave function in moduli degrees of freedom of CD changes. This implies "dispersion" in the moduli space of CDs experienced as flow of time with definite arrow. This view lead to a precise definition of self as sequence of quantum jumps to the reducing to the same boundary of CD.

Each reduction leaves the passive boundary of CD invariance and also the part of zero energy state associated with it but can induce localization to single CD. The reduction must have some effect on state and it might be that the localization is this effect.

4. This approach codes also the arrow of time at the space-time level: the average space-time sheet in quantum superposition increases in size as the average position of the "upper boundaries" of CDs drift towards future state function reduction by state function reduction.

5. In principle the arrow of time can temporarily change and probably takes place in elementary particle scales and living matter routinely. Phase conjugate laser beam is a non-biological example about reversal of the arrow of time. The act of volition would correspond to the first state function reduction to the opposite boundary so that the reversal of time arrow at some level of the hierarchy of selves would take place in the act of volition.

This vision involves minimal number of assumption and is the most convincing one found hitherto and the challenge is to invent objections in order to develop it in more detail.

In the following different views about how the arrow of time is generated, how self experiences the quantum jumps at lower levels of self hierarchy as a continuous flow of time, and how the contents of sensory experience seem to be localized around a rather narrow interval of geometric time.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L17].

8.2 The Most Recent Vision About Zero Energy Ontology And P-adicization

The generalization of the number concept obtained by fusing real and p-adics along rationals and common algebraics is the basic philosophy behind p-adicization. One must be able to speak about rational points common to real and various p-adic variants of H. The basic objection is the necessity to fix some special coordinates in turn implying the loss of a manifest general coordinate invariance. The isometries of the embedding space could save the situation provided one can identify some special coordinate system in which isometry group reduces to its discrete subgroup. The loss of the full isometry group could be compensated by assuming that WCW is union over sub- WCW s obtained by applying isometries on basic sub- WCW with discrete subgroup of isometries.

The combination of zero energy ontology realized in terms of a hierarchy of causal diamonds (CDs) and hierarchy of Planck constants providing a description of dark matter and leading to a generalization of the notion of embedding space suggests that it is possible to realize this dream. The article [K118] provides a brief summary about recent state of quantum TGD helping to understand the big picture behind the following considerations.

8.2.1 Zero Energy Ontology Briefly

1. The basic construct in the zero energy ontology is the space $CD \times CP_2$, where the causal diamond CD is defined as an intersection of future and past directed light-cones with time-like separation between their tips regarded as points of the underlying universal Minkowski space M^4. In zero energy ontology physical states correspond to pairs of positive and negative energy states located at the boundaries of the future and past directed light-cones of a particular CD.

2. CDs form a fractal hierarchy and one can glue smaller CDs within larger CDs. This construction recipe when combined with TGD inspired theory of consciousness allows to understand the asymmetry between positive and negative energies and why the arrow of experienced

time corresponds to the arrow of geometric time and why the contents of sensory experience is located to so narrow interval of geometric time. One can imagine evolution to occur as quantum leaps in which the size of the largest CD in the hierarchy of personal CDs increases in such a manner that it becomes sub-CD of a larger CD. p-Adic length scale hypothesis [K118] follows if the values of temporal distance T between tips of CD come in powers of 2^n: $T = 2^n T_0$. This is probably too strong an assumption: a more realistic hypothesis is that the distances are integer multiples of T_0.

All conserved quantum numbers for zero energy states have vanishing net values. The interpretation of zero energy states in the framework of positive energy ontology is as physical events, say scattering events with positive and negative energy parts of the state interpreted as initial and final states of the event.

3. In the realization of the hierarchy of Planck constants $CD \times CP_2$ is replaced with a Cartesian product of book like structures formed by almost copies of CDs and CP_2s defined by singular coverings and factors spaces of CD and CP_2 with singularities corresponding to intersection $M^2 \cap CD$ and homologically trivial geodesic sphere S^2 of CP_2 for which the induced Kähler form vanishes. The coverings and factor spaces of CDs are glued together along common $M^2 \cap CD$. The coverings and factors spaces of CP_2 are glued together along common homologically non-trivial geodesic sphere S^2. The choice of preferred M^2 as subspace of tangent space of X^4 at all its points and interpreted as space of non-physical polarizations, brings M^2 into the theory also in different manner. S^2 in turn defines a subspace of the much larger space of vacuum extremals as surfaces inside $M^4 \times S^2$.

4. WCW (the world of classical worlds, WCW) decomposes into a union of sub- WCW s corresponding to different choices of M^2 and S^2 and also to different choices of the quantization axes of spin and energy, color isospin and hyper-charge for each choice of this kind. This means breaking down of the isometries to a subgroup. This can be compensated by the fact that the union can be taken over the different choices of this subgroup.

5. p-Adicization requires a further breakdown to discrete subgroups of the resulting sub-groups of the isometry groups but again a union over sub- WCW s corresponding to different choices of the discrete subgroup can be assumed. Discretization relates also naturally to the notion of number theoretic braid.

8.2.2 WCW Spinor Fields

In TGD framework zero energy states correspond to the modes of completely classical WCW spinor fields with fermionic second quantization at space-time level having purely geometric interpretation at the level of WCW . The analysis of the degrees of freedom involved demonstrates that WCW spinor fields are analogous to ordinary quantum fields but hav infinite number of components.

1. WCW decomposes to a sub- WCW s association with unions of causal diamonds (CDs). Individual CD is partially characterized by the moduli defined by the positions of its upper and lower tips. The proposal is that the temporal distances between the tips are quantized in octaves of CP_2 time scale and thus coming in good approximation as secondary p-adic time scales for primes very neary to power of two. The most general proposal is that also the position of the upper tip at proper time = constant hyperboloid of future light-cone M^4_+ is quantized for positive energy states. For negative energy states this happens to the lower tip. This disrete set would provide a discretized quantum version of Robertson-Walker cosmology with discretized lattice like structure replacing the continuum. The interpretation would be that first tip corresponds to the usual Minkowski space-time of special relativity and the discretized position of second tip - or rather the space M^4_+ representing the relative position of the tips- to the space-time of cosmology. This implies very strong predictions such as the quantization of cosmic redshifts which is indeed observed [K98]. Similar quantization would take place in CP_2 degrees of freedom for either tip. WCW spinor fields for single CD would depend on these moduli and for positive (negative) states one would have wave functions in the space formed by sub- WCW s with wave function basis consisting of products of plane waves in M^4 with a wave function in the discrete subset of $M^4_\perp$. These degrees of freedom

generalize those of a quantum field in Minkowski space. If the upper tip is assigned with observer, the sub-CDs in the interior of CD correspond to astrophysical objects and M_+^4 as empty Robertson-Walker cosmology predicts automatically cosmic redshift.

2. The notion of generalized imbdding space forces to assign to a given CD a selection of quantization axis of energy and spin which in the case of M^4 boils down to a choice of a preferred plane $M^2 \subset M^4$ plus a choice of time direction (rest system). In the case of CP_2 the choice of quantization axes of color isospin and hypercharge means a choice of a homologically trivial geodesic sphere of CP_2 plus preferred isospin quantization axes. The space for possible choices of quantization axis defines additional moduli. The selection of quantization axes in state function reduction means a localization in these degrees of freedom. The space characterizing the selections of color quantization axis represents an example of so called flag manifold. It has already earlier appeared in TGD inspired biology with a motivation coming from the observation of topologists Barbara Shipman that the mathematical model for honeybee dance leads naturally to the introduction of this space. Shipman speculated that quarks have some role in biology [A12]. Dark matter hierarchy indeed makes indeed possible scaled up copies of QCD type theory in biological length scales.

3. WCW spinor fields restricted to a CD with fixed moduli have infinite number of bosonic and fermionic degrees of freedom. Spin-like degrees of freedom for these fields correspond to WCW spinors, which describe many-fermion states consisting of quarks and leptons and bosons defined as their bound states. This Fock state is assigned to each 3-surface and the dependence on 3-surface defines purely bosonic ("orbital") degrees of freedom, which can be coded by using a state basis whose elements have well-defined spin and color quantum numbers. The bosonic and fermionic degrees of freedom are super-symmetrically related.

Is it really possible to speak about zero energy states for a given sector defined by generalized embedding space with fixed M^2 and S^2? Classically this is possible and conserved quantities are well defined. In quantal situation the presence of the light-cone boundaries breaks full Poincare invariance although the infinitesimal version of this invariance is preserved. Note that the basic dynamical objects are 3-D light-like "legs" of the generalized Feynman diagrams glued together along their ends at generalized vertices.

8.2.3 Definition Of Energy In Zero Energy Ontology

The approach relying on the two super conformal structures of quantum TGD gives hopes of defining the notion of energy for positive and negative energy parts of the state.

1. CD allows translational invariance only in its interior and since partonic two surfaces are located to the boundary of CD, one can argue that translations assigned to them lead out from CD. One can however argue that if it is enough to assign eigenstates of four-momentum to partons and require that only the total four-momentum generators acts on the physical state by shifting CD. Since total four-momentum vanishes for CD this would mean that wave function in cm degrees of CD is just constant plane wave. Super-conformal invariance would indeed allow to assign momentum eigenstates to the super-conformal representations.

2. A more stringent condition would be that four-momentum generators act as translation like operators on partons themselves. Since light-like 3-surfaces assignable to incoming and outgoing legs of the generalized Feynman diagrams are the basic objects, one can hope of having enough translational invariance to define the notion of energy. If translations are restricted to time-like translations acting in the direction of the future (past) then one has local translation invariance of dynamics for classical field equations inside $\delta M_{\pm}^4$ as a kind of semigroup. Also the M^4 translations leading to interior of X^4 from the light-like 2-surfaces surfaces act as translations. Classically these restrictions correspond to non-tachyonic momenta defining the allowed directions of translations realizable as particle motions. These two kinds of translations can be assigned to super-symplectic conformal symmetries at $\delta M_{\pm}^4 \times CP_2$ and and super Super-Kac-Moody type conformal symmetries acting as super-symplectic isometries. Super-symplectic algebra is realized in terms of second quantized spinor fields and

covariantly constant modes of right-handed neutrino. Symplectic group has as sub-group symplectic isometries and the Super-Kac-Moody algebra associated with this group and represented in terms of spinor modes localized to string world sheets plays also a key role in TGD.

Finite M^4 translations to the interior of CD do not respect the shape of the partonic 2-surface. Local M^4 translations vanishing at the boundary of CD however act as Kac-Moody symmetries of the light-like 3-surfaces and reduce physically to gauge transformations: hence one could allow also the deformations of the partonic 2-surface in the interior of the light-like 3-surface. This corresponds to the effective metric 2-dimensionality stating that all information both about the geometry of WCW and quantum physics is carried by the partonic 2-surfaces X^2 resulting as intersections of the light-like 3-surfaces X_l^3 and space-like 3-D surfaces X^3 at the boundaries of CD and the distribution of 4-D tangent planes of X^2.

3. The condition selecting preferred extremals of Kähler action is induced by a global selection of $M^2 \subset M^4$ as a plane belonging to the tangent space of X^4 at all its points [K25] and interpreted as a plane of nonphysical polarizations so that direct connection with number theory and gauge symmetries emerges. The M^4 translations of X^4 as a whole in general respect the form of this condition in the interior. Furthermore, if M^4 translations are restricted to M^2, also the condition itself - rather than only its general form - is respected. This observation, the earlier experience with p-adic mass calculations, and also the treatment of quarks and gluons in QCD encourage to consider the possibility that translational invariance should be restricted to M^2 translations so that mass squared, longitudinal momentum and transversal mass squared would be well defined quantum numbers. This would be enough to realize zero energy ontology. Encouragingly, M^2 appears also in the generalization of the causal diamond to a book-like structure forced by the realization of the hierarchy of Planck constant at the level of the embedding space.

4. That the cm degrees of freedom for CD would be gauge like degrees of freedom sounds strange. The paradoxical feeling disappears as one realizes that this is not the case for sub-CDs, which indeed can have non-trivial correlation functions with either upper or lower tip of the CD playing a role analogous to that of an argument of n-point function in QFT description. One can also say that largest CD in the hierarchy defines infrared cutoff.

8.2.4 P-Adic Variants Of The Embedding Space And Adelic Structure Of Space-Time And Embedding Space

The need to fuse p-adic physics with TGD emerged originally from the discovery that p-adic mass calculations based on p-adic thermodynamics give excellent predictions for elementary particle masses if one assumes p-adic length scale hypothesis stating that primes near integer powers of 2 are physically favored [K118]. Later came the interpretation of p-adic physics as cognition cognition. The following somewhat technical construction of p-adic variants of the embedding space provides new insights concerning the understanding of the arrow of geometric time.

1. Rational values of p-adic coordinates are non-negative so that light-cone proper time $a_{4,+} = \sqrt{t^2 - z^2 - x^2 - y^2}$ is the unique Lorentz invariant choice for the p-adic time coordinate near the lower tip of CD. For the upper tip the identification of a_4 would be $a_{4,-} = \sqrt{(t-T)^2 - z^2 - x^2 - y^2}$. In the p-adic context the simultaneous existence of both square roots poses additional conditions on T. For 2-adic numbers $T = 2^n T_0$, $n \geq 0$ (or more generally $T = \sum_{k \geq n_0} b_k 2^k$), would allow to satisfy these conditions, which would be one additional reason for $T = 2^n T_0$ implying p-adic length scale hypothesis. The remaining coordinates of CD are naturally (hyperbolic) cosines and sines of the spherical coordinates θ and ϕ (hyperbolic angle $\eta_{\pm,4}$).

2. The existence of the preferred plane M^2 of un-physical polarizations would suggest that 2-D light-cone proper times $a_{2,+} = \sqrt{t^2 - z^2}$ $a_{2,-} = \sqrt{(t-T)^2 - z^2}$ can be also considered. The remaining coordinates would be naturally $\eta_{\pm,2}$ and cylindrical coordinates (ρ, ϕ).

3. The p-adically transcendental values of a_4 and a_2 are literally infinite as real numbers and could be visualized as points in infinitely distant geometric future so that the arrow of time might be said to emerge number theoretically.

4. The selection of the preferred quantization axes of energy and angular momentum unique apart from a Lorentz transformation of M^2 would have purely number theoretic meaning in both cases. One must allow a union over sub-WCWs labeled by points of $SO(1,1)$. This suggests a deep connection between number theory, quantum theory, quantum measurement theory, and even quantum theory of mathematical consciousness.

5. In the case of CP_2 there are three real coordinate patches involved [A23]. The compactness of CP_2 allows to use cosines and sines of the preferred angle variable for a given coordinate patch.

$$
\begin{aligned}
\xi^1 &= tan(u)exp(i\frac{(\Psi + \Phi)}{2})cos(\frac{\Theta}{2}) \ , \\
\xi^2 &= tan(u)exp(i\frac{(\Psi - \Phi)}{2})sin(\frac{\Theta}{2}) \ .
\end{aligned}
\tag{8.2.1}
$$

The ranges of the variables u, Θ, Φ, Ψ are $[0, \pi/2], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively. Note that u has naturally only positive values in the allowed range. S^2 corresponds to the values $\Phi = \Psi = 0$ of the angle coordinates.

6. The rational values of the (hyperbolic) cosine and sine correspond to Pythagorean triangles having sides of integer length and thus satisfying $m^2 = n^2 + r^2$ ($m^2 = n^2 - r^2$). These conditions are equivalent and allow the well-known explicit solution [A4]. One can construct a p-adic completion for the set of Pythagorean triangles by allowing p-adic integers which are infinite as real integers as solutions of the conditions $m^2 = r^2 \pm s^2$. These angles correspond to genuinely p-adic directions having no real counterpart. Hence one obtains p-adic continuum also in the angle degrees of freedom. Algebraic extensions of the p-adic numbers bringing in cosines and sines of the angles π/n lead to a hierarchy increasingly refined algebraic extensions of generalized embedding space. Since the different sectors of WCW directly serve as correlates of selves, this means a direct correlation with the evolution of the mathematical consciousness. Trigonometric identities allow to construct points which in the real context correspond to sums and differences of angles.

7. Negative rational values of the cosines and sines correspond as p-adic integers to infinite real numbers and it seems that one use several coordinate patches obtained as copies of the octant $(x \geq 0, y \geq 0, z \geq 0,)$. An analogous picture applies in CP_2 degrees of freedom.

How the different variants of p-adic embedding space and real embedding space relate to each other? The original guess was that one can speak about real and p-adic space-time sheets and that in intentional action the p-adic space-time sheet transforms to a real one and in the formation of cognitive representation the opposite transformation occurs. The formulation of quantum transition amplitudes to describe this process might be however impossible. Rather, cognition and sensory aspects of the geometric existence are simultaneously present: space-time and embedding space are adelic. This indeed conforms with the success of p-adic mass calculations.

1. What seems clear that there must exist kind of chart mappings between them. The notion of p-adic space-time surface is formulated in [K122]. The idea is that p-adic space-time surfaces are cognitive charts of real space-time surface. Both real and p-adic space-time surfaces satisfy the field equations and are thus preferred extremals of Kähler action. There is discretization due to both number theoretic reasons and the points in discretization correspond to points which are common to reals and p-adic number fields. This includes rationals and algebraic numbers in the extension of p-adic number field.

2. At the level of world of classical worlds (WCW) the discretization would be more abstract since the naïve discretization of higher-dimensional objects can be argued to be zero-dimensional as a point set. The parameters defining the geometric object are rational or in the algebraic extensions of rationals.

3. It is now clear the discretization introduced in [K122] might be too naïve. The above described abstraction applies also to the discretization various objects such as partonic 2-surfaces and their 3-D light-like orbits, string world sheets, space-like 3-surfaces, and space-time surfaces. Co-dimension two rule would apply. Partonic 2-surfaces are replaced with discrete point sets at which the fermion lines identified as boundaries of string world sheets meet. The orbits of partonic 2-surface correspond to fermion lines. Space-time surfaces is discretized to a collection of string world sheets which are in the intersection of reality and p-aicities in the sense that the defining parameters belong are in the algebraic extensions associated with p-adic numbers.

   Concerning the construction of preferred extremals this means strong form of holography. One starts from string world sheets (carrying vanishing induced W boson fields so that em charge for the spinor modes is well-defined) and partonic 2-surfaces and continues them to space-time surfaces satisfying field equations for preferred extremals. These include infinite number of conditions stating that the Noether charges of super-symplectic algebra vanish and that the classical conserved charges correspond to the eigenvalues of quantal charges associated with string world sheets. This guarantees the generalization of AdS/CFT correspondence. The preferred extremal is defined only modulo conformal gauge transformations defining $n = h_{eff}/h$ conformal equivalence classes.

4. All p-adic variants of the space-time surface are present and meet each other along string world sheets, which is like a back of a book. Fermions representing Boolean cognition reside in this intersection and are thus number theoretically universal, which conforms with the fact that the anti-commutation relations for the oscillator operators can be written in a form which does not involve any numbers except unity. One can say that string world sheets and fermions define the fundamental cognitive representations in the intersection of realities and p-adicities. In this intersection also the notion of negentropic entanglement makes sense.

5. One can assign to elementary particles definite value of p-adic prime. For this p-adic prime the p-adic preferred extremal should provide a better representation of real space-time surface than others. The reason could that the classical nondeterminism of Kähler action for them is very similar to the p-adic non-determinism for the p-adic prime involved. 4-D spin glass character of the landscape of maxima of Kähler function together with the fact that ordinary spin glass landscape consisting of minima of free energy allows ultra-metric topology about which p-adic topologies are examples. This suggests that real preferred extremal obeys some p-adic topology in discretization in some length scale range.

8.3   Zero Energy Ontology, Self Hierarchy, And The Notion Of Time

Consider now the formulation of TGD inspired quantum theory of consciousness [L8] and quantum biology [L7] in terms of zero energy ontology.

One should understand the asymmetry between positive and negative energies and between two directions of geometric time at the level of conscious experience, the correspondence between experienced and geometric time, and the emergence of the arrow of time. One should explain why human sensory experience is about a rather narrow time interval of about.1 seconds and why memories are about the interior of much larger CD with time scale of order life time. One should have a vision about the evolution of consciousness: how quantum leaps leading to an expansion of consciousness occur.

Negative energy signals to geometric past - about which phase conjugate laser light represents an example - provide an attractive tool to realize volitional action as a signal inducing neural activities in the geometric past (this would explain Libet's classical findings), a mechanism of

remote metabolism, and the mechanism of declarative memory as communications with geometric past. One should understand how these signals are realized in zero energy ontology and why their occurrence is so rare.

In the following I try to demonstrate that TGD inspired theory of consciousness and quantum TGD proper indeed are in tune.

8.3.1 Space-Time And Embedding Space Correlates For Selves

Quantum jump as a moment of consciousness, self as a sequence of quantum jumps integrating to self, and self hierarchy with sub-selves experienced as mental images, are the basic notions of TGD inspired theory of consciousness. In the most ambitious vision self hierarchy reduces to a fractal hierarchy of quantum jumps within quantum jumps. Quantum classical correspondence demands selves to have space-time correlates both at the level of space-time and embedding space.

At the level of space-time the first guess for the correlates is as light-like or space-like 3-surfaces. If one believes on effective 2-dimensionality and quantum holography, partonic 2-surfaces plus their 4-D tangent space distribution would code the information about the space-time correlates. By quantum classical correspondence one can also identify space-time sheets as the correlates modulo the gauge degeneracy implied by super-conformal symmetries.

It is natural to interpret CDs as correlates of selves at the level of the embedding space. CDs can be interpreted either as subsets of the generalized embedding space or as sectors of WCW . Accordingly, selves correspond to CDs of the generalized embedding space or sectors of WCW , literally separate interacting quantum Universes. The spiritually oriented reader might speak of Gods. Sub-selves correspond to sub-CDs geometrically. The contents of consciousness of self is about the interior of the corresponding CD at the level of embedding space. For sub-selves the wave function for the position of tip of CD brings in the de-localization of sub- WCW .

The fractal hierarchy of CDs within CDs is the geometric counterpart for the hierarchy of selves: the quantization of the time scale of planned action and memory as $T(k) = 2^k T_0$ suggest an interpretation for the fact that we experience octaves as equivalent in music experience. This assumption is however un-necessarily restrictive. In order to understand interactions between selves one must also allow intersections of CDs. The interactions would correspond to the formation of magnetic flux tubes contacts between the 3-surfaces involving also strings connecting the partonic 2-surfaces and defining string world sheets.

It seems that string world sheets can be identified as the intersection of space-time surfaces in various number fields identified as preferred extremals of Kähler action. They would define the fundamental cognitive representations. Therefore partonic 2-surfaces and string world sheets would serve also as cognitive representation of selves and the negentropic entanglement would be associated the fermions at them serving as correlates of Boolean cognition. To be in the intersection of various number fields would mean in the case of string world sheets and partonic two-surfaces that the parameters characterizing them are algebraic numbers in the extension of p-adic numbers. This suggests that the algebraic continuation to all possible p-adic number fields is not possible. Maybe those p-adic primes for which this is possible characterize the particle. By generalized conformal invariance the algebraic values of conformal moduli of partonic 2-surfaces and string world sheets could define the parameters in question so that the situation would reduce to finite-dimensional one.

8.3.2 Weak Form Of NMP

The notion of number theoretic entropy obtained by can be defined by replacing in Shannon entropy the logarithms of probabilities p_n by the logarithms of their p-adic norms $|p_n|_p$. This replacement makes sense for algebraic entanglement probabilities if appropriate algebraic extension of p-adic numbers is used. What is new that entanglement entropy can be negative, so that algebraic entanglement can carry information and NMP can force the generation of bound state entanglement so that evolution could lead to the generation of larger coherent bound states rather than only reducing entanglement. A possible interpretation for algebraic entanglement is in terms of experience of understanding or some positive emotion like love.

Standard formalism of physics lacks a genuine notion of information and one can speak only about increase of information as a local reduction entropy. It seems strange that a system gaining

wisdom should increase the entropy of the environment. Hence number theoretic information measures could have highly non-trivial applications also outside the theory consciousness.

NMP combined with number theoretic entropies leads to an important exception to the rule that the generation of bound state entanglement between system and its environment during U process leads to a loss of consciousness. When entanglement probabilities are rational (or even algebraic) numbers, the entanglement entropy defined as a number theoretic variant of Shannon entropy can be non-positive (actually is) so that entanglement carries information. NMP favors the generation of algebraic entanglement. The attractive interpretation is that the generation of algebraic entanglement leads to an expansion of consciousness ("fusion into the ocean of consciousness") instead of its loss.

State function reduction period of the quantum jumps involves much more than in wave mechanics. For instance, the choice of quantization axes realized at the level of geometric delicacies related to CDs is involved. U-process generates a superposition of states in which any sub-system can have both real and algebraic entanglement with the external world. If state function reduction involves also a choice between generic and negentropic entanglement (between real world, a particular p-adic world, or their intersection) it might be possible to identify a candidate for the physical correlate for the choice between good and evil. The hedonistic complete freedom resulting as the entanglement entropy is reduced to zero on one hand, and the algebraic bound state entanglement implying correlations with the external world and meaning giving up the maximal freedom on the other hand. The hedonistic option is risky since it can lead to non-algebraic bound state entanglement implying a loss of consciousness. The second option means expansion of consciousness - a fusion to the ocean of consciousness as described by spiritual practices. Note that if the total entanglement negentropy defined as sum of contributions from various levels of CD hierarchy up to the highest matters in NMP then also sub-selves should develop negentropic entanglement. For instance, the generation of entropic entanglement at cell level can lead to a loss of consciousness also at higher levels. Life would evolve from short to long scales.

The consistency with quantum measurement theory leads to an important constraint on the density matrix giving rise to negentropic entanglement. The density matrix of the final state must be a projector as in the ordinary quantum measurement theory. It's dimension can be however higher than one now. Therefore negentropic entanglement cannot be confused with real entanglement and there is no problem due to the fact that for real number based entanglement it is impossible to know in practice whether the entanglement coefficients are rational numbers. The entanglement giving rise to a density matrix, which is projector corresponds in the 2-particle case entanglement matrix proportional to unitary matrix typical for quantum computer type systems.

TGD inspired theory of consciousness forces to challenge the hypothesis that NMP always forces the state function reduction to the sub-space defined by the projector with maximal dimension appearing in the decomposition of the density matrix. NMP would not allow the self to make choices, which are bad deeds in the sense that they do not increase maximally the negentropic resources of the Universe. We would live in the best possible Universe becoming better all the time. This is obviously too good to be true.

A weaker form of NMP allows the choice leading to maximal negentropy gain but allows also those choices for which the reduction occurs to a sub-space of the space defined by projector. When this sub-space is 1-dimensional standard quantum measurement results and the self is isolated from the target of observations. Negentropic entanglement has interpretation as attention with positively colored contents of consciousness. Experience of love would be one attribute of this kind of state. Weak form of NMP would be like God allowing the sinner to chose between Good and Evil.

8.3.3 Conscious Entities And Arrow Of Time In TGD Universe

"Fractality from your blog" posed an interesting question about possible asymmetry between boundaries of causal diamond CD. The answer to the question led to recall once again the incomplete understanding of details about how the arrow of time emerges in zero energy ontology (ZEO).

The basic vision is following.

1. CDs form a fractal scale hierarchy. Zero energy states possess a wave function in moduli degrees of freedom characterizing sizes of CDs as well telling what Lorentz boost leaving

      boundary invariant are allowed for them. Boosts form by number theoretic constraints a discrete subgroup of Lorentz group defining analogs of lattices generated by boosts instead of translations.

2. The arrow of subjective time maps to that of geometric time somehow. The origin of arrow comes from the fact that state function reductions can occur to either boundary of given CD and reduction creates time-asymmetric state since second boundary of CD is in a quantum superposition of different sizes and there is a superposition of many-particle states with different particles numbers and quantum number distributions. It is possible that each state function reduction leaving the passive boundary intact, involves localization in the moduli space of CDs with second boundary fixed.

3. Subjective existence corresponds to a sequence *of moments of consciousness*: state function reductions at opposite boundaries of CDs. State function reduction localizes either boundary but the second boundary is in a quantum superposition of several locations and size scales for CD. This predicts that the arrow of time is not constant. In fact, there is considerable evidence for the variation of the arrow of time in living systems and Fantappie [J97] introduced long time ago the notion of syntropy to describe his view about the situation.

4. The first very naïve proposal was that state function reductions occur *alternately* to the two boundaries of CD. This assumption would be indeed natural if one considered single fixed CD rather than superposition CDs with different size and state function reduction localizing their either boundary: restriction to single CD was what I indeed did first.

5. This assumption leads to the question about why do we not observe this alternation of the arrow of time all the time in our personal experience. Some people actually claim to have actually experienced a temporary change of the arrow of time: I belong to them and I can tell that the experience is frightening. But why do we experience the arrow of time as stable in the standard state of consciousness?

      One possible way to solve the problem - perhaps the simplest one - is that state function reduction to the same boundary of CD can occur many times repeatedly. This solution is so absolutely trivial that I could perhaps use this triviality to defend myself for not realizing it immediately!

      I made this totally trivial observation only after I had realized that also in this process the wave function in the moduli space of CDs change in these reductions. Zeno effect in ordinary measurement theory relies on the possibility of repeated state function reductions. In the ordinary quantum measurement theory repeated state function reductions do not affect the state in this kind of sequence but in ZEO the wave function in the moduli space labelling different CDs with the same boundary could change in each quantum jump. It would be natural that this sequence of quantum jumps give rise to the experience about flow of time? This option would allow the size scale of CD associated with human consciousness be rather short, say.1 seconds. It would allow to understand why we do not observe continual change of arrow of time.

      Maybe living systems are working hardly to keep the personal arrow of time un-changed - living creatures try to prevent kettle from boiling by staring at it intensely. Maybe it would be extremely difficult to live against the collective arrow of time.

      An objection against this picture as compared to the original one assuming alternate reductions to the opposite boundaries of CD is that is that one can understand state preparation as state function reduction to the opposite boundary. This interpetation makes sense almost as such also in the new picture if the average time period for which the reductions occur to a given boundary is shorter in elementary particles scales than in macroscopic scales characteristic for human consciousness. The approximate reversibility in elementary particle scales can be understood as summing up of the two arrows of time to no arrow at all.

      This picture allows also to identify self as a continuous entity as the sequence of state function reductions occurring at the same boundary of CD. The average increase of the temporal distance between the tips of cD defines the life-time of self. The number of reductions would give a measure for the subjectively experienced of life-time of self.

In elementary particle time scales reversibility is a good approximation and this suggests that in elementary particle scales the number of state function reductions at the same boundary of CD is small so that the effects due to the change of the arrow of time cancel on the average.

NMP would eventually force "death" of self since the state function reduction at opposite boundary would generate more negentropy. "Death" of self would mean birth of self asssociated with the opposite boundary of CD. The age of self identified as the proper time distance between the tips would increase in statistical sense even when its arrow can change. The act of volition would have a natural identification as the first state function reduction at the opposite boundary of CD.

This picture raises a series of questions. Do our wake-up periods correspond to sequences of state function reductions for self and are sleeping periods wake-up periods of the self at the opposite boundary of CD? The arrow of geometric time should change at some space-time sheet associated with the self hierarchy. How could one demonstrate this? Are the memories of the "other" self predictions of future from our point of view? Do we sleep in order to get information from future, to remember what the future will be?

How the hierarchy of Planck constants defining a hierarchy of quantum criticalities does relate to this picture? The ageing of self having has as a correlate the increase of the size scale of CD. Could this increase be due to the increase of h_{eff} expected to occur spontaneously since it corresponds to a reduction of criticality and therefore to the appearance of new physical degrees of freedom as symplectic gauge degrees of freedom transform to physical ones in gauge symmetry breaking. This is not the case. The time evolution must be analogous to shift in time rather than scaling. This of course corresponds to the QFT view about time evolution.

In the first state function reduction to the opposite boundary of CD however scaling of CD is possible and would correspond to the scaling of CD represented by exponent of infinitesimal scaling operator as in conformal field theories. The emergence of bew physical degrees of freedom suggest increasing perceptive and cognitive capabilities. The increase of h_{eff} could be seen as evolution as also the associated increase of resources of negentropic entanglement suggests. The total increase of h_{eff} measured by the ratio $h_{eff}(final)/h_{eff}(initial)$ could be seen as a measure for the progress per single life period of self.

8.3.4   Why Sensory Experience Is About So Short Time Interval?

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

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

1. The localization of contents of sensory experience to a narrow time interval would be due to the concentration of sub-CDs representing mental images near the either boundary of CD representing self.

2. Phase conjugate signals identifiable as negative energy signals to geometric past are important when the arrow of time differs from the standard one in some time scale. If the arrow of time establishes itself as a phase transition, this kind of situations are rare. Negative energy signals as a basic mechanism of volitional action and transfer of metabolic energy would explain why living matter is so special.

3. Geometric memories would correspond to sub-selves in the interior of CD, the oldest of them to the regions near "lower" boundaries of CD. Since the density of sub-CDs is small there geometric memories would be rare and not sharp. A temporal sequence of mental images, say the sequence of digits of a phone number, would correspond to a temporal sequence of sub-CDs.

4. Sharing of mental images corresponds to a fusion of sub-selves/mental images to single sub-self by quantum entanglement: the space-time correlate could be flux tubes connecting space-time sheets associated with sub-selves represented also by space-time sheets inside their CDs.

8.3.5 The Mechanism Of Self Reference

Self reference is perhaps the most mysterious aspect of conscious experience. When formulated in somewhat loose manner self reference states that self can be conscious about being conscious of something. When trying to model this ability in say computer paradigm one is easily led to infinite regress. In TGD framework a weaker form of self referentiality holds true: self can become conscious that it *was* conscious of something in previous quantum jump(s). Self reference therefore reduces to memory. Infinite regress is replaced with evolution recreating Universe again and again and adding new reflective levels of consciousness. It is however essential to have also the experience that memory is in question in order to have self reference. This knowledge implies that a reflective level is in question.

The mechanism of self reference would reduce to the ability to code information about quantum jump into the geometry and topology of the space-time surface and to the quantum entanglement assignable the fermions. This representation defines an analog of written text which can be read if needed: memory recall is this reading process. The existence of this kind of representations means quantum classical correspondence in a generalized sense: not only quantum states but also quantum jump sequences responsible for conscious experience can be coded to the space-time geometry. The reading of this text induces self-organization process re-generating the original conscious experience or at least some aspects of it (say verbal representation of it). The failure of strict classical determinism for Kähler action is absolutely essential for the possibility to realize quantum classical correspondence in this sense.

Consider now the problem of coding conscious experience to space-time geometry and topology so that it can be read again in memory recall. Let us first list what I believe to know about memories.

1. In TGD framework memories corresponds to sub-CDs inside CDs and are located in geometric past. This means fundamental difference from neuroscience view according to which memories are in the geometric now. Note that standard physicist would argue that this does not make sense: by the determinism of field equations one cannot think 4-dimensionally. In TGD however field equations fail to be deterministic in the standard sense: this actually led to the introduction of zero energy ontology.

2. The reading wakes up mental images which are essentially 4-D self-organization patterns inside sub-CDs in the geometric past. Metabolic energy is needed to achieve this wake up. What is needed is generation of space-time sheets representing the potential images making possible memories.

This picture combined with the mechanism for generating the arrow of psychological time and explaining why sensory experience is located to so short time interval as it is (.1 second, the time scale of CD associated with electron by p-adic length scale hypothesis) allows to understand the mechanism of self reference. It deserves to be mentioned that the discussion with Stephen Paul King in Time discussion group served as the midwife for this step of progress.

1. When the film makes a shift to the direction of geometric past in quantum jump sub-selves representing mental images representing the reaction to the "news" are generated. These correspond to sub-CDs contains space-time surfaces as correlates of sub-selves created and the information contents of immediate conscious experiences is about this region of space-time and embedding space. They are like additional comment marks on the film giving information about what feelings the news from the geometric future stimulated.

2. In subsequent quantum jumps film moves downwards towards geometric past and markings defined in terms of space-time correlates for mental images are shifted backwards with the film and define the coding of information about previous conscious experience. In memory recall metabolic energy is fed to these subsystems and they wake up and regenerate the mental images about the remembered aspect sof the previous conscious experience. This would not be possible in positive energy ontology and if determinism in strict sense of the world would hold true.

3. Something must bring in the essential information that these experiences are memories rather than genuine sensory experiences (say). Something must distinguish between genuine experiences and memories about them. The space-time sheets representing self reference define cognitive representations. If the space-time sheets representing the correlates for self-referential mental images are p-adic, this distinction emerges naturally. That these space-time sheets are in the intersection of real and p-adic worlds is actually enough and also makes possible negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) carrying the conscious information. In TGD inspired quantum biology this property is indeed the defining characteristic of life.

4. There is quite concrete mechanism for the realization of memories in terms of braidings of magnetic flux tubes discussed in [K2].

Interesting questions relate to the role of p-adicity and the realization of the active aspects of consciousness. One can consider also quantum jumps in which the space-time surface inside CD does not suffer mere passive shift downwards but is affected also in the geometric past. The mechanism of intentional action, which could have been inspired by Libet's finding that neuronal activity seems to precede conscious decision, can be understood in terms of negative energy signals sent to the geometric past, where they generate neuronal activity replacing the space-time surface with a new one.

If p-adicity is involved, the possibility seems that comes to mind is that the space-time sheets representing the signal to the geometric past are first generated as p-adic space-time sheets representing intention and transformed in quantum jump to their real counterparts representing the "desire" for action in turn generating the action.

8.3.6   Can Selves Interact And Evolve?

Interesting questions relate to how dynamical selves are.

1. Is self doomed to live inside the same sub- WCW eternally as a lonely god? This question has been already answered: there are interactions between sub-CDs of given CD, and one can think of selves as quantum superposition of states in CDs with wave function having as its argument the tips of CD, or rather only the second one since T is assumed to be quantized.

2. Is there largest CD in the personal CD hierarchy of self in an absolute sense? Or is the largest CD present only in the sense that the contribution to the contents of consciousness coming from very large CDs is negligible? Long time scales T correspond to low frequencies and thermal noise might mask these contributions. Here however the hierarchy of Planck constants and generalization of the embedding space could come in rescue by allowing dark EEG photons to have energies above thermal energy.

3. Can selves evolve in the sense that the size of CD increases in quantum leaps so that the corresponding time scale $T = 2^k T_0$ of memory and planned action increases? Geometrically this kind of leap would mean that CD becomes a sub-CD of a larger CD - either at the level of conscious experience or in absolute sense. The leap can occur in two senses: as an increase of the largest p-adic time scale in the personal hierarchy of space-time sheets or as increase of the largest value of Planck constants in the personal dark matter hierarchy. At the level of individual organism this would mean emergence of new lower frequencies of generalized EEG and levels of personal dark matter hierarchy with larger value of Planck constant.

8.3.7   Questions And Answers

Answering to question is the best possible manner to develop ideas in more comprehensible form. In this respect the questions of Hamed at my blog have been especially useful. Many questions below are originally made by him and inspired the objections, many of them discussed also in previous discussions. The answers to these questions have changed during latest years as the views about self and the relation between experienced time and geometric time have developed. The following answers are the most recent ones.

Question: The minimalistic option suggests very strongly that our sensory perception can be identified as quantum measurement assignable to state function reductions for upper or lower boundaries of our personal CD. Our sensory perception does not however jump between future and past boundaries of our personal CD (containing sub-CDS in turn containing...)! Why?

Possible answer: The answer to this question comes from the realization that in ordinary quantum theory state function reductions leaving the reduced state invariant are possible. This must have counterpart in ZEO. In ZEO reduces zero energy states are superpositions of zero energy states associated with CDs with second boundary fixes inside light-cone boundary and the position of the second boundary of CD varying: one can speak about wave function in the moduli space of CDs. The temporal distance between the tips of CD and discrete lattice of the 3-D hyperbolic space defined by the Lorentz boosts leaving second tip invariant corresponds to the basic moduli.

The repeated state function reductions leave both the fixed boundary and parts of zero energy states associated with this boundary invariant. They however induce dispersion in the moduli space and the average temporal distance between the tips of CDs increases. This gives rise to the flow of psychological time and to the arrow of time. Self as counterpart of observer can be identified as a sequence of quantum jumps leaving the fixed boundary of CD invariant. Sensory perception gives information about varying boundary and the fixed boundary creates the experience about self as invariant not changed during quantum jumps.

The repeated reductions must do something for the state and the simplest assumption is that they induce localization in the moduli space of CDs. The time evolution operator inducing the superposition could be analogous to exponent of translation generator appearing in quantum field theories.

Self hierarchy corresponds to the hierarchy of CDs. For instance, we perceive from day to day the - say- positive energy part of a state assignable to this very big CD. Hence the world looks rather stable.

Question: This suggests that our sensory perception actually corresponds to sequences of state function reductions to the two fixed boundaries of CDs of superposition of CDs so that our sensory inputs would alternately be about upper and lower boundaries of personal CDs. Sleep-awake cycle could correspond to a flip flop in which self falls asleep at boundary and wakes up at opposite boundary. Doesn't this lead to problems with the arrow of time?

Possible answer: If we measure time relative to the fixed boundary then the geometric time defined as the average distance between tips in superposition of CDs would increase steadily and we get older also during sleep. Hence we would experience subjective time to increase. Larger CDs than our personal CD for which the arrow of time remains fixed in the time scale of life cycle would provide the objective measure of geometric time.

Question: What is the time scale assignable to my personal CD: the typical wake-up cycle: 24 hours? Or of the order of life span. Or perhaps shorter?
Possible answer: The durations of wake-up periods for self is determined by NMP: death means that NMP favors the next state function to take place at the opposite boundary. The first naïve guess is that the duration of the wake up period is of the same order of magnitude as the geometric time scale of our personal CD. In wake-up state we we would be performing state function reduction repeatedly to say "lower" boundary of our personal CD and sensory mental images as sub-CDs would be concentrated near opposite boundary. During sleep same would happen at lower boundary of CD and sensory mental images would be at opposite boundary (dreams, ...).

Question: Are dreams sensory perceptions with opposite arrow of time or is some sub-self in wake-up state and experiences same arrow of time as we during wake-up state? If the arrow is

different in dreams, is the "now" of dreams in past and "past" in the recent of wake-upe state

   Possible answer: Here I can suggest an answer based on my own subjective experiences and it would be cautious "yes".

   Question: Why we do remember practically nothing about sensory perceptions during sleep period? (Note that we forget actively dream experiences).

   Possible answer: That we do not have many memories about sleep and dream time existence and that these memories are unstable should relate to the change of the arrow of personal time as we wake up. Wake-up state should somehow rapidly destroy the ability to recall memories about dreams and sleep state. Wake-up memory recall means communications to geometric past, that is to the boundary of CD which remains fixed during wake-up state. In memory recall for dreams in wake-up state these communications should take place to geometric future. Memory recall of dreams would be seeing to future and much more difficult since the future is changing in each state function reduction so that dream memories are erased automatically during wake-up.

   Question: Does the return to childhood at old age relate with this time flip-flop of arrow of time in the scale of life span: do we re-incarnate in biologically death at opposite end of CD with scale of life span?

   Possible answer: Maybe this is the case. If this boundary corresponds to time scale of life cycle, the memories would be about childhood. Dreams are often located to the past and childhood.

8.4 What Does Arrow Of Time Mean At The Level Of Quantum States?

The previous discussion does not touch the question what arrow of time means at the level of quantum states. Therefore the notion of negative energy signal propagating backwards in geometric time crucial for TGD inspired quantum biology remains somewhat fuzzy. The recent progress in the understanding of the basic properties of zero energy states makes it possible to understand what arrow of geometric time and the notion of negative energy state and signals propagating to the direction of geometric past mean at the level of zero energy states. This understanding has surprisingly non-trivial philosophical implications.

8.4.1 Arrow Of Time As An Inherent Property Of Zero Energy States

The basic idea can be expressed in very conscise form. In positive energy ontology arrow of time characterizes dynamics. In zero energy ontology arrow of time characterizes quantum states.

1. The breaking of time reversal invariance means that zero energy states can be localized with respect to particle number and other quantum numbers only for future or past light-like boundary of CD but not both. M−matrix generalizing S−matrix provides the time-like entanglement coefficients expressing the state at the second boundary as quantum superposition of states with well-defined particle numbers and other quantum numbers. But only at the second end of CD since one cannot choose freely the states at both boundaries: if this were the case the counterpart of Schrödinger equation would be completely non-deterministic. This is what the breaking of time reversal symmetry means. It occurs spontaneously and assigns to the arrow of subjective time geometric arrow of time.

   This picture gives a precise meaning to the arrow of geometric time and therefore also for the otherwise fuzzy notion of negative energy signals propagating backwards in space-time playing key role in TGD based models of memory, metabolism, and intentional action [**?**]

2. Quantum jump begins with the unitary U-process between zero energy states generating a superposition of zero energy states. After that follows state function reduction cascade proceeding from the level of CD to the level of sub-CDs forming a fractal hierarchy. The reductions cannot take independently at both light-like boundaries of CD as is also clear from the fact that scattering state leads from a prepared state to a quantum superposition of prepared states.

The first guess is that the cascade takes place for the second boundary of CD only so that the arrow of geometric time would be same in all scales. This need not be the case always: the geometric arrow of time seems to change in some situations: phase conjugate laser light and spontaneous self-assembly of bio-molecules are good examples about this [K116, **?**]. In fact, one of the defining properties of living matter could be just the possibility that the arrow of geometric time is not same in all scales (size scales of CDs) so that memory, metabolism, and intentional action become possible. In any case, the second end remains a superposition of quantum states.

The lack of quantum measurements at the second end of space-times could explain why the conscious percepts are sharply localized in time at the second end of CD. This could also allow to understand memories as reductions occurring at the second, non-standard, end of sub-CDs in the geometric past.

3. The correspondence between the reduced state and the quantum superposition of states at the opposite boundary of CD allows an interpretation in terms of logical implication arrow with all statements present in the superposition implying the statement represented by the reduced state. Only implication arrow rather than equivalence is possible unless the M-matrix is diagonal meaning that there are no interactions. If it is possible to diagonalize M-matrix then in diagonal basis one has equivalences. It must be however emphasized that the physically preferred state basis fixed as in terms of eigenstates of density matrix does not allow diagonal M-matrix. Number theoretic conditions required that the density matrix corresponds to fixed algebraic extension of rationals can also make possible the diagonalization without leaving the extension and this condition might be highly relevant in the TGD inspired view about cognition relying on p-adic number fields and their algebraic extensions [K103].

4. In classical logic implication corresponds to the inclusion of subset by subset. In quantum case it corresponds to the inclusion for sub-space of state space. The inclusions of hyper-finite factors (WCW spinors define HFF of type II_1) realize the notion of finite measurement resolution, which would suggest that inclusion arrow has also interpretation in terms of finite measurement resolution.

All quantum states equivalent with a given state in the resolution used imply it. Finite measurement resolution would mean that there would infinite number of instances always in the quantum superposition representing the rule A → B. Ironically, both finite measurement resolution and dissipation implying the arrow of geometric time and usually regarded as something negative from the point of view of information processing would be absolutely essential element of logical thinking in this framework.

5. Conscious theorem proving would has as correlate to building of sequences zero energy states representing A → B, B → C, C → D with basic building bricks representing simple basic rules. These sequences would represent more complex truths.

8.4.2 Does State Function-State Preparation Sequence Correspond To Alternating Arrow Of Geometric Time?

The state function reduction at light-like boundary of CD implies de-localization at the opposite boundary. This inspires so fascinating questions.

1. Could the state function reduction process take place alternately at the two boundaries of CD so that a kind of flip-flop in which the arrow of geometric time changes back and forth would result, and have interpretation as an alternating sequence of state function reductions and state preparations in the framework of positive energy ontology?

2. State function reductions are needed for sensory percepts. Could the sleep-wake-up period correspond to this kind of process so that during what we call sleep the past boundary of our personal CD would be in wake-up state? Could dreams and memories represent sharing of mental images of this kind of consciousness? Could it be that in the time scale of entire life cycle death is accompanied by birth at the second boundary of personal CD? Could this quantum physics representation for endless sequence of deaths and rebirths? Could

the fact that old people often spend they last years in childhood have interpretation in this framework?

3. State preparation-reduction cycle might characterize only living matter whereas for inanimate matter second choice for the arrow of time would be dominant between two U-processes. TGD based reformulation [K114] of entropic gravity idea of Verlinde [B4] in terms of ZEO does not assume the absence of gravitons and the emergence of space-time. The formulation leads to the proposal that thermodynamical stability selects the arrow of the geometric time and that it could be different for matter and antimatter implying that matter and antimatter reside at different space-time sheets. This would explain the apparent absence of antimatter and also support the view that the arrow alternates only in living matter. Note that state preparation also corresponds to intentional action not possible in the world of standard thermodynamics with fixed arrow of thermodynamical time.

8.4.3 Or Does "Dispersion" At Second Boundary Of CD Cause Generate The Arrow Of Time?

"Fractality from your blog" posed an interesting question about possible asymmetry between boundaries of causal diamond CD. The answer to the question led to recall once again the incomplete understanding of details about how the arrow of time emerges in zero energy ontology (ZEO).

The basic vision is following.

1. CDs form a fractal scale hierarchy. Zero energy states possess a wave function in moduli degrees of freedom characterizing sizes of CDs as well telling what Lorentz boost leaving boundary invariant are allowed for them. Boosts form by number theoretic constraints a discrete subgroup of Lorentz group defining analogs of lattices generated by boosts instead of translations.

2. The arrow of subjective time maps to that of geometric time somehow. The origin of arrow comes from the fact that state function reductions can occur to either boundary of given CD and reduction creates time-asymmetric state since second boundary of CD is in a quantum superposition of different sizes and there is a superposition of many-particle states with different particles numbers and quantum number distributions.

3. Subjective existence corresponds to a sequence *of moments of consciousness*: state function reductions at opposite boundaries of CDs. State function reduction reduction localizes either boundary but the second boundary is in a quantum superposition of several locations and size scales for CD. This predicts that the arrow of time is not constant. In fact, there is considerable evidence for the variation of the arrow of time in living systems and Fantappie introduced long time ago the notion of syntropy to describe his view about the situation.

4. The first very naïve proposal was that state function reductions occur *alternately* to the two boundaries of CD. This assumption would be indeed natural if one considered single fixed CD rather than superposition CDs with different size and state function reduction localizing their either boundary: restriction to single CD was what I indeed did first.

5. This assumption leads to the question about why do we not observe this alternation of the arrow of time all the time in our personal experience. Some people actually claim to have actually experienced a temporary change of the arrow of time: I belong to them and I can tell that the experience is frightening. But why do we experience the arrow of time as stable in the standard state of consciousness?

One possible way to solve the problem - perhaps the simplest one - is that state function reduction to the same boundary of CD can occur many times repeatedly. This solution is so absolutely trivial that I could perhaps use this triviality to defend myself for not realizing it immediately!

I made this totally trivial observation only after I had realized that also in this process the wave function in the moduli space of CDs change in these reductions. Zeno effect in ordinary

measurement theory relies on the possibility of repeated state function reductions. In the ordinary quantum measurement theory repeated state function reductions do not affect the state in this kind of sequence but in ZEO the wave function in the moduli space labelling different CDs with the same boundary could change in each quantum jump. It would be natural that this sequence of quantum jumps give rise to the experience about flow of time? This option would allow the size scale of CD associated with human consciousness be rather short, say.1 seconds. It would allow to understand why we do not observe continual change of arrow of time.

Maybe living systems are working hardly to keep the personal arrow of time changed - living creatures try to prevent kettle from boiling by staring at it intensely. Maybe it would be extremely difficult to live against the collective arrow of time.

An objection against this picture as compared to the original one assuming alternate reductions to the opposite boundaries of CD is that is that one can understand state preparation as state function reduction to the opposite boundary. This interpetation makes sense almost as such also in the new picture if the average time period for which the reductions occur to a given boundary is shorter in elementary particles scales than in macroscopic scales characteristic for human consciousness. The approximate reversibility in elementary particle scales can be understood as summing up of the two arrows of time to no arrow at all.

8.4.4 Quantum Dynamics For The Moduli Of CDs And The Arrow Of Geometric Time

How the arrow of geometric time at the level of space-time and embedding space is induced from the arrow of subjective time identified in terms of sequence of quantum jumps forming a fractal hierarchy of quantum jumps within quantum jumps? This is one of the long lasting puzzles of TGD and TGD inspired theory of consciousness.

In zero energy ontology (ZEO) the geometry of CD (I often use the sloppy notation $CD \equiv CD \times CP_2$, where the latter CD is defined as the intersection of future and past directed light-cones) is that of double light-cone (double pyramid) and this must relate closely to the problem at hand. An easy manner to obtain absolute arrow of geometric time at least statistically is to assume that embedding space is $M^4 + \times CP_2$- that is product of future like cone with CP_2. The problem is however that of finding a convincing quantal mechanism generating the arrow of time, and also explaining why the geometric arrow of time sometimes changes from the standard one (say for phase conjugate laser beams).

The latest vision about the generation of the arrow of geometric time the level of embedding space and space-time discussed in previous section involves rather radical features but is consistent with the second law if generalized so that the geometric arrow of time at the level of embedding level alternates as state function reduction takes place alternately at opposite light-like boundaries of a fixed CD. If the partially non-deterministic dynamics at space-time level defines a correlate for the dissipative dynamics of quantum jumps, the arrow of geometric time level at space-time level is constant (space-time surface can assignable to the state function reductions can be seen as folded surface spanned between boundaries of CD) and entropy defines monotonically increasing time coordinate. This is rather radical revision of the standard view but makes definite predictions: in particular syntropic aspects of the physics of living matter [J97] could be assigned with the non-standard direction of geometric time at the space-time level.

This approach however still suffers from a defect. CDs are regarded as completely non-dynamical: once CD is created it remains the same from quantum jump to quantum jump and thus serves as a fixed arena of dynamics. This cannot be the case.

Some questions about CDs and their quantum dynamics

One can raise several questions relating to CDs.

1. CDs are assumed to form a fractal hierarchy of CDs within CDs. The size scale of CD has been argued to come as an integer multiple of CP_2 size scale on basis of number theoretic arguments. One can ask whether CDs can overlap and interact and what interaction means.

2. What is the proper interpretation of CD? Could CD correspond to a spotlight of consciousness directed to a particular region of space-time surface, so that space-time surface need not end

at the boundaries of CD as also generalized Feynman diagrammatics mildly suggests? Or do the space-time surfaces end at the boundaries of CD so that CD defines a sub-Universe?

3. Should one assign CD to every subsystem - even elementary particles and fermion serving as their building bricks? Can one identify CD as a carrier of topologically quantized classical fields associated with a particle?

As already noticed the picture based on static CDs is too simplistic. This inspires several questions relating to the possible dynamics of CDs.

1. In ZEO one can in principle imagine a creation of CD from and its disappearance to vacuum. It is still unclear whether the space-time sheets associated with CD restricted to the interior of CD or whether they can continue outside CD.

   For the first option appearance of CD would be a creation of sub-Universe contained by CD. CD could be assigned with any sub-system. For the latter option the appearance of CD would be a generation of spotlight of consciousness directing attention to a particular region of embedding space and thus to the portions of space-time surfaces inside it. Quantum super-position of space-time surfaces is actually in question and should be determined before the presence of CD by vacuum functional. How to describe possible creation and disappearance of CDs quantally, is not clear. For instance, what is the amplitude for the appearance of a new CD from vacuum in given quantum jump?

2. CDs have various moduli and one could assign to them quantum dynamics. The position of cm or either tip of CD in M^4 defines moduli as does also the point of CP_2 defining the origin of complex Eguchi-Hanson coordinates in which $U(2) \subset SU(3)$ acts linearly: these points are in general assumed to be different at the two ends of CD. If either tip of CD is fixed the Lorentz boost leaving the tip fixed, moves the other along constant proper time hyperboloid H^3 and the tessellations defined by the factor space H^3/Γ, where Γ is discrete subgroup of $SL(2, C)$, are favored for number theoretical reasons.

   Quantum classical correspondence inspires the question whether the boost is determined completely by the four-momentum assignable to the positive/negative energy part of zero energy states and corresponds to the four-velocity β defined by the ratio P/M of total four-momentum and mass for the CD in question. It seems that this kind of assumption can be justified only in semiclassical approximation.

3. In ZEO cm degrees of freedom of CD cannot carry Poincare charges. One can however assign the Poincare charges of the positive energy part of zero energy state to a wave function depending on the coordinate differences m_{12} defining the relative coordinate for the tips of the CD.

   The most general option is that the size scale of CD is continuous. This would allow to realize momentum eigen state as the analogs of plane waves as a function of the position m_{12} of the (say) upper tip of CD relative to the lower tip.

   The size scale of CD has been however assumed to be quantized. That is, the temporal distance T between the tips comes as an integer multiple of CP_2 time T_{CP_2}: this scale is about 10^4 Planck lengths so that this discretization has not practical consequences. Discretization is suggested both by the number theoretical vision, the finite measurement resolution, and by the general features of the U-matrix expressible in terms of S-matrix and hermitian square roots of density matrices forming orthonormal basis. U-matrix relates M-matrices associated with CDs with different size scales, which correspond to the Lorentz invariant temporal distance $T_n = nT_{CP_2}$ between the tips. The scaling up of the temporal distance would represent scaling of CD in the rest system defined by the fixed tip thus translating the second tip with integer multiple of T_{CP_2} from T_{n_1} to T_{n_2}.

   A further quantization would relate to the tessellations defined by the subgroups Γ. The counterparts of plane waves for the momentum eigenstates would be defined in a discretized version of Minkowski space obtained by dividing it to a sequence of discretized hyperboloids with proper time distance $a = nT_{CP_2}$ from the lower tip of CD.

4. There is evidence that one can assign a CDs with a fixed size scale to a given particle as secondary p-adic length scale: for electron this size scale would correspond to Mersenne prime M_{127} and frequency 10 Hz defining a fundamental biorhythm. This would give a deep connection between elementary particle physics and physics in macroscopic length scales. The integer multiples of the secondary p-adic length size scale would correspond to integer values of the effective Planck constant.

A natural interpretation of this scale would be as infrared cutoff so that the wave functions approximating momentum eigenstates and depending on the relative coordinate m_{12} would be restricted in the region between light-cone boundary and hyperboloid $a = M_{127}T_0$. Similar restriction would take place for all elementary particles. For particle with effective Planck constant $\hbar_{eff} = n\hbar_0$ the IR cutoff would be n-multiple of that defined by the secondary p-adic time scale.

Could CDs allow to understand the simultaneous wave-particle nature of quantum states?

One of the paradoxical features of quantum theory is that we observe always particles - even with well-defined momentum - to have rather well-defined spatial orbits. As if spatial localization would occur in quantum measurements always and would be a key element of perception and state function reduction process. This raises a heretic question: could it be possible that the localized particles in some sense have a well-defined momentum. In standard quantum theory this is definitely not possible. The assignment of CD with particle - or any physical system - however suggests that this paradoxical looking assignment is possible. Particle would be localized with respect to (say) the lower tip of CD and de-localized with respect to (say) the upper tip and localization of the lower tip would imply de-localization of the upper tip.

It is indeed natural to assume that either tip of CD - say lower one - is localized in M^4 in state function reduction. Unless one is willing to make additional assumptions, this implies not only the non-prepared character of the state at the upper tip, but also a de-localization of the upper tip itself by non-triviality of M-matrix: one has quantum superpositions of worlds characterized CDs with fixed lower tip. The localization at the lower tip would correspond to the fact that we experience the world as classical. Each zero energy state would be prepared at the either (say lower) end of CD so that its lower tip would have a fixed position in M^4. The unprepared upper tip could have a wave function in the space of all possible CDs with a fixed lower tip.

One could also assign the spinor harmonics of $M^4 \times CP_2$ to the relative coordinates m_{12} and their analogs in CP_2 degrees of freedom. The notion of CD would therefore make possible to realize simultaneously the paricle behavior in position space (localization of the lower tip of CD) and wave like nature of the state (superposition of momentum eigenstates for the upper tip relative to the lower tip).

This vision is only a heuristic guess. One should demonstrate that the average dynamical behavior for coordinate differences m_{12} corresponds to that for a free particle with given four-momentum for a given CD and fixed quantum numbers for the positive energy part of the state.

The arrow of geometric time at the level of embedding space and CDs

In the earlier argument the arrow of geometric time at embedding space level was argued to relate to the fact that zero energy states are prepared only at the either end of CD but not both. This is certainly part of the story but something more concrete would be needed. In any case, the experienced flow of time should relate to what happens CDs but in the proposed model CDs are not affected in the quantum jump. Th is would leave only the drifting of sub-CDs as a mechanism generating the arrow of geometric time at embedding space level. It is however difficult to concretize this option.

Could one understand the arrow of geometric time at embedding space level as an increase of the size of the size of CDs appearing in zero energy state? The moduli space of CDs with a fixed upper/lower tip is without discretization future/past light-cone. Therefore there is more room in the future than in past for a particular CD and the situation is like diffusion in future light-cone meaning that the temporal distance from the tip is bound to increase in statistical sense. This

means gradual scaling up of the size of the CD. A natural interpretation would be in terms of cosmological expansion.

There are two options to consider depending on whether the embedding space is $M^4 \times CP_2$ or $M_+^4 \times CP_2$. The latter option allows local Poincare symmetry and is consistent with standard Robertson-Walker cosmology so that it cannot be excluded. The first option leads to Russian doll cosmology containing cosmologies within cosmologies in ZEO and is aesthetically more pleasing.

1. Consider first the $M^4 \times CP_2$ option. At each tip of CD one has arrow of geometric time at the level of embedding space and these arrows are opposite. What does this mean? Do the tips correspond to separate conscious entities becoming conscious alternately in state function reductions? Or do they correspond to a single conscious entity with memories?

   Could sleep awake cycle correspond to a sequence of state function reductions at opposite ends of personal CD? It would seem that we are conscious (in the sense we understand consciousness) only after state function reduction. Could we be conscious and have sensory percepts about the other end of CD during sleep state but have no memories about this period so that we would be living double life without knowing it? Does the unprepared and de-localized part (with respect to m_{12}) of zero energy state contribute to the conscious experience accompanying state function reduction? Holography would suggest that this is not the case.

   If CD corresponds to a spotlight of consciousness, the time span of conscious experience could increase in both time directions for the latter option. The span of human collective consciousness has been increasing in both direction all the time: we are already becoming conscious what has probably happened immediately after the Big Bang. Could this evolution be completely universal and coded to the fundamental physics?

2. If the embedding space is assumed to be $M_+^4 \times CP_2$, one obtains only one arrow of time in the long run. The reason is that the lower tip of any CD sooner or later reaches $\delta M_+^4 \times CP_2$ and further expansion in this direction becomes impossible so that only the expansion of CD to the future direction becomes possible.

Summary

The proposed vision for the dynamics of the moduli of CDs is rather general and allows a concrete understanding of the arrow of geometric time at embedding space level and binds it directly to expansion of CDs as analog of cosmic expansion. The previous vision about how the arrow of geometric time could emerge at the level of space-time level remains essentially un-changed and allows the increase of syntropy [J97] to be understood as the increase of entropy but for a non-standard correspondence between the arrows of subjective time and the arrow of embedding space time.

Embedding space spinor harmonics characterizing the ground states of the representations of symplectic group of $\delta M_\pm^4 \times CP_2$ define the counterparts of single particle wave functions assignable to the relative coordinates of the second tip of CD with respect to the one fixed in state function reduction. The surprising outcome is the possibility to understand the paradoxical aspects of wave-particle duality in terms of bi-local character of CD: localization of given tip implies de-localization of the other tip.

8.4.5   The Arrow Of Geometric Time And The Arrow Of Logical Implication

If physics is mathematics in the sense that there is nothing behind quantum states regarded as purely mathematical objects, Boolean logic must have a direct manifestation in the structure of physical states. Physical states should represent quantal Boolean statements which get their meaning via quantum jumps. In TGD framework WCW ("world of classical worlds") spinor fields represent quantum states of the Universe and WCW spinors correspond to fermionic Fock states for second quantized induced spinor fields at space-time surface. Fock state basis has interpretation in terms of Boolean algebra. In positive energy ontology the problem is that fermion number as a

super-selection rule would allow very limited number of Boolean statements to be represented. In ZEO the situation changes.

The fermionic parts of positive and negative energy parts can be seen as quantum superpositions of Boolean statements with fermion number in given mode (equal to 0 or 1) representing yes/no or true/false. Also various spin like quantum numbers associated with oscillator operators have same interpretation. Zero energy state could be seen as quantum superposition of pairs of elements of Boolean algebras associated with positive and negative energy parts of the zero energy state.

The first - and incorrect - interpretation is that zero energy state represents a quantum superposition of equivalent statements $a \leftrightarrow b$ and thus abstraction $A \leftrightarrow B$ involving several instances of A and B. The breaking of time reversal invariance allowing localization to definite fermionic quantum numbers at single end of CD only however implies that quantum states can only represent abstraction of logical implication to $A \rightarrow B$ rather than equivalence. p-Adic physics for various primes pc [?]ould represent correlates for cognition and intentionality.

8.4.6 The Roles Of Sensory Perception And Motor Action In TGD Framework

The attempts to define consciousness rely on two basic approaches. The first approach emphasizes direct sensory awareness and formation of cognitive representations from it (phenomenal consciousness and reflective consciousness). Second approach emphasizes volition, motor plans, and motor actions.

The analogs of sensory representations and motor actions emerge at the fundamental level in quantum TGD without mentioning anything about brain. In ZEO state function reduction is replaced with a cascade of state function reductions corresponding to various scales for CDs forming a fractal hierarchy. State function reduction can take place to either of the opposite boundaries of CD in a given length scale. The reduction at given boundary of CD would always force de-localization of the opposite boundary of CD creating quantum superposition of CDs with various sizes. Also new sub-CDs (correlates for sensory mental images) within the resulting bigger CDs are naturally generated. This would explain the arrow of geometric time at embedding space level but the arrows are opposite at the opposite boundaries of CD.

The reduction to opposite boundaries of CD gives rise to zero energy states related by time reversal at the level of embedding space. If "my" conscious experience corresponds to reductions to either "upper" or "lower" boundary of CD of wake-up cycle defining me, I will experience that the arrow of geometric at the level of embedding space arrow is constant and would be basically due to the scaling up of the average size of "personal" CD. "Upper" "lower" can be fixed by the arrow of time assignable to large enough CD defining environment.

Standard quantum measurement theory assumes that a state function reduction followed immediately by a new one does not affect the reduced state [this gives rise to so called quantum Zeno effect: quantum monitoring of unstable particle prevents its decay (watched kettle does not boil)]. That repeated state function reduction at given boundary of CD does not affect the part of zero energy state at that boundary resulting in the reduction for given CD would generalize this hypothesis. Note that the the parts of zero energy states at the opposite boundary are affected: in particular, the size scale of CD increases.

If this assumption hold true, the subsequent reductions at the same boundary of CD would effectively correspond to single reduction at the passive boundary of CD, and one would effectively have an alternating sequence of cascades of state function reductions beginning from opposite boundaries of CDs. Note however that there a fractal cascade of reductions beginning from sub-CDs the CD is assumed changing the state in smaller scales.

In TGD framework the counterpart of quantum Zeno effect would be achieved by closing an unstable particle inside small enough CD so that the unitary time evolution restricted to CD would not affect the particle appreciably and state function reductions at boundaries of this CD very rarely would give rise to a final state of decay. Watchdog in this case would be the self to which this CD corresponds to.

Motor action as time reversal of sensory perception

In TGD framework motor action could be seen as a time reversal of sensory perception so that sensory-motor pairing could be seen as fundamental element of all conscious existence. This symmetry is very profound and strong prediction and forces to modify dramatically the beliefs about the arrow of geometric time and its relation to the subjective arrow of time. The variation of the arrow of time would be basic feature of living matter.

Just to fix conventions let us fix arrow of time as the arrow of the embedding space time for a very large CD, maybe of cosmic size scale, so that there is unique time direction corresponding to future.

1. All scales for CDs are possible. For sub-CDs of given CD the experiences associated with sub-CD define mental images of CD and the experience can be assigned with either boundary of sub-CD. Let us tentatively agree that for a given CD "lower" and "upper" boundaries are in future and past when seen from the center point of CD (past and future could be permuted in the convention).

   This choice would conform with the interpretation that motor "me" I_m makes a fuzzy prediction of future as superposition of space-time sheets extending from the lower boundary of CD and sensory "me" I_s generates memories represented by superposition of space-time sheets extending downwards from the upper boundary of CD. I do not quite have the courage to completely exclude the second option in which the roles of motor me and sensory me are changed.

2. With this assumption one can assign to a sub-CD near upper *resp.* lower boundary of sub-CD sensory mental images *resp.* their time reversals. In the interior they would represent memories *resp.* predictions. The larger CD would experience these sub-selves as mental images and interpret them in terms of ordinary sensory percepts *resp.* volitions, decisions, and plans. The primary sensory experience, phenomenal experience, involves generation of negentropic entanglement as the sensory mental image combines as a tensor factor with the existing sequence of mental images forming a sensory representation defining memory. The reading of this sequence of mental images using interaction free quantum measurement gives rise to a conscious memory about the mental image sequence.

3. A prediction, which looks rather strange at first glance, follows. "My" CD would be seat for two selves having their own phenomenal experiences seated at the opposite boundaries of my CD. They would be sensory me I_s assignable to sensory perception and motor me I_m assignable to motor action as time reversed sensory perception and assignable to the opposite boundaries of CD when they are localized in state function reduction. The time reversed sensory percept is interpreted in terms of predictions, volitions, and plans at least by larger CD having the CD as sub-CD. Sensory and motor "mes" would appear in all scales in the hierarchy of sub-CDs.

4. Since the scale of CDs increases quantum jump by quantum jump on the average and new sub-CDs emerge, the size scale of the largest CD in hierarchy increases and the perceptual fields of the two "me" s associated with it shift towards geometric future *resp.* past of the embedding space. The sub-CDs near the boundaries of largest CD give rise to sensory percepts of the two "me" s involved with the largest CD in the hierarchy. Those in the interior define memories. The flow of time would correspond to the gradual shifting of the upper/lower boundary of largest CD to future/past and generation of sensory mental images (sub-CDs) near the boundary. Same would of course occur for the smaller CDs. The time interval about which memories are about and also the time scale for predictions of future increases since the size of the personal CD is gradually scaled up.

Quantitative considerations

One can make also quantitative questions.

1. What is the average increase of the temporal distance between the tips of CD in a pair of state function reductions to opposite boundaries defining the chronon of subjective experience? The duration of this chronon can depend on the level of the self hierarchy.

For human sensory consciousness this chronon would naturally correspond to the time scale of about.1 seconds having interpretation as a duration of sensory mental image. Each pair of state function reductions would generate a layer of the sensory mental images at the lower and upper boundary of "our" CD.

This leaves open the size scale of "our" CD and lifetime would represent only the size scale for the increase of "our" CD during life cycle. This would mean that the durations of consciousness for the two "me" s assignable to "our" CD would be measured using.1 second as a natural unit.

2. What can one say about the size scales of CDs themselves? Since the memories are about the time interval, which is roughly the duration of life cycle at most, the first guess is that the size of personal CD is of the order of duration of life cycle. By the previous argument however only the increase of the distance between the tips of "personal" CD naturally corresponds to the duration of life cycle so that the size scale of personal CD could be much larger. Note that the conscious experiences of I_s and I_m assignable to sensory percepts and motor actions should correspond to sub-CD: s with size scale not much larger than.1 seconds. This is consistent with the interpretation of sensory percepts of I_m as plans, decisions, predictions, and volitions. The sub-CDs with time scale of say years are however possible and would correspond to memories and plans in time scales of years.

3. One can imagine also a fractal hierarchy for the increments ΔT_i of the temporal distance T_i between tips of CDs assignable to single pair of quantum jumps to opposite boundaries of CD in given length scale. $\Delta T = .1$ seconds would not be the only possible duration of chronon. This time scale is however very special since it corresponds to the Mersenne prime M_{127} assignable to electron which corresponds to largest Mersenne prime which does not correspond to completely super-astrophysical p-adic length scale. The smaller Mersenne primes - such as M_{107} and M_{89} could correspond to shorter time scales perhaps assignable to nerve pulse in the case of lightest quarks. All primes characterizing elementary particles could define chronons of this kind serving as clocks. The hierarchy of chronons could mean sensory percepts and motor actions have a fractal hierarchy of resolutions identifiable as kind of abstraction hierarchy.

The clocks defined by these chronons of duration T_i should be synchronized in the sense that there would $N_{ij} = \Delta T_i/\Delta T_j$ quantum jumps with time increment T_j per single quantum jump with time increment T_i.

Could various periodic phenomena such as diurnal period of 24 hours defining sleep-awake cycle, annual cycle, and various bio-rhythms such as EEG rhythms, define also chronons? Could cyclicity which seems to appear at the level of sensory and cognitive mental images relate to this kind of chronons: for instance, after images are a good example about mental images having analog of wake-up-sleep cycle.

Questions

There are also questions about the relation to the functioning of brain.

1. How sleep-awake cycle relates to this picture? The above argument suggest that.1 second time scale rather than 24 hour time scale defines the increase of CD scale assignable to single pair of state function reduction assignable to "me". Therefore the period assignable to single moment of human sensory conscious of the two "me" s would be of order.1 seconds.

This strongly suggests that due to the lack of sensory input and absence of motor actions we are conscious during sleep but do not have memories from this period. Dreams generated by virtual sensory input to retina would produce memories during sleep state. Revonsuo indeed mentions that according to the reports of subject persons after awakenings sleeping period seems to involve either dreams or sleep mentation. Sleep mentation is very simple during nREM sleep: for instance, repetition of some word of internal speech. Sleep mentation would involve motor actions generating internal speech and in some cases also genuine speech. Also genuine motor actions such as sleep walking are possible.

2. Could the sensory-motor dichotomy have some relation to the right-left dichotomy at the level of brain? Right and left brain hemisphere could naturally correspond to parallel CDs of same size scale. Could right and left brain (or parts of them) organize their wake-up periods as in shift work: if left brain hemisphere is awake right hemisphere sleeps (sensorily perceives the opposite end of its CD) and vice versa, an alternating dominance by either hemisphere results, and one could understand sensory rivalry. The time scale of CDs possibly involved would be much shorter than that of sleep-awake cycle in this case. Interestingly, the duration of hemisphere dominance period in some disorders like schizophrenia is anomalously long.

The CD containing both these CDs - "entire brain CD" - would be also present. The view of "brain CD" about world represented by entangled right and left negentropic mental images would be analogous to initial and final state and thus contain much more information than given by either right or left hemisphere. In the case of visual mental images this would give rise to stereo vision.

Could this shift work between parts of right and left hemisphere be realized in several time scales of CDs? Even in the scale corresponding to sleep-awake rhythm? It is known that in case of some birds and mammals, which must be motorially and sensorily active all the time, the brain hemispheres have this kind of shift work in long time scale.

8.4.7 Trying To Understand The Relationship Between Subjective And Geometric Time

I am trying to improve my understanding about the relationship between subjective and geometric time. Subjective time corresponds to a sequence of quantum jumps at given level of hierarchy of selves having as correlates causal diamonds (CDs). Geometric time is fourth space-time coordinate and has real and p-adic variants. This raises several questions.

1. How the subjective times at various levels of hierarchy relate to each other? Should/could one somehow map sequences of quantum jumps at various levels to real or p-adic time values in order to compare them - as quantum classical correspondence indeed suggests?

2. Subjective existence corresponds to a sequence *of moments of consciousness*: state function reductions at opposite boundaries of CDs. State function reduction reduction localizes either boundary but the second boundary is in a quantum superposition of several locations and size scales for CD.

   There are two obvious problems related to the time experience.

   (a) If state function reductions occur alternately- one at time- then it is very difficult to understand why we experience same arrow of time continually: why not continual flip-flop at the level of perceptions. Some people claim to have actually experienced a temporary change of the arrow of time: I belong to them and I can tell that the experience is frightening. Why we experience the arrow of time as constant?

   One possible way to solve this problem - perhaps the simplest one - is that state function reduction to the same boundary of CD can occur many times repeatedly. This solution is so absolutely trivial that I could perhaps use this triviality to defend myself for not realizing it immediately! I made this totally trivial observation only after only after I had realized that also in this process the wave function in the moduli space of CDs could change in these reductions. Zeno effect in ordinary measurement theory relies on the possibility of repeated state function reductions. In the ordinary quantum measurement theory repeated state function reductions don't affect the state in this kind of sequence but in ZEO the wave function in the moduli space labelling different CDs with the same boundary could change in each quantum jump. It would be natural that this sequence of quantum jumps give rise to the experience about flow of time? This option would allow the size scale of CD associated with human consciousness be rather short, say.1 seconds. It would also allow to understand why we do not observe continual change of arrow of time. Maybe living systems are working hardly to keep the personal arrow of time changed and that it would be extremely difficult to live against the collective arrow of time.

(b) We experience time as a continuous flow rather than sequence of discrete jumps. Is this a problem or not? One could argue that it is not possible to be conscious about being unconscious so that gaps would not be experienced. But is this so simple? We are indeed able to experience the gap in sensory consciousness caused by sleeping over night (this does not mean we have been unconscious: we just do not remember).

3. Subjective time is certainly not metricizable whereas geometric time is and defines a continuum. But are moments of consciousness well-ordered as the values of real variant of geometric time are? This relates closely to the relationship of subjective time to geometric time. Certainly subjective time does not allow any continuous measure in real sense as geometric time does. One can however map moments of consciousness to integers.

(a) It would seem natural to be able to say about two moments of consciousness - call them A and B, - whether A is before B or vice versa. Moments of consciousness would be well-ordered and could be mapped to *real* integers. But is this the case always? There is experimental evidence for the fact that consciously experience time ordering does not always correspond to the physical one. This was observed already by Libet (see `http://tinyurl.com/yathqkzv`) for my first attempt to understand these findings [K116]).

(b) What about p-adic integers as labels for moments of consciousness as suggested by the vision about p-adic space-time sheets as correlates for cognition. Given p-adic integers m and n, one can only say whether the p-adic norm of m is larger than, smaller than, or equal to that of n. One can say that p-adic integers are weakly ordered.

p-Adic integers form a continuum in p-adic topology. Could one map the infinite sequence of quantum jumps already occurred to p-adic integers and in this manner to p-adic continuum instead of real one? Could the p-adic cognitive representations allow to achieve this? If so, the experience about conscious flow of time could be due to the p-adic topology for cognitive representation for the sequence of quantum jumps!

Could p-adic integers label moments of consciousness and explain why we experience conscious flow of time?

Next arguments give a more precise formulation for the idea that p-adic integers might label the sequence of quantum jumps at the level of conscious experience, or rather reflective consciousness involving various representations realized as "Akashic records": NMP and ZEO considerably modify the standard quantum measurement theory).

1. Most p-adic integers expressible as $n = \sum_k n_k p^k$ are infinite in real sense and in p-adic topology they form a continuum. Suppose that the infinite sequence of moments of consciousness that have already taken place can be labelled by p-adic integers and look what might be the outcome.

2. Sounds very strange in ears of real analyst but is true: the integers n and $n + kp^N$, for N large are very near to each other p-adically. In real sense they are very far. This allows to fill the gaps between say integers $n = 1$ and 2 by p-adic integers which are very large in real sense.

3. The p-adic correlate of the sequence of discrete quantum jumps/moments of consciousness would define p-adic continuum which in turn can be mapped to real continuum by canonical identification.

This map sequence of moments of consciousness to p-adic continuum would be nice but maybe tricky for any-one accustomed to think in terms of real topology!

This raises two questions.

1. p-Adic integers are not well-ordered. Could one induced the well-ordering of real time to p-adic context by mapping p-adic time axis to real one in a continuous manner and in this manner achieving mapping of moments of consciousness to real time axis?

2. Could canonical identification $\sum_k n_k p^k \to \sum_k n_k p^{-k}$ map (or its appropriate modification) allow to map p-adic integers to real numbers and in this manner induce real well ordering to the p-adic side. The problem is that real number with finite pinary expansion has second infinite expansion (1=.9999... is example using decimal expansion) so that two p-adic time values correspond to any real time value with finite pinary digits. Should one restrict the consideration to integers with finite number of pinary digits (finite measurement resolution) and select either branch? Could the two branches correspond to real time coordinates assignable to the opposite boundaries of CD defining two conscious selves in this scale?

What happens when I type letters in wrong order?

One can speak about sensory and cognitive orderings of events corresponding to reals and p-adics (for various values prime p or course). The cognitive ordering of events would not be well-ordering if cognition is p-adic. Is there any empirical support for this besides Libet's mysterious looking findings?

Maybe. For instance, as I am typing text I experience that I am typing the letters of the word in the correct order but now and then it happens that the order is changed, even the order of syllables and sometimes even that of short words can change. It is probably easy to cook up a very mundane explanation in terms of neuroscience or even electric circuits from keyboard to computer memory, or computer itself. One can however also ask whether this could reflect the fact that p-adic ordering of the intentions to type letter is not well-ordering and does not always correspond to the real number based order for what happened ?

In TGD Universe writing process involves a sequence of transformations of p-adically realized intention to type a letter to a real action (doing it). At space-time level it is therefore a map from p-adic realm to real realm by a variant of canonical identification crucial in the definition of p-adic manifold concept (see `http://tinyurl.com/ydxw3zvm`) assigning to real preferred extremal of Kähler action a p-adic preferred extremal in finite measurement resolution [K122]).

The variant of canonical identification in question defines chart maps from real to p-adic realm and vice versa, and is defined in such a manner that discrete and rationals in a finite subset of rationals are mapped to themselves and defining intersection of real and p-adic realms.

1. In the case of p-adic integers this subset is characterized by a cutoff telling the power of p below which p-adic integers and real integers correspond to each other as such. For the corresponding moments of consciousness (now intentions to type letter) one has same ordering in both realms. For integers containing higher powers of p a variant of canonical identification mapping p-adics to reals continuously is applied. In this case ordering anomalies can appear.

2. Another pinary cutoff comes from physics: real preferred extremals are mapped to p-adic preferred extremals and vice versa: without the cutoff the p-adic image of real extremal would be continuous but non-differentiable so that field equations would not make sense. The cutoff tells the largest power of p up to which the variant of canonical identification is performed for p-adic integers. Also now ordering anomalies appear if one regards p-adic integers as ordinary integers.

3. For the remaining integers the map is obtained by completing the discrete set of points to a preferred extremal of Kähler action on both real and p-adic sides so that physics enters into the game. This assignment need not be unique and the most natural manner to handle the non-uniqueness is to form quantum superposition of all allowed completions with same amplitude: this effective gauge invariance would be very natural from the point of view of finite resolution and conforms with the vision about inclusions of hyper-finite factors (see `http://tinyurl.com/yaye9z3w`) as a representation for finite measurement resolution giving rise to the analog of dynamical gauge symmetry [K120].

Could the strange inconsistencies between cognitive (sequences of intentions) and sensory time orderings (sequence of typed letters) reflect the fact that the ordering of p-adic integers as real integers is not the same as the ordering of their real images under canonical identification? Could it be possible to test this and perhaps deduce the prime p characterizing p-adic topology of cognitive representation in question?

8.5   In What Sense The Flow Of Time Could Correspond To The Increase Of The Effective Planck Constant?

I like answering questions. It gives a lot of meaning to the life of a theoretician who is not allowed to enjoy the pleasures of academic existence. Career builder would of course argue that writing again and again similar answers is a waste of time: I should be building social networks to important people instead. This activity however allows to make important observations and little discoveries. This time I answered to the questions relating to non-determinism of Kähler action. How this non-determinism relates to quantum non-determinism? How the non-determinism in elementary particle scales relates to that in biology?

The unexpected fruit was a little might-be discovery: the mechanism generating the arrow of geometric time in zero energy ontology might rely in crucial manner to a sequence of phase transitions increasing the value of Planck constant $h_{eff}/h = n$ and hence the size of the causal diamond (CD) characterized by quantum average temporal distance. Since the second boundary of CD is fixed, the second one moves to future in average sense: hence the flow of experienced time and its arrow. Conscious entities become more intelligent as they age! It became also clear that large h_{eff}/h characterizes many-particle system rather than single particle. This leads to view in which intelligent consciousness involving the experienced about the flow of time emerges as the complexity of the systems measured by the number of fundamental particles increases.

The guess was wrong as such. It seems that the time evolution by repeated state function reductions leaving the state at passive boundary of CD invariant should correspond to localizations in the moduli space for causal diamonds with second boundary fixed. It cannot affect the value of h_{eff} since this would scale up the size of CD and affect also the state at the passive boundary by scaling up the sizes of 3-surfaces.

Rather, this time evolution should be analogous to a sequences of time shifts: the time would be the integer valued proper time distance between the tips of CD and the operator acting on zero energy state would be exponent of energy. Each shift would be followed by a localization in the modular degrees of freedom of CD but no state function reduction would occur since this would change the arrow of time and opposite boundary of CD would become the passive boundary.

The scaling of h_{eff} by integer would define the scaling of CD in the first state function reduction to the opposite boundary. This reduction would be preceded by a unitary time evolution defined by exponent of conformal scaling generator. Of course, this scaling could be also trivial! If one considers only these discrete moments of time one obtains a time evolution consisting of discrete time and it is kind if jumping forth and back with increasing amplitude. The repeated birth and death of mental image could corresponds to this kind of evolution at the level of conscious experience.

8.5.1   Background

Quantum classical correspondence suggests that the non-determinism of Kähler action could be correlated for quantum non-determinism. An alternative but not exclusive interpretation is as a correlate for quantum criticality.

The non-determinism of Kähler action and quantum non-determinism

The first question was about the relationship between non-determinism of preferred extremals and quantum non-determinism. As a matter of fact, I like to use the phrase "partial failure of determinism for Kähler action" rather than "non-determinism of Kähler action".

A possible interpretation could be as a correlate for quantum non-determinism. Second interpretation would be in terms of quantum criticality implying non-determinism. I do not know whether the interpretations are actually equivalent.

I certainly do not believe that one could get rid of quantum non-determinism and there is no need for it. The generalisation of quantum-classical correspondence is however natural in ZEO, where basic objects are 4-D surfaces- classical time evolutions serving as space-time correlates for quantal evolutions.

The origin of the failure of classical determinism is following.

1. Kähler action has a huge vacuum degeneracy. For instance, for space-time surfaces, which are maps from M^4 to at most 2-D Lagrangian manifold of CP_2 having by definition vanishing induced Kähler form (configuration space and momentum space are Lagrangian manifolds in the context of classical mechanics) induced Kähler form of course vanishes. These vacuum extremals define an analog of gauge degeneracy of Maxwell action for vacuum extremals. For non-vacuum externals it is expected to be lifted at least partially. Hence 4-dimensional spin glass degeneracy is more appropriate analogy. One could say that classical gravitation breaks the analog of gauge invariance for non-vacuum extremals.

2. For CP_2 type vacuum externals one has also non-determinism, which corresponds directly to Virasoro conditions expressing the light-likeness of 1-D M^4 projection of the CP_2 type vacuum extremal. Now induced Kähler form does not vanish.

3. Zero energy ontology (ZEO) and causal diamond (CD) are essential notions concerning the interpretation but leave these notions as an exercise for the reader. The ends of the vacuum extremal at light-like boundaries of CD are connected by infinite number of vacuum extremals.

   One expects that some of the vacuum degeneracy is present also non-vacuum externals. Part of this degeneracy must be analogous to gauge degeneracy since by strong form of general coordinate invariance implying strong form of holography, only the partonic 2-surfaces and their 4-D tangent space data fix the physics since WCW metric depends only on this data. Hence the interiors of 3-surfaces carry very little information about quantum states.

Identification of gauge degeneracy as hierarchy of broken conformal gauge invariances

The conjecture is that conformal symmetries acting as partially broken gauge symmetries realize this vision. TGD allows several kinds of conformal symmetries, and a huge generalisation of string model conformal symmetries (including Kac-Moody) [K26] but I will not go to this here. Suffice it to say that the generalization of conformal symmetries means replacement of AdS/CFT correspondence with a correspondence which looks intuitively much more realistic [K101], [L25].

Classical conformal charges would vanish for sub-algebra for which the conformal weights are multiples of some integer n, $n = 1, 2, \ldots$. These conditions would give the long-sought-for precise content to the notion of preferred extremal. These conditions would be the classical counterparts of corresponding quantum conditions and define a Bohr orbitology. This hierarchy would correspond to the hierarchy of Planck constants $h_{eff} = n \times h$ and to the hierarchy of dark matters [K36]. There would be infinite number of hierarchies $(1, n_1, n_2, \ldots n_i, \ldots)$ such that n_i would divide n_{i+1}. They would correspond to the hierarchies of inclusions of hyper-finite factors of type II_1 (HFFs) [K120]. Included algebra defines measurement resolution, which would thus realized as generalized conformal gauge symmetries. Evolution would correspond to a sequence of symmetry breakings: this is not a new idea but emerges naturally if n serves as a quantum "IQ".

The proposal is that that there is a finite number $n = h_{eff}/h$ of conformal equivalence classes of four-surfaces with fixed 3-D ends at the opposite boundaries of CD so that the non-determinism with gauge fixing would be finite and would correspond to the hierarchy of Planck constants and hierarchy of conformal symmetry breaking defined by the hierarchy of sub-algebras of various conformal algebras with weights comings as integer multiples of integer $n = 1, 2, , \ldots$. These n surfaces would be analogous to Gribov copies for gauge conditions in non-Abelian gauge theories.

8.5.2 The Non-Determinisms Of Particle Physics And Biology

There was also a question about the non-determinism of partcle physics contra that of biology, where it manifests itself as partially free will.

NMP

Before continuing it is good make clear that a new principle is involved: Negentropy Maximization Principle (NMP) [K56]. Also a new kind of entanglement entropy based p-adic norm is involved. This entanglement entropy is negative unlike ordinary entanglement entropy and characterizes

two-particle system rather than single particle system. By consistency with quantum measurement theory it corresponds to identical entanglement probabilities $p_i = 1/n$.

Negentropic entanglement is assumed to be associated with pairs of n-sheeted coverings (at least these) defined by the space-time surfaces in n conformal equivalence classes associated with $n = h_{eff}/h$ and connecting same 3-surfaces at the ends of space-time surface. Two systems of this kind can entangle negentropically. The entanglement matrix associated with quantum computation proportional to a unitary matrix gives rise to negentropic entanglement. Also n-partite negentropic entanglement makes sense. Note that for hyper-finite factors of type II$_1$ the entanglement matrix is strictly unitary.

What could be common for particle physics and biology?

Basically the non-determinism of particle physics and of biology could be essentially the same thing but for living matter whose behave is dictated by dark matter the value of $h_{eff}/h = n$ would be large and make possible macroscopic quantum coherence in spatio-temporal scales, which are longer by factor n. Note that n could characterize macroscopic quantum phase rather than single particle system: this distinction is important as will be found.

The hierarchy of CDs brings additional spatio-temporal scale identified as secondary p-adic scale characterising the minimal size of CD. This size scales like $h_{eff}/h = n$ and one can think of a superposition of CDs with different values of n and that the average value of n measuring the age of self increases during the sequence of quantum jumps. Since n is kind of IQ, NMP says that conscious entities should become wiser as they get older: maybe this is too optimistic hypothesis in the case of human kind but maybe electrons are different! I swear that this interpretation is not due to the fact that I have passed the magic threshold of 60 years when one begins to feel that the ageing means growing wisdom. I must confess that the interpretation of experience time flow in terms of increasing h_{eff}/h charactering CD scaling has not come into my mind earlier. One could even consider the possibility that there is no superposition - just a sequence of h_{eff}/h increasing (in average sense) phase transitions, kind of spiritual growth even at the level of elementary particles - or rather, the macroscopic quantum phases.

For instance, for electron characterised by Mersenne prime $M_{127} = 2^{127} - 1$ the minimal CD time scale is .1 seconds (note that it defines a fundamental biorhythm of 10 Hz) and thus macrotemporal. Corresponding size scale is of the order of Earth circumference. This size scale could characterize quite generally the magnetic body of the elementary particle or the magnetic body at which macroscopic quantum phase of particles resides. In both cases there would be a direct connection between elementary particle physics and macroscopic physics becoming manifest in living matter via alpha rhythm for instance.

What distinguishes between particle physics and biology?

There are essential differences between elementary particle physics and biology. The first differences comes from quantum measurement theory in ZEO.

1. The repeated state function reduction does nothing for the state in standard ontology. In TGD the state is invariant only at the second boundary at which the reduction occurs. For second boundary of CD the average value if n increases. This gives rise to the experienced flow of geometric time and the arrow of time. Self exists as long as reductions take place on same boundary of CD and dies as the first reduction to opposite boundary is forced by NMP.

2. In particle physics context one expects that the duration of self identified as a sequence of state function reductions at the same boundary of CD is much shorter than in living matter. Otherwise one would have too strong breaking of reversibility in elementary particle time scales. One could also argue that for visible matter the value of h_{eff} should not change in the first state function reduction to the opposite boundary.

   Here one must be very cautious. The flux tubes connecting the wormhole contacts serving as building bricks of the elementary particle could have very large h_{eff} having the p-adic prime characterizing the elementary particle as a factor and that the dynamics of elementary particles corresponds to the ordinary value of Planck constant as long as this flux tube is not involved. If the flux tubes mediate gravitational interaction scaling the size of the

gravitational bound state from the naïvely expected Planck scale to Compton length, the effects on other particle interactions would be negligible as gravitational interactions.

Objections usually help to make the formulations more precise. Now the objection is that the increase of average h_{eff}/h so that particles darken gradually, should have been observed long time ago since reaction rates are independent of Planck constant only the lowest order in h_{eff} that is in classical approximation. The attempt to circumvent this objection leads to two crucial questions?

1. Does h_{eff} characterize elementary particle (or fundamental fermion) or a magnetic/field body of physical system which could be also many-particle system.

   If $h_{eff}/h = n$ corresponds to n-sheeted covering which becomes singular at the ends of space-time surface so that sheets co-incide at partonic 2-surfaces representing particles, it seems that large h_{eff} is a phenomenon assignable to the field/magnetic body inside CD rather than particle identified as partonic 2-surface or 3-surface at the end of CD. If so large h_{eff} effects would relate to the dynamics associated with the magnetic/field bodies carrying dark matter.

2. Is darkness single particle phenomenon or many-particle phenomenon? For the latter option elementary particle physics would not be any challenge so that it looks the reasonable option. Note that negentropic entanglement requires at least one pair of (say) electrons and suggests macroscopic quantum phase - say high-T_c super-conductivity or super-fluidity.

   The idea about evolution of many-electron systems at dark magnetic body generating increasing value of h_{eff} makes sense, and would conform with the observation that electrons secondary p-adic time scale defines fundamental bio-rhythm. Dark magnetic bodies carrying dark particles are indeed in key role TGD inspired quantum biology. Bose-Einstein condensates and spontaneously magnetized dark phases at magnetic bodies would conform with the idea that dark matter is many-particle phenomenon.

   Large h_{eff} would not be seen in elementary particle physics. This does not seem to support the idea that sparticles in TGD SUSY might have same p-adic mass scale as particles but be more stable in dark phase (this would be due to the scaling up of the size of CD) [K95]. Note however that in TGD already elementary particles are many-fermion systems so that it might be possible to circumvent this objection.

3. The original formulation for darkness was at single particle level so that h_{eff} characterizes elementary particles rather than many-particle systems. In elementary particle reactions the particles in the same vertex would always have the same value of h_{eff}/h. It was assumed that h_{eff} can change only in 2-vertex analogous to mass insertion vertex.

   The previous arguments suggest that darkness makes sense only for many-particle systems so that mass insertion vertex becomes phase transition. These phase transitions would occur routinely in living matter but as phase transitions involving large number of particles. For instance, bio-photons would result from dark photons in this manner. This picture seems to make sense at least at the level of many-particle systems but not necessary for Feynman graphs.

   This many-particle aspect would explain at very general level why the search for dark particles has been fruitless.

Could one regard elementary particle as a conscious entity?

The previous considerations support the view that it is macroscopic quantum phases of particles at magnetic flux tubes which can be seen as conscious and intelligent evolving entities experience the flow of time. In the case of single elementary particle previous arguments would suggest that only single state function reduction occurs at given boundary of CD so that the lifetime of elementary particle self would have zero duration! This in accordance with the absence of the arrow of time at elementary particle level. Strictly speaking this does not exclude consciousness but excludes intelligence and experience of time flow.

Could already systems with small particle number, be conscious entities and develop - not necessarily large - $h_{eff}/h > 1$. Hadrons consist of quarks and I have considered the possibility that valence quarks and gluons at the color magnetic body are dark. Also nuclei as many-nucleon systems could be dark. In TGD even elementary particles consist of fundamental fermions so that one can ask whether elementary particles possess some elementary aspects of consciousness identified as the possibility of non-vanishing "biological" life-time. This kind of picture would conform with the idea about consciousness as something emerging as the complexity of the system increases.

The average lifetime of elementary particle as a conscious entity cannot be longer than the life-time of particle in the sense of particle physics. In the case of electron having infinite lifetime as elementary particle the "biological" lifetime must be finite since otherwise the irreversibility would manifest itself as a breaking of time reversal invariance in electron scale. The temporal time scale of CD characterising the dimensions of the magnetic body of the elementary particle is the first order of magnitude estimate for the lifetime of elementary particle self. The "biological death" of electron means state function reduction in the sense of ordinary quantum measurement theory implying for instance localization of electron or giving eigenstate of spin in given quantization direction and these quantum jumps meaning re-incarnations of electron certainly occur.

This time scale could give an idea about the geometric duration of elementary particle self (the growth of the temporal distance between tips of CD during the sequence of reductions or equivalently the increase of n). One expects that Δn is by NMP rather small for single particle systems.

Could thermodynamical breaking of time reversal symmetry relate to the CP/T breaking in particles physics?

Could the "thermodynamical" breaking of time reflection symmetry (T) correspond to the breaking of T as it is observed for elementary particles such as neutral kaon? I think that most colleagues tend to be skeptic about this kind of identification, and so do I.

The point is that particle physicist's T breaking could be purely geometric whereas thermodynamical breaking of T involves the notion of subjective time, state function reduction, and consciousness. One could however ask whether the particle physicist's T could serve as space-time correlate for thermodynamicist's T and whether systems showing CP breaking could be seen as conscious entities in very primitive sense of the word ($n_f/n_i > 1$ but small). An important point is that the time evolution for CDs corresponds to scaling so that usually exponential decay laws are replaced with their hyperbolic variants. Hyperbolic decay laws become an important signature of consciousness. For instance, bio-photon intensity decays in hyperbolic manner.

Consider neutral kaon as example.

1. The mean lifetimes are of long-lived and short lived neutral kaon are $\tau_L = 1.2 \times 10^{-8}$ seconds and $\tau_S = 8.9 \times 10^{-11}$ seconds: the ratio of the time scales is roughly 2^7. This does not conform with the naïvest guess that the size of CD gives estimate for the duration of elementary particle self (increase of the temporal distance between tips of CD): the estimate would be $_L = 10^{-7}$ seconds from the fact that the mass of neutral kaon is roughly 10^3 times electron mass.

2. This is not too far from the lifetime of K_L^0 but is about 2^7 times longer than the life-time of short-lived kaon. Why K_S would be so short-lived? Could the lifetime be dictated by quark level: the longer time scale could be assigned as secondary p-adic time scale with the p-adic prime $p \simeq 2^k$, $k = 104$, characterising b quark. Could the short life-time be understood in terms of loops involving heavier quarks with shorter lifetimes as conscious entities: they indeed appear in the description of CP/T breaking?

8.6 Time For Time

I was very happy to find that Sean Carroll in Cosmic Variance (see `http://tinyurl.com/p9pvefz`) gave links to really interesting talks in Time conference arranged by fQXI. I have not been too happy for the elitistic nature of these conferences making impossible the communication of really new

theoretical ideas. By listening the brilliant talk [J49] by neuroscientist David Eagleman (see `http://tinyurl.com/credoxs`), I however learned that this conference made possible communication of extremely interesting experimental findings about the relation of the time of physicist to the subjective time. I sincerely hope that my colleagues would listen this talk and realize that there are fascinating problems to be solved. There is simply no theory and therefore no list of dead theories among which graduate student is allowed to choose as in theoretical physics.

Eagleman together with other neuro scientists make distinction between time and subjective time and the experimental work has revealed that this relationship looks very complex and is poorly understood. One of the key realizations forced by TGD inspired theory of consciousness - in a well-defined sense a generalization of quantum measurement theory - is that geometric time (the time of field equations) and subjective time (experienced time) are two different notions. The challenge is to understand how they relate and under what conditions and in what approximation their identification performed routinely my the naïve colleagues is possible. This was an excellent reason for continuing listening and I warmly recommend this for the reader. Also the other lectures might be equally rewarding. In the following I just represent TGD based interpretation of the findings and suggest that the reader would not take it too seriously and would try to build his or her own interpretation.

Eagleman talks about what he calls relativity of subjective time. This has of course nothing to do with the relativity of the geometric time. At the basic level subjective time need not even allow any metric measure (as is the case in TGD where subjective time corresponds to a sequence of quantum jumps).

8.6.1 Flash-Lag Effect And Its Modification

Eagleman tells first about very simple visual illusion known as flash-lag effect. One rotates a small circle around a circular orbit. As the circle passes the horizontal line there is a flash of light in the middle of the circle. If our perception were ideal the flash would be perceived in the middle of the circle. The circle is perceived to be 5 degrees ahead of the flash.

The first explanation to come in mind is that brain anticipates the motion of the flash and represent it to us in a position in which it would be in nearby future. Eagleman decided to test this proposal and studied three different situations. Two of them correspond to a circle rotating in opposite directions and the third one to a situation in which the circle stops at the position of the flash. The theory predicts that the circle is perceived to be ahead in all situations since the perveiver should not know anything about what happens in future. The surprise was that there was no flash-lag when the circle stopped. As if the brain would know what happens in the nearby future.

This kind of observation is not new. I remember more than a decade old experiment studing the galvanic response created by emotionally very provocative picture appearing as an odd-ball in a series of neutral pictures. This kind of response was observed. The mystery was that it was observed before the picture was seen! The result was of course not taken seriously by serious scientists. When a serious scientist associates something with the word "parapsychology" he loses totally ability to rational thinking and begins to rage.

The conclusion is that our moment of subjective time seems to have a finite duration about 80 ms and all events that occur in this time interval are associated with one and same moment of subjective time. This time interval would correspond to 12.5 Hz frequency. In TGD framework the interpretation could be in terms of the time scale assignable to causal diamond (CD) identified as intersection of future and past directed light-cones, which serves as embedding space-correlate for the moment of consciousness: this time would be the temporal distance between the tips of CD.

The fractal hierarchy of quantum jumps within quantum jumps (identifiable as with a hierarchy of selves withing selves) has the hierarchy of CDs as an embedding space correlate. For electron the time scale of CD is 100 seconds. What is troubling is that 80 ms corresponds to a time interval which is by 20 per cent shorter. One could of course assign this time scale to some cyclotron frequency in TGD framework but I would be very happy if it would correspond to a time duration of electron's CD.

As Eagleman tells, perception involves gaps. For instance, during saccadic motion necessary for visual consciousness (the explanation in TGD framework is that the conscious experience is associated with nondeterministic change, quantum jump) visual system is not on. We do not

however perceive these gaps although we perceive the gaps created by putting lights off. Could it be that the gaps are absent because the 100 ms CDs in the sequences have overlap producing on the average 80 ms intervals without overlap? Could the absence of gaps also tell us that it is retina and various sensory organs which build the fundamental qualia and that brain only constructs a cognitive representation about it decomposing the world to objects with certain properties and names and also builds all kinds of useful associations? This picture applies to all sensory qualia in TGD Universe and one can circumvent various objections against it in terms of TGD view about time.

8.6.2   We Live In The Past: But In What Sense?

One surprising fact about consciousness is that we live in the past. The justification for this in terms of standard neuroscience, where brain builds both sensory and cognitive representations of the external world, does not require refined arguments.

     Neural communications are extremely slow using light-velocity as the standard. The velocities of nerve pulses are between 1-100 m/s as compared with the light velocity 3×10^8 m/s. The communication of the sensory data to brain takes time which can be of order second. The data coming from various sensory organs with varying velocities must be processed and combined to single view about external world at associative cortex. This takes time since it is the slowest signalst that determine the time used for the processing. Eagleman gives a humorous example: tall people should live father in past than the short ones since it takes longer time for neural signals from feet to arrive from cortex to the brain! Different sensory inputs must be also combined together in a realistic manner.

     Is the brain really able to meet this enormous challenge? The representation about the external world is not enough: this representation must be also realistic and 80 ms seems to represent the maximum duration of moment of sensory consciousness. Is the velocity of nerve pulses quite too slow to achieve this? And is information processing based on nerve pulse conduction really fast enough?

1. These questions could have been motivation for TGD proposal (or almost-prediction) that sensory organs are seats of primary sensory qualia experienced instantanously.

2. They could have also motivated what proposal that quantum entanglement is needed to bind various parts of the body and brain to form single coherent conscious unit. Quantum entanglement makes possible effective signalling with infinite velocity. Of course, genuine signals are not in question. It is better to speak about macroscopic system behaving like an elementary particle. Dark matter realized as a hierarchy of macroscopic quantum phases with a larger value of Planck constant is what would make this possible.

3. Light velocity is ideal for the communication purposes in the scale of biological body. Could it be that biology might have been stupid enough to miss this kind of an opportunity? Could it be that neuroscientists are the stupid one and simply on a wrong track? In TGD inspired model dark photons with large value of $\hbar$ (bio-photons would be dark photons transformed to ordinary photons) define a central element both in the communications from sensory organs to brain and to magnetic body and from magnetic body to biological body. At the level of body the communications would be practically instantaneous.

4. Even in Earth length scale the time taken by EEG photons to travel from biological body to the corresponding layear of the magnetic body would still be be of order.1 seconds and the experiments of Libet demonstrate among other things that our sensory data is a fraction of second old. This has nothing to do with the conduction velocity of nerve pulses. The purpose of nerve pulses would be quite different: they would create fundamental memory representations and the model for this is based on DNA as topological quantum computer vision.

    Explaining this would however require TGD based view about memory as 4-D perception: causal diamonds are 4-D objects and our conscious experience is always about 4-D space-time region. For sensory perception the scale of this region is.1 seconds. For the perceptions that

we call memories the scale is often years or even decades. Our conscious experience is 4-dimensional. Also our motor actions are essentially 4-dimensional: moment of consciousness replaces 4-D world (or quantum superpositions of them) with a new one: also our geometric past is changed in every moment of consciousness. This view resolves many puzzles related to memory but time is far from mature for the revolution. My hope is that the talks of Time conference could open the minds of at least some young colleagues.

5. The communications with light velocity make possible feedback from brain to sensory organs making possible the building of standardized mental images by using the virtual sensory input from brain to create a charicature. Our brain would be an artist using primary sensory input as a raw material.

8.6.3 Kublai Khan's Problem And Three More Surprises

Eagleman tells about the problem of emperor Kublai Khan. At that time people did not have internet and being a head of an empire of the size of Asia posed many problems. Kublai Khan used emissars travelling around the empire and bringing news about what happened. The problems was the correct integration of these data: the news about ending of some local war somewhere could arrive before the news telling that it had begun! Brain is faced with a similar problem. When the television came, one of the big problems was thought to be the synchronization of pictures and sound. It however turned out that brain takes care of this problem if the picture and sound to be associated with each other are withing 80 milliseconds. The moment of subjective time has this duration.

That we live in past was the first surprise of neuroscience already discussed. Eagleman tells about three more big surprises of neuroscience.

Time perception recalibrates

The brain must build a logical story about sensory data coming through different sensory channels. To achieve this time perception recalibrates. When one comes from bright sunlight to a dim room, the response function of retina gets slower. This does not however happen at the level of conscious experience. A simple test is a sequence of button clicks causing a flash of light. Experimenter can cheat the subject person by producing the light flash with a delay. Surprisingly, the subject person notices nothing. What is even more surprising that when one adds to the sequence of click-flash pairs an odd-ball for which flash is not delayed, the flash is experienced to take place earlier than clicking! Again a direct evidence for the TGD prediction that our perceptive field is 4-dimensional.

In this kind of situation the natural conclusion of subject person would be that it was not me who did the click. Some other agent caused the flash whereas my own attempt fails. Eagleman suggests that schizophrenia might be a disorder of time perception. Person would attribute his own thoughs sometimes heard as internal voices to some external subjects since the time order is pathological. Maybe. What is known that schizophrenics have very sharp sensory perception which cannot be cheated and that there might be no re-calibration. Eagleman talks about temporal inflexibility. This is of course just a suggestion as Eagleman emphasizes. I am not enthusiastic about this kind of interpretation: the bicameral views of Jaynes fit much better with the idea that magnetic body uses biological body as sensory receptor and motor instrument.

Time is not one thing

Time perception is much more complex than one might think: it involves many aspects such as duration, simultanety, flicker rate, time ordering. What brain does is the analysis of the sensory imput, and its reconstruction from the resulting small pieces. This is very much what is done in the processing of the raw sound (and also pictures) in movies. This applies also to time perception. In TGD framework also the feedback from brain is essential and basic communications would take place using light. Nerve pulse patterns would serve quite different purpose and are also hopelessly slow for building the percept.

The rate of time flow correlates with the rate of neural metabolism

There is large number of findings supporting the few that the experienced rate for the flow of subjective time correlates with the rate of neural metabolism and therefore with the intensity of consciousness.

1. Slowing down of the subjective time

Slowing down of subjective time flow is familiar to anyone. This can happen in troublesome situation or in so called flow state. Interestingly, also in very boring situations (say waiting for someone to come) the same can happen. From my own experience I would say that the slowing down of subjective time characterizes very intense conscious experiences involving intense concentration. But why it would occur when you are bored: perhaps just because you are so intensely conscious about how boring your life is just now. You are not drowsy: you are inpatient and irritated.

Various explanations have been proposed. The proposal that the slowing down of time is analogous to the slowing down of the magnetic tape reducing the frequencies of sounds fails. Another explanation could be in terms of increased time resolution and also I have proposed this explanation. This explanation was tested.

Eagleman did an experiment which could be also seen as a tongue-in-cheek variant of Galileo's famous experiment in which he dropped various objects from the tower or Pisa and measured the time of fall and observed that it does not depend on the weight of the material object. Eagleman dropped subject persons instead of stones!

First of all Eagleman constructed an instrument which he calls perceptive chronometer producing random sequence of digits. In the simplest situation only single digit appeared alternatively as its positive or negative. As the rate of digits exceeds certain critical rate -presumably rather near to 12.5 Hz under normal circumstances- it becomes impossible to distinguish between subsequent digits: one sees only single fuzzy digit. The critical duration for the digit defines a natural unit of subjective time. The idea is to calibrate the rate of the chronometer in such a way that the subject person is not able to distinguish between digits but that only a small reduction of the digit rate makes this possible. In this kind of situation it is enough to make the person scared and see whether he becomes able to distinguish between subsequent digits.

What Eagleman wanted to test was whether this time resolution increases when a person is really scared. If so, the subjective time measured using this critical unit would be longer in scaring situations. The method of really scaring was ingenious: drop the person from quite high a tower! During the free fall the person first found the critical time resolution of his visual perception which became the time unit used to measure the time of fall. The rate for Person reported his time resolution in two cases: when another person was falling and during own fall. The resolution increased during own fall: the falling time was estimated to be about 36 per cent longer for own falling down using the resolution as a unit.

What does this mean? It seems that the rate of the experienced time flow depends on the level of neural activity. In TGD framework the proper measure of subjective time is single quantum jump (recall that they form fractal hierarchy): this would be the tick of subjective clock. The larger the number of these ticks in a given interval of geometric time, the longer the experienced time duration is. More abstractly: the number of sub-CDs within CD representing mental images of self would provide a measure for the number of ticks during single CD.

Since metabolic energy is the necessary prerequite for the build-up of sensory and cognitive representations (mental images), the prediction is that the rate with which metabolic energy is used by brain correlates directly with the rate of the experienced time flow. When the subject person is falling from a tower, the rate of brain metabolism is higher than normally so that the observations can be understood in terms of the theory. As a matter fact, the correlation of the subjective duration with neural activity is well-known in neuroscience and Eagleman gives a long list of examples.

2. Odd ball effect

In this experiment the subject person perceives a series of figures. The figures are identical apart from some odd-balls between the repeating ones. The duration of odd-ball is experienced to be longer than that of the repeating picture although it is the same. The explanation would be that brain wants to save energy. Less metabolic energy for repeating items and nore metabolic energy

for odd-balls, which literally wake-up the partially sleeping brain. The rate of neural metabolism correlating with the intensity of conscious experience (and number of quantum jumps per unit of geometric time/density of sub-CD: s within CD) seems to correlated directly with the experienced slowing down of time.

To sum up, the findings discussed by Eagleman are not easy to understand in the standard conceptual framework of neuroscience. The basic assumptions of TGD inspired theory of consciousness make the explanation trivial. In particular, the hierarchy of quantum jumps containing quantum jumps (of selves having sub-selves with sub-selves interpreted as mental images of self) and having as an embedding space correlate the hierarchy of CDs within CDs, explains the correlation of neural metabolic energy consumption with the experienced rate for the flow of subjective time. The higher the density of sub-CDs within CD representing mental images, the higher the intensity of conscious experience, the higher the consumption of metabolic energy to build mental images, and the shorter the average time interval taken by given mental image and serving as a natural unit of subjective time and the longer the experienced duration of time interval.

8.7 Some comments related to quantum measurement theory according to TGD

In the following some comments on quantum measurement theory inspired by FB discussions. The TGD view about time is involved because measurement theory in TGD relies crucially on zero energy ontology (ZEO).

8.7.1 Does the analog of repeated second quantization take place at the level of WCW?

The world of classical worlds (WCW) is the basic structure of quantum TGD. It can be said to be the space of 3-surfaces consisting of pairs of (not necessarily connected 3-surfaces) at the boundaries of causal diamond (CD) and connected by a not necessarily connected 4-surface. 4- surface defines the interaction between the states associated with the 3-surfaces. The state associated with given 3-surface correspond to WCW spinor and one has modes of WCW spinor fields. WCW decomposes to sub-WCWs assignable to CDs and effectively the universe reduces to CD.

The key idea is that the WCW spinor fields are purely classical spinor fields. No second quantization is performed for them. Second quantization of induced spinor fields at space-time level is however carried out and gamma matrices of WCW anticommuting to its Kähler metric are linear combinations of fermionic oscillator operators.

The classicality of WCW spinor fields looks somewhat problematic.

1. The classicality of WCW spinor fields has implications for quantum measurement theory. State function reduction involves reduction of entanglement between systems at different points of space-time and therefore also many-particle states and second quantization are involved. However, second quantization does not take place at the level of WCW and it seems that entanglement between two 3-surfaces is not possible. Therefore measurements at WCW level should correspond to localizations not involving a reduction of entanglement. Measurements could not be interpreted as measurements of the universal observable defined by density matrix of subsystem. This looks problematic.

2. At the space-time level second quantization is a counterpart for the formation of many-particle states. Particles are pointlike and one of the outcomes is entanglement between point like particles. Since the point of WCW is essentially point-like particle extended to 3-surface, one would expect that second quantization in some sense takes place at the level of WCW although the theory is formally purely classical.

3. Also the hierarchy of infinite primes suggests an infinite hierarchy of second quantizations. Could it have counterpart at the level of WCW: can WCW spinor field be second quantized and classical simultaneously?

Could the counterpart for the hierarchy of infinite primes and second quantization be realized automatically at WCW level? One can indeed interpret the measurements at WCW as either localizations or as reductions of entanglement between states associated with different points of WCW. The point is that the disjoint union of 3-surfaces X^3 and Y^3 can be regarded either as a pair (X^3, Y^3) of 3-surfaces in $WCW \times WCW$ or as a 3-surface $Z^3 = X^3 \cup Y^3 \subset WCW$. The general identity behind this duality $WCW = WCW \times WCW = ... = WCW^n = ...$

One could think the situation in terms of $(X^3, Y^3) \in WCW \times WCW$ in which case one can speak of entanglement between WCW spinor modes associated with X^3 and Y^3 reduced by the measurement of density matrix. Second interpretation as a localization of wave function of $Z^3 = X^3 \cup Y^3 \in WCW$.

8.7.2 About the notion of observable

In ordinary quantum theory observables are hermitian operators and their eigenvalues representing the values of observables are real.

In TGD using $M^4 \times CP_2$ picture the gauge coupling strengths are complex and therefore also classical Noether charges are complex. This should be the case also for quantum observables. Total quantum numbers could be still real but single particle quantum numbers complex. I have proposed that this is true for conformal weights and talked about conformal confinement.

Also in ordinary twistor approach virtual particles are on mass shell and thus massless but complex. Same is expected in TGD for 8-momenta so that one obtains particles massive in 4-D sense but massless in 8-D sense: this is absolutely crucial for the generalization of twistor approach to 8-D context. Virtual momenta could be massless in 8-D sense but complex but *total* momenta would be real. This would apply to all quantal charges, which for Cartan algebra are identical with classical Noether charges.

I learned also a very interesting fact about normal operators for which operator and its hermitian conjugate commute. As the author mentions, this trivial fact has remained unknown even for professionals. One can assign to a normal operator real and imaginary parts, which are commuting as hermitian operators so that - according to the standrd quantum measurement theory - they can be measured simultaneously.

For instance, complex values of various charge predicted by twistor lift of TGD would therefore in principle be allowed even without the assumption that the total charges are real (*total* charges as hermitian operators). Combining the two ideas one would have that single particle charges are complex and represented by normal operators and total charges are real and represented by hermitian operators.

8.7.3 What does amplification process in quantum measurement mean?

Quantum measurement involves an amplification process amplifying the outcome of state function reduction at single particle level to a macroscopic effect. This aspect of quantum measurement theory is poorly understood at fundamental level and is usually though to be unessential concerning the calculation of the predictions of quantum theory.

The intuitive expectation is that the amplification is made possible by criticality - I would suggest quantum criticality - and involves the analog of a phase transition generated by seed. This is like the change for a direction of single spin in magnet at criticality inducing change of the magnetization direction.

Quantum criticality [?] involves long range fluctuations and correlations for which $h_{eff}/h = n$ serves as a mathematical description in terms of adelic physics in TGD framework. Long range correlations would make possible the classical macroscopic state characterizing the pointer. This large $h_{eff}/h = n$ aspect would naturally correspond to the presence of intelligent observer: h_{eff} indeed closely relates to the description of not only sensory but also cognitive aspects of existence and has number theoretic interpretation as a measure for what might be called IQ of the system.

If this is tge case, one cannot build proper quantum measurement theory in the framework of standard quantum mechanics, which is unable to say anything interesting about cognition and observer. A theory of consciousness is required for this and ZEO based quantum measurement theory is also a theory of consciousness.

8.7.4 Zero energy ontology and Afshar experiment

Afshar experiment [D10] challenges Copenhagen and many-universe interpretations (see `http://tinyurl.com/ycsttpb9`) and it is interesting to look how it can be understood in ZEO.
  Consider first the experimental arrangement of Afshar.

1. A modification of double slit experiment is in question. One replaces the screen with a lense, which reflects from slit 1 to detector 1' and from slit 2 to detector 2'. Lense thus selects the photon path that is the slit through which the photon came.

   The detected pattern of clicks at detectors consists of two peaks: this means particle behavior. One can say that at single photon level either detector/path/slit is selected.

2. One adds a grid of obstacles to the nodes (zeros) of the interference pattern at imagined screen behind the lense. The photons entering the points of grid are absorbed. Since grid is at nodes of the interference pattern this does not affect the detected pattern, when both slits are open but affects the pattern when either slit is closed (grids points are not nodes anymore). This in turn means wave like behavior. This conflicts with principle of complementary stating that either of these behaviors is realized but not both.

   Consider the analysis of the situation in the usual positive energy ontology and assuming that state function reduction occurs at the detectors.

1. Photon wave function Ψ in the region between slits and lense is superposition of two parts: $\Psi = \Psi_1 + \Psi_2$ with Ψ_i assignable to slit $i = 1, 2$. The lense guides Ψ_1 to detector 1 and Ψ_2 to detector 2. State function reduction occurs and Ψ is projected to Ψ_1 or Ψ_2. Either detector 1 or 2 fires and photon path is selected.

   It however seems that state function reduction - choice of the path/slit - can occur only in the region in front of the grid. In the region between slits and grid one should still have $\Psi1 + \Psi_2$ since for Ψ_i the grid would have effect to the outcome. This effect is however absent. This does not fit with Copenhagen interpretation demanding that the path of photon is selected also behind the grid. This is the problem.

2. What about the interpretation in ZEO? After state function reduction - detection at detector 1 say - the time evolution between opposite boundaries of CD is relaced with a time reversed one. To explain the observations of Afshar (no deterioration of the pattern at detector caused by grid), one must have time evolution in which the photons coming from the detectors in reversed time direction have wave functions which vanish at the points of grid. This determines the "initial" values for the reversed time evolution: they are most naturally at grid so that grid corresponds naturally to a surface at boundary of CD in question. This is of course not the only choice since one can use the determinism of classical field equations to choose the intersection with CD differently. If time reversal symmetry holds true, the final state in geometric past corresponds to a signal coming from slit 1 (in the case considered as example). There would be no problem! Afshar experiment would be the first laboratory experiment selecting between Copenhagen interpretation and ZEO based quantum measurement theory.

8.8 Maxwell's demon from TGD viewpoint

In Facebook I received a link to an interesting popular Science News article titled "*A New Information Engine is Pushing the Boundaries of Thermodynamics*" (see `http://tinyurl.com/y74bfrpu`). The article told about the progress in generalizing the conventional second law of thermodynamics to take information as an additional parameter.
  Carnot engine is the standard practical application. One has two systems A and B, both in thermal equilibrium but with different temperatures T_A and $T_B \geq T_A$. By second law one has heat flow Q from A to B the two systems, and Carnot's engine transforms some of this heat to work. Carnot's law gives an upper bound for the efficiency of the engine as $\eta \equiv W/Q \leq (T_2 - T_1)/T_2$. The possibility to transform information to work forces to generalize Carnot's law.

Since information is basically conscious information, this generalization is highly interesting from the point of view of quantum theories of consciousness and quantum biology. Certainly the generalization is highly non-trivial. Especially so in standard physics framework, where only entropy is defined at fundamental level and is regarded as ensemble entropy and basically has very little to do with conscious information. Therefore the argumentation is kind of art work.

8.8.1   Maxwell's demon in its original form

Maxwell's demon (see `http://tinyurl.com/q829my5`) is a thought experiment in which one considers a system consisting of two volumes A and B of gas in thermal equilibrium at same temperature. At the boundary between A and B having a small hole sits a demon checking whether a molecule coming from A has velocity above some threshold: if so it allows the molecule to go to B. Demon monitors also the molecules coming from B and if the velocity is below the threshold it allows the molecule to continue to A. As a consequence, temperature and pressure differences develop between A and B. Pressure difference can do work very much voltage between the cathode and anode of battery. One can indeed add a tube analogous to wire between ends of the entire system and pressure difference causes a flow of mass doing thus work: one has pump.

The result is in conflict with the second law and one can ask what goes wrong. From the Wikipedia article one learns that a lot of arguments have been represented con and pro Maxwell's demon. Biologist might answer immediately. Demon must measure the states of molecules and this requires cognition and memory, which is turn require metabolic energy. When one takes this into account this, paradox should disappear and second law should remain true in a generalized form in which one takes into account the needed metabolic energy.

8.8.2   Experimental realization of Maxwell's demon

The popular article describes an experiment actualizing Maxwell's demon carried out by Govind Paneru, Dong Yun Lee, Tsvi Tlusty, and Hyuk Kyu Pak (see `http://tinyurl.com/y9sn9j7o`). Below is the abstract of the article *Lossless Brownian Information Engine* published in Phys Rev Letters.

We report on a lossless information engine that converts nearly all available information from an error-free feedback protocol into mechanical work. Combining high-precision detection at a resolution of 1 nm with ultrafast feedback control, the engine is tuned to extract the maximum work from information on the position of a Brownian particle. We show that the work produced by the engine achieves a bound set by a generalized second law of thermodynamics, demonstrating for the first time the sharpness of this bound. We validate a generalized Jarzynski equality for error-free feedback-controlled information engines.

Unfortunately, the article is behind paywall and I failed to find it in arXiv. The popular article uses notions like "particle trapped by light at room temperature" and photodiode as "light trap" without really defining what these expressions mean. For instance, it is said that the light trap would follow particles moving in definite direction (from A to B in Maxwell's thought experiment). I must admit that I am not at all sure what the precise meaning of this statement is.

8.8.3   TGD view about the situation

TGD inspired theory of consciousness can be regarded as a quantum measurement theory based on zero energy ontology (ZEO) and it it is interesting to try to analyze the experiment in this conceptual framework.

TGD view about the experiment

The natural quantum interpretation is that the photodiode following the photon is performing repeated quantum measurements, which in standard quantum theory do not affect the state of the particle after the first measurement. From the viewpoint of TGD inspired consciousness, which can be regarded as a generalization of quantum measurement theory forced by zero energy ontology (ZEO), the situation could be as follows.

1. Photo-diode following the particle by would be like conscious entity directing attention its to the particle and keeping it in focus. In TGD Universe directed attention has as classical space-time correlates flux tubes connecting attendee and target of attention: in ER-EPR correspondence the flux tubes are replaced with wormholes, which suit better to GRT based framework. Flux tubes make also possible entanglement between attendee and target. The two systems become single system during the period of attention and one could say that the attention separates the particle from the rest.

2. Directed attention costs metabolic energy. Same would be true also now - photo-diode indeed requires energy feed. Directed attention creates mental image the conscious entity associated with the mental images can be regarded as a generalized Zeno effect or as a sequence of weak measurements.

   Tracking would thus mean that particle's momentum is measured repeatedly so that the particle is forced to continue with the same momentum. Gradually this would affect the thermal distribution and generate temperature and pressure gradients. Directed attention could be also seen as a mechanism of volition in quantum biology.

3. This looks nice but one can ask what about the collisions of the particle with other molecules of gas: don't they interfere with the Zeno effect? If the period between repeated measurements is shorter than the average time between the collisions of particles, this is not a problem. But is there any effect in this case? The directed attention or a sequence of quantum measurements could separate the particle from the environment by de-entangling it from the envirobment. Could it be that collisions would not occur during this period so that attendee and target would form a subsystem de-entangled from rest of the world?

ZEO variant of Maxwell's demon

Zero energy ontology (ZEO) [L39] forces to consider different arrangement producing energy somewhat like in perpetuum mobile but not breaking the conservation of energy in any obvious manner. The idea pops into my mind occasionally and I reject it every time and will do so again.

1. Zero energy states (ZESs) are like physical events: pairs of positive and negative energy state with energy E and $-E$: this codes for energy conservation.

2. One can have quantum superposition of ZESs with different values of energy E and with average value $\langle E \rangle$ of energy. In state function reduction $\langle E \rangle$ can change and in principle this does not break conservation of energy since one has still superposition of pairs with energies E and $-E$.

3. For instance, the probabilities for states with energy E could be given by thermal distribution parameterized by temperature parameter T: one would have "square root" of thermodynamic distribution for energies. "Square root" of thermodynamics is indeed forced by ZEO. One would have essentially entanglement in time direction. Single particle states would realize square root of thermodynamical ensemble, which would not be a fictive notion anymore.

   The coefficients for the state pairs would have also phases and these phases would bring in something new and very probably very important in living matter. System characterized by temperature T would not be so uninteresting as we think, there could be hidden phase information.

   If T increases in reduction then $\langle E \rangle$ increases in state function reduction. Reduction could also measure the value of E. Could the system increase its $\langle E \rangle$ in state function reductions? My proposal for an answer is "No".

   In ordinary thermodynamics energy should be fed from environment to increase $\langle E \rangle$: how environment would enter into the game now?

1. State function reduction always reduces the entanglement of system S with environment, call it S_{env}. Could the increase of $\langle E \rangle$ be compensated by compensating change of $-\langle E \rangle$ in S_{env}. Indeed, the conservation of energy for single state is expected have statistical counterpart: energy would come from environment as a kind of metabolic energy. Therefore also the "square root" of thermodynamics would prevent perpetuum mobile.

2. This would be the case if the reduction measures the energy of the entire system $S_{tot} = S + S_{env}$ - so that S_{tot} is always in energy eigenstate with eigenvalue E_{tot} and E_{tot} does not change in reductions and in unitary evolutions between them. Can one pose this condition?

Time reversal and apparent breaking of second law in zero energy ontology (ZEO)

ZEO based theory of consciousness [L39] forces to consider also a genuine breaking of the second law.

1. In ZEO self as a conscious entity corresponds to a generalized Zeno effect or equivalently a sequence of analogs of weak measurements as "small" state function reductions. The state at passive boundary of CD is unaffected as also the members of state pairs at it.

   Second boundary of CD (active boundary) shifts farther away from the passive one and the members of state pairs at it change giving rise to the conscious experience of self. Clock time time identified as temporal distance between the tips of CD increases. This gives rise to the correspondence between clock time and subjective time identified as sequence of weak reductions.

2. Also "large" state function reductions are possible and also unavoidable. The roles of active and passive boundary are changed and time reversal occurs for the clock time. One can say that self dies and re-incarnates as a time-reversed self.

   At the next re-incarnation self with the original arrow of clock time would be reborn and continue life from time value shifted towards future from the moment of death: its identity as a physical could be however very different. One can of course wonder whether sleep could mean a life in opposite direction of clock time and wake-up a reincarnation in the usual sense.

   The time-reversed self need not have conscious memories about its former life cycle: only the collections of un-entangled subsystems at passive boundary carry information about this period. A continuation of conscious experience could however take place in different sense: the contents of consciousness associated with the magnetic body of self could survive the death as near-death-experiences indeed suggest.

3. The time reversed system obeys second law but with opposite time direction as normally. Already Italian physicist Fantappie proposed that this occurs routinely in living matter and christened the entropy for time reversed systems syntropy [J97]. Processes like spontaneous assembly of complex molecules from their building bricks could be controlled by time reversed selves.

   In TGD inspired biology motor actions could be seen as generation of signal propagating backwards in time and defining sub-system with revered arrow of time and inducing the activity preceding motor activity before the conscious decision leading to it is made: this with respect to geometric time. There are many effects supporting the occurrence of these time reversals.

4. How the possibility of time reversals relates to the second law? One might argue that second law emerges from the non-determinism of state function reduction alone. Second law would transform to its temporal mirror image when one looks the system from outside with unchanged arrow of clock time.

   But does the second law continue to hold in statistical sense as one takes average over several incarnations? One might think that this is the case since generalized Zeno effect generalizes ordinary Zeno effect and at the limit of positive energy ontology one would effectively have a sequence of ordinary state function reductions leading leading to second law.

Negentropy Maximization Principle (NMP)

TGD also predicts what I call Negentropy Maximization Principle (NMP) [K56] [L39].

1. Entanglement coefficients belong to extension of rationals allowing interpretation as both real and p-adic numbers in the extension of p-adics induced by the extension of rationals defining the adele.

One can assign ordinary entanglement entropy to the real sector of adele and entanglement negentropy with the p-adic sectors of adelic physics: for latter the analog of ordinary Shannon entropy is negative and thus the interpretation as conscious information is possible. The information is assigned with the pairing defined by entanglement whereas entropy is associated with the loss of precise knowledge about the state of particle in entangled state.

2. One can also consider the difference of sum of p-adic entanglement negentropies and real entanglement entropy as the negentropy. This quantity can be positive for algebraic extensions of rationals and its maximal value increases with the complexity of the extension and with p-adic prime.

   Also the information defined in this manner would increase during evolution assignable to the gradual increase of dimension of algebraic extension of rationals, which can take place in "large" state function reductions (re-incarnations of self): if the eigenvalues of density matrix are algebraic numbers in an extension of the extension of rationals, the "large" state function must take place.

3. NMP would hold true in statistical sense - and mathematically very much analogous to second law - and would relate to evolution. In particular, one can understand why the emergence of intelligent systems is - rather paradoxically - accompanied by the generation of entropy. To have large entanglement negentropy in p-adic sectors one must have large entanglement entropy in real sector since same entanglement defines both.

Dark matter as phases of matter labelled by the hierarchy of Planck constants

The hierarchy of Planck constants $h_{eff}/h = n$ [**?**, K73] is a further key notion in TGD inspired quantum biology.

1. The hierarchy of Planck constants $h_{eff}/h = n$ implied by adelic physics as physics of both sensory experience (real numbers) and cognition (p-adic number fields) is basic prediction of TGD [L37]. Planck constant characterizes the dimension of the algebraic extension of rationals characterizing the cognitive representations, and is bound to increase since the number of extensions with dimension larger than given dimension is infinite whereas those with smaller dimension is finite.

2. The ability to generate negentropy increases during evolution. System need not however generate negentropy and can even reduce it. In statistical sense negentropic resources however increase: things get better in the long run. In biology metabolic energy feed brings to system molecules having valence bonds with $h_{eff}/h = n$ larger than that for atoms [L35], and this increases the ability of the system to generate negentropy and in statistical sense this leads to the increase of negentropy.

The most recent ZEO based view about demonic activities in TGD Universe

Maxwell's demon is at the boundary of the region which can be seen as physics disregarding totally the observer. Maxwell's demon allows only particles with velocity above threshold to travel from A to B. This leads to generation of pressure gradient in conflict with the second law.

The basic objection against Maxwell's demon is that the demon is an intelligent living being which thinks and although there is no mainstream physical theory about cognition, the empirical fact is that this requires metabolic energy feed. This must be taken in account also and means that the development of the gradient requires metabolic energy.

In zero energy ontology (ZEO) one must reconsider the situation since time reversal occurs in ordinary state function reductions (BSFRs) [L58]. This means time reversed dissipation and forces a generalization of the second law [L56]. For the observer with the standard arrow of time, this shows itself as a generation of various gradients, demonic activity.

Living matter is full of examples of self-organization in which such this seems to happen and the explanation is in terms of non-equilibrium thermodynamics and thermodynamical fluctuations basically. Essential is that energy flows are involved as in the example of Maxwell demon and metabolic energy feed explains this partially. But eventually the energy flows are gradients and

eventually disappear and heat death of the Universe occurs. The emergence of life therefore seems very implausible: England [**?**] would be thus incorrect [L22].

Usually the energy flow to the system is taken as passive - arranged from outside. In ZEO the opposite arrow of time makes it active. System extracts energy from the environment, "eats" rather than waiting for the food to flow into its mouth spontaneously and to creep to the stomach without help. This leads to what I call remote metabolism or credit card mechanism as a way to extract radiative energy from the environment or from systems analogous to population inverted lasers able to provide it.

Living matter is also full of examples about self-organized criticality (SOC) very difficult to understand in standard thermodynamics. System manages to stay near a critical state which is by definition unstable. This is nothing but homeostasis [L92]. What in standard biology looks like extremely tightly planned programs involving endlessly various biochemical pathways is unplanned spontaneous dissipation with a reversed arrow of time: this simplifies enormously the biological modelling. In time reversed direction critical state is an attractor rather than repeller and time reversal would be the basic mechanism of homeostasis.

There are specific molecules - stress proteins (SPs) specialized to act as coolers, heaters, and heat engines using the thermal energy at their magnetic body (MB), whose temperature has maximum - presumably near physiological temperature - by the fact the number of degrees of freedom is infinite [L92]. SPs a near this maximal temperature known as Hagedorn temperature and have very large heat capacity. Stress molecules provide in the case of cold shock energy to DNA and basic proteins to heat them so that they remain functional. In the case of heat shock they reduce the temperature of the environment by sucking thermal energy by time reversal for their magnetic body serving as an energy reservoir. They can act also as heat engines driving molecular motors.

8.9 Why the outcome of an event would be more predictable if it is known to occur?

I learned from Reza Rastmanesh about highly interesting findings of Armor and Sackett, and this section is essentially the article [L93] written together with him about the topic.

Past research in experimental psychology has brought evidence showing that certain changes in internal neurocognitive environments of human subjects can influence their predictions of near future events. In the series of experiments published in a recognized psychological Journal of Personality and Social Psychology, Armor and Sackett [J31] examined how the nature of future events influence the participants´ predictions about their future performance in different tasks.

In Study 1, half of participants were informed that they will complete a scavenger hunt task, i.e. finding particular objects at the university campus during 30 minutes, whereas the second half of participants were not informed. Thus, the expectations of participants were manipulated in terms of real versus hypothetical future events and this manipulation also causes different changes in internal neurocognitive environments in each half of participants. The participants were asked "How well will you do on the scavenger hunt?" or "How well would you do, if you were asked to complete the scavenger hunt?". After that, all the participants completed the scavenger hunt task and their predictions were compared with their real performance in this task. Strikingly, participants who did expect to complete the task predicted their own performance quite accurately. In contrast, participants who believed that the task is only a hypothetical future event showed much higher prediction-performance discrepancy, i.e. they were not able to predict their future performance accurately.

These findings were replicated also in Study 2, where another kind of task was used (a completion of test used for Graduate Record Examination). One may ask how it is possible that participants that were informed about their future life event predicted their real performance in the task better than non-informed participants. The authors of this study were quite surprised by obtaining these results and labeled them as "seemingly anomalous findings". If this finding is real it provides a difficult challenge for model builders.

In the context of Minkowski spacetime, several possible explanations can be theoretically conceptualized:

1. In classical GRT, the causal structure is the structure of light cones of the space-time metrics. As the matter-energy degrees of freedom determine the metric through Einstein's equations, the causal structure of a region of space-time is dynamical: it depends on the state of the matter energy in its past light cone. If one identifies the causality of human actions experienced as acts of free will with the deterministic causality of field equations, the ability to predict the near future is theoretically possible. This applies also to person's own behavior if it does not involve free will: if this is the case, the two causalities cannot be identified.

2. Also a general quantal explanation may be considered. Quantum measurement provides information. In the context of the above-outlined experiments, the participants who were told about the purpose of the experiment gained information. Could this action have involved state function reduction of some kind improving the ability to predict their own future? Also this option would assume that HOs are passive inspectors of their own fate and does not conform to the direct experience of having (partially) free will.

3. One can consider also an explanation in terms of precognition based on future-to-past communications requiring change of the arrow of time and therefore also violation of standard thermodynamics. Precognition is classified as belonging to the field of parapsychology by materialists accepting only a single arrow of time. Also this explanation fails if one accepts free will: precognizing of own unpredictable acts of free will is impossible.

In the sequel the problems of various physicalistic explanations are discussed in more detail and the TGD based model relying on zero energy ontology (ZEO) [L58] replacing the standard ontology of quantum theory in TGD framework and solving the basic paradox of quantum measurement theory. The basic prediction is that the arrow of time changes in "big" (ordinary) states function reductions (BSFRs) but is preserved in "small" SSFRs as analogs of "weak" measurements. This forces to distinguish between geometric and subjective time.

This leads to an understanding of the findings of Libet [J34] about active aspects of consciousness challenging the reality free will: in BSFR the arrow of causality changes and the outcome of BSFR causes the neural activity rather than vice versa. Also the findings of Armor and Sackett seem to give direct support for the physicalistic picture: the members of group A would be passive inspectors of their own future actions and therefore would have not free will. Precognition, which is not accepted in the physicalistic framework, is however required, which suggests that BSFRs transforming precognition to memory recall might be involved.

In the sequel the findings of Armor and Sackett are taken at face value and an explanation based on TGD inspired theory of consciousness relying on zero energy ontology (ZEO) allowing to get rid of the basic paradox of quantum measurement theory is proposed. There are 2 new elements essential for the explanation.

1. There is a hierarchy of magnetic bodies carrying dark matter as $h_{eff} = nh_0$ phases of ordinary matter and defining a self-hierarchy.

2. The time reversal in BSFRs makes memory recall in reversed time direction possible: these memories need not be personal and it is possible to get information about the memories of MB at a higher level of hierarchy with a reversed arrow of time after BSFR.

In the scavenger hunt BSFR at higher level would be assignable to the experiment which had already occurred with respect to subjective time at a higher level of the hierarchy in the geometric future of participants. This BSFR would be followed by a cascade of BSFRs proceeding to shorter scales in subjective future but located in the geometric past.

The subject persons who were told that that they will participate a scavenger hunt would have received non-personal memories about those abstract aspects of the scavenger hunt at higher level of hierarchy, which they could not affect by BSFRs: the number of objects found by the participant would have been this kind of aspect and already determined by a BSFR at a higher level of hierarchy. Ordinary motor action would be very similar process involving communications to lower levels of self hierarchy in the geometric past.

This explanation is akin to the earlier TGD based explanation [L20] [K109] for psychedelic experiences in which subject persons experience meeting of representatives of advanced civilizations of outer space. That these encounters could be actual telepathic contacts was proposed in

a book about psychedelic induced experiences titled as "Inner paths to outer space" (`http://tinyurl.com/gnb4bp9`) written by Rick Strassman, Slawek Wojtowicz,   Luis Eduardo Luna and Ede Frecska [J71]. In ZEO the arrow of time is not fixed so that   instantaneous communications over arbitrarily long distances become possible by what might be called time reflection involving BSFR.

The explanation relies on   sending a signal, which is reflected back as a time reversed signal (involving BSFR): this allows to circumvent the barrier caused by finite speed of light.   In principle this would make signalling with arbitrarily distant civilizations possible.

8.9.1   Why the standard physics based explanation for the findings of Armor and Sackett looks implausible?

What seems clear to me is that it is very difficult to understand the findings of Armor and Sackett [J31] - if real - in the standard physics framework.

1. Standard physics excludes precognition: the thermo-dynamical arrow of time is fixed and also the quantization procedure of quantum field theory fixes the arrow of time. Creation operators create states and annihilation operators destroy them. The change of arrow of time would change the roles of these operators. Classically this corresponds to the fact that signals propagate in preferred direction only. It is difficult to see how quantum effects according to standard QM could help. State function reductions happen in standard physics only in very short scales and have no effect in macroscales. They do not make possible effective precognition.

2. The idea that the persons in group A got bored after they had found the number of objects that they had estimated to find does not work since the same should have happened in group B.

3. The experimenter effect [K55] is encountered in parapsychology experiments and also in experiments involving living subjects (testing of drugs). There are extremely successful parapsychology experimenters and often their findings cannot be replicated. Could the experimenters somehow affect the subject persons so that the outcome of the experiment is what the experimenter would regard as desired? Physicalists deny the possibility of this kind of effect so that fraud or bad experimentation remains the only explanation. The reality of Placebo effect cannot be denied and suggests that the state of mind of the patient affects the healing in conflict with the physicalistic expectations. These effects are discussed from the TGD point of view in an article [K55] prepared in the project organized by Lian Sidoroff. Experimenter effect leads to ask whether the strong belief of experimenter on the expected result could induce the result also in the experiment of Armor and Sackett. This hypothesis could be tested by replicating the experiment sufficiently many times by other experimenters.

4. The causal reference frame model of Guerin and Bruckner [J31] involves a rather speculative proposal that classical GRT could allow anomalies in which the order of events is different for different observers modelled in terms of lightcones. One can ask whether it could differ in the recent experiments between participants a in group A and participants b in group B. For persons in group A it would have been changed and they could "remember" their performance whereas the participants in B only estimated it since they did not know that effective memory recall is possible! The information would have entered as classical signals in reversed time direction to the participants in group A. Somehow the information about the participation to the actual experiment would have made possible this effective change of arrow of time.

   Classical Relativity predicts that gravitation is extremely weak interaction so that the explanation does not look plausible to me. There are however some black-hole like solutions of Einstein's equations known as Kerr-Newman metrics [B23] describing rotating objects having opposite arrows of time in near-field and far-field regions but these solutions do not seem relevant in the recent case.

   It is difficult to see how standard quantum physics could help. One must however notice that there is no generally accepted quantum theory of gravitation.

8.9.2 A model for the findings of Armor and Sackett based on the notions of magnetic body (MB) and zero energy ontology (ZEO)

TGD based explanation of the findings relies on the notions of magnetic body (MB) and zero energy ontology (ZEO).

The notion of magnetic body (MB)

The notion of classical field differs from that it classical field theories. Gauge potentials - in particular electromagnetic gauge potential - are induced from the spinor connection of embedding space $M^4 \times CP_2$ as defining static and non-dynamical gauge potentials. Sama applies to gravitational field as deviation from flat metric of Minkowski space. The dynamics of space-time surface makes the induce gauge potentials and metric dynamical. Locally the dynamics is however extremely simple since only 4 field like variables are involved. Even approximate superposition of fields is lost and possible only for massless modes propagating in the same direction and is replaced with superposition of effects.

This extreme local simplicity is compensated by the extremely complex topology of the many-sheeted space-time distinguishing TGD from standard model plus General Relativity. Many-sheeted space-time prevailing in long length scales means that there is very large number of space-time sheets parallel in the sense that they intersecting 4-D M^4 projections. This is crucial for all applications. Any system the induced gauge fields at space-time sheets characterizing the system and since these sheets are separate for separate system, these induce fields do not interfere. One can say that the system has field body, in particular magnetic body (MB). In gauge theories this is not the case.

How does this picture relate to ordinary field theoretic description. Particle like entity as a small 3-surface touches all space-time sheets with 4-D M^4 projection and therefore experiences the sum of induced gauge fields associated with the space-time sheets. Effects superpose and this superposition corresponds basically to a set theoretic union of space-time surface with intersection M^4 projections. In ordinary field theory this is used as justification for the assumption that fields superpose. Field theory limit of TGD is defined by replacing the many-sheeted space-time with single regions of M^4 with gauge fields and gravitational fields defined as superpositions of the induced fields.

Also brain has MB. Quite generally MB is assumed to contain dark matter identified as ordinary matter characterized by extension of rationals with dimension $h = h_{eff}/h_0 = n$ measuring algebraic complexity and having interpretation as a kind of universal IQ. Also the scales of quantum coherence increase with h_{eff}. The layers of MB characterized by the value of n form naturally a slaving hierarchy in which ordinary matter with smallest Planck constant is at the bottom and controlled by higher levels. The energies of systems increase with h_{eff} and since h_{eff} tends to be spontaneously reduced, energy feed is needed to preserve the distribution of h_{eff}: the interpretation is as metabolic energy feed.

In the TGD framework the onion-like hierarchical structures of MB of brain would correspond to brain regions. The structure of MB with levels labelled by extensions of rationals characterized partially by $n = h_{eff}/h_0$ measuring the scale of quantum coherence, would also reflect the geometric and topological structure of the brain. There is evidence that functionally similar neurons can be modelled using statistically determined hyperbolic geometry [J65]. Functionally similar neurons not necessarily near to each other physically would be near to each other in the effective hyperbolic geometry.

In TGD framework MB could realize this hyperbolic geometry quite concretely as an abstract representation of the hierarchical functional structure of brain [L65]: functionally similar neurons and also higher level structures would be connected to nearby points at MB by flux tubes. Classification experienced as putting similar things to the same box is one of the basic cognitive functions and hierarchy of MBs could realize classification geometrically: functionally similar neurons would be connected by flux tuges to points near each other at MB - they would belong to the same box.

There is an astonishing finding supporting the notion of MB. The neurons of the brain of salamander were shuffled like a pack of cards. The salamander however recovered and preserved its memories (identified as learned behaviors) [J119]. In [K77, K79] this finding was considered

as a support for the view about the brain as an analog of hologram (for the idea about TGD Universe as a conscious hologram see [K14]). It is however clear that a single neuron cannot represent the information content of the entire brain. However, if memories are represented by the images of neurons at the level of MB, the shuffling of neurons has no effect on memories as indeed found. Neurons would represent the analog of RAM in computer science.

What does ZEO mean?

The TGD based explanation would be based on ZEO allowing to solve the basic paradox of quantum measurement theory. First a brief summary of ZEO [L58].

1. In ZEO quantum states are not 3-dimensional but superpositions of 4-dimensional deterministic time evolutions connecting ordinary initial 3-dimensional states. By holography they are equivalent to pairs of ordinary 3-D states identified as initial and final states of time evolution.

   Quantum jumps replace this state with a new one: a superposition of deterministic time evolutions is replaced with a new superposition. Classical determinism of individual time evolution is not violated and this solves the basic paradox of quantum measurement theory. There are two kinds of quantum jumps: ordinary ("big") state function reductions (BSFRs) changing the arrow of time and "small" state function reductions (SSFRs) (weak measurements) preserving it and giving rise to the analog of Zeno effect [L58].

2. To avoid confusion it is good to emphasize some aspects of ZEO.

   (a) ZEO does not mean that physical states in the usual 3-D sense as snapshots of time evolution would have zero energy state pairs defining zero energy states as initial and final states have same conserved quantities such as energy. Conservation implies that one can adopt the conventions that the values of conserved quantities are opposite for these states so that their sum vanishes: one can think that incoming and outgoing particles come from geometric past and future is the picture used in quantum field theories.

   (b) ZEO implies *two* times: subjective time as sequence of quantum jumps and geometric time as space-time coordinate. These times are identifiable but are strongly correlated.

3. In BSFRs the arrow of time is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. BSFRs can occur in all scales since TGD predicts a hierarchy of effective Planck constants with arbitrarily large values. There is empirical support for BSFRs.

   (a) The findings of Minev *et al* [L51] in atomic scale can be explained by the same mechanism [L51]. 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 [J34] 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 [J27] 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 [L52]. 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 [L56, L92].

Some implications of ZEO

ZEO has profound implications for understanding self-organization [L56] and self-organized quantum criticality [L92] in terms of dissipation with non-standard arrow of time looking like a generation of structures. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

1. Second law in the standard sense does not favor - perhaps even not allow - realization of planned actions. ZEO forces a generalization of thermodynamics: dissipation with a non-standard arrow of time for a subsystem would look like self-organization and planned action and its realization.

   Could most if not all planned action be like this - induced by BSFR in the geometric future and only apparently planned? There would be however the experience of planning and realizing induced by the signals from geometric future by a higher level in the hierarchy of conscious entities predicted by TGD! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than agents with completely free will.

2. The notion of magnetic body (MB) serving as a boss of ordinary matter would be central. MB carries dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n serving as a measure for algebraic complexity of extension of rationals as its dimension and defining a kind of universal IQ. There is a hierarchy of these phases and MBs labelled by extension of rationals and the value of n.

   MBs would form a hierarchy of bosses - a realization for master slave hierarchy. Ordinary matter would be at the bottom and its coherent behavior would be induced from quantum coherence at higher levels. BSFR for higher level MB would give rise to what looks like planned actions and experienced as planned action at the lower levels of hierarchy. One could speak of planned actions inducing a cascade of planned actions in shorter time scales and eventually proceeding to atomic level.

3. This interpretation is actually not new. I proposed in [L89, L91] that motor actions could correspond to BSFRs and sensory percepts to their time reversals. It took still some time to realize that sensory perceptions naturally correspond to SSFRs ("weak" measurements), and that both BSFRs and SSFRs can occur with both arrows of time. Motor action would be a cascade of BSFRs with each BSFR inducing sensory perceptions as SSFRs at lower level inducing in turn motor actions as BSFRs in shorter time and length scales. The above model is a generalization of this picture.

The model

Could one apply ZEO also to the experiment under consideration?

1. Could one think that the experiment involving BSFR had in some sense already occurred (with respect to subjective time) when the experimenters got the idea to perform the experiment as a control signal from the geometric future? Experimenters and participants would have been like neurons in the brain of participants of Libet's experiment demonstrating that neural activity precedes experience about act of free will [J34]. They did what the already occurred experiment forced them to do. They of course had a lot of free will but not at this level of hierarchy of conscious entities but in shorter time scales and this made possible the needed preparations.

2. Experimenter informed the members of group A about the arrangement of the experiment. Therefore the members of group A concentrated on a process which was actually an attempt

to remember in a reversed time direction and they were successful. The participants in group B did not know that the experiment would be arranged and made only guesses.

3. The objection is that in applications to atomic systems, Libet's experiments and earthquakes, one speaks of what an outsider with the standard arrow of time observed. Now one however talks about the participants of experiments and BSFR would now affect them. Does this really make sense?

   Here the notion of MB could come in rescue. BSFR would occur at the level of a collective MB of the system involving participants and experimenters and induce the outcome of BSFR and would change the arrow of time only at this level of MB. The participants at lower levels of hierarchy would receive information from the collective MB as time reversed control and communication signals. The signals would be received if the participant tunes herself to the correct wavelength - that is performs a memory recall, which would become possible after learning that the experiment will be actually performed.

8.9.3 How could the higher levels of MB use the brain to realize their free will?

The proposed model assumes that the experienced long terms goals (in the recent case the goal of experimenter to perform the experiment) correspond to SFRs that have already occurred at some higher layer of MB controlling the brain.

Neuroscience supports the view that frontal lobes are responsible for long term planning and decision making. They are involved also with the self model. This suggests that the highest layers of MB control frontal lobes. There would be a hierarchy of layers of MB having frontal lobes at the bottom.

Model for the coupling of MB with frontal lobes in terms of cognitive entanglement

A natural assumption is that the control of biological body by MB involves entanglement. Since frontal lobes are associated with high level cognition, this entanglement could be cognitive entanglement discussed in [L68]. Cognitive entanglement is a hierarchical entanglemen between wave functions in hierarchy of sub-groups in the factorization of Galois group to a product $G_1 G_2 ... G_n$ of sub-groups reflecting directly the representationof extension as extension of extensions of .... of rationals.

What is special is that entanglement is directed like attention and hierarchical just like for the slaving hierarchy. The entanglement between states in group algebras of G_1 and $G_2...G_n$ is directed from boss G_1 to slave $G_2..G_n$. Cognitive SFRs are cascades proceeding downwards and reducing entanglement. Negentropy Maximization Principle can however prevent the cognitive measurement cascade from proceeding down to G_n [L72] if it does not give rise to negentropy gain.

Long term goals could involve this kind of cognitive entanglement assignable to directed attention and motor actions as BSFRs at this layer of MB would produce what is experienced by the levels of the hierarchy with the standard arrow of time as a behavior with long term goals. This would produce what could be regarded as analog of precognition [L89] and identifiable as sensory perception of signals propagating to non-standard direction of time. Precognitive dreams would be an example of this.

What happens when frontal lobes are damaged?

This vision conforms with what happens when frontal lobes are damaged. Although intellectual abilities are not lost, long term planning is not possible and the patient loses the ability to initiate actions. Damage can also lead to idiot savant phenomenon [J54]. Although the person seems to lack conceptual thinking completely, he/she can possess miraculous looking mathematical skills [L28] [K90] or artistic gifts [L24] [L24]. In some poorly understood sense idiot savants can be extremely intelligent.

Is the character of the cognitive entanglement changed or replaced with something totally different in these situations? TGD predicts two kinds of information related to two different representations of genetic code which relate to each other like function represented by its local

values to its Fourier transform as a non-local and holistic representation [L67, L71]. The local representation of the genetic code is in terms of bits and using sequences of genetic codons as units of 6 bits. The second representation is in terms of 3-chords of light defining the allowed chords of a bio-harmony. Music expresses and induces emotions and bio-harmony would characterize a mood. Emotional intelligence would relate to this representation. Could it be that for idiot savants non-verbal emotional intelligence dominates.

The duality of these two representations of genetic code is highly analogous to the duality of momenta and position coordinates in wave mechanics. In quantum TGD this duality has as an analog $M^8 - H$ duality [L63, L64] stating that space-time surfaces can be regarded as 4-surfaces in $H = M^4 \times CP_2$ or in M^8. $M^8 - H$ duality relates these representations. H corresponds to ordinary differential geometric space-time representation involving also the notion of field. M^8 identifiable as 8-D momentum space corresponds to non-local algebraic and number theoretic representation, which is non-local and holistic since the momenta are analogous to frequencies. Scattering amplitudes in particle physics provide an example of this representation.

Both representations can be used and it depends on the situation which representation is more appropriate. Could it be that for ordinary *resp.* emotional intelligence H *resp.* M^8 representation is more appropriate? Could one exaggerate and say that not only idiot savants but also people in timeless meditative state and experiencing no separations (produced by cognitive SFRs), and maybe also children "live" in M^8 whereas the ordinary people with their tight time schedules and busily performing comparisons "live" in H? Momentum eigenstates are delocalized.

Are meditative states labelled by finite simple groups?

What could be the counterpart of meditative state without cognition be at the level of cognitive representations? Could it correspond to a situation in which it is not possible to create separations as decompositions to unentangled system pairs by reducing the entanglement between the factors of the Galois group G?

This is certainly the case if G is simple, that is does not allow this factorization at all. Simple finite groups are the basic building bricks of finite groups: the classification theory for simple groups [A2] (`https://cutt.ly/Pj2i2Nx`) states that simple finite groups is cyclic and of prime order, alternating group consisting of even permutations of n objects, group of Lie type or one of the 26 sporadic groups or Tits group. The meditative states of pure consciousness would correspond to finite simple groups!

A question about possible classification of meditative states definitely raises eyebrows. But the power of mathematics is miraculous: if one agrees that thinking means SFRs (thought generates separations and comparisons) and that in meditative states thinking ceases, this is the conclusion. Rather paradoxically, the "idiot savant state" would be cognitively irreducible in the same sense as the states of Hilbert space with prime dimension do not allow a representation as entangled states. They would represent elementary particles of cognition - fundamental ideas - from which more complex thoughts are composed by performing repeated extensions. The basic advice of meditative practices is to stop thinking: maybe this is indeed the manner to achieve the state of understanding.

Chapter 9

Quantum Model of Memory

9.1 Introduction

The ideas related to the quantum model of memory have developed gradually from very general ideas to reasonably concrete models and a connection with biological quantum computer type systems has emerged. It is good to list the basic ideas and notions briefly to get and idea about this process which is still continuing.

9.1.1 ZEO And Self

Zero energy ontology (ZEO) allows a rigorous formulation of earlier vision about memories as something involving communication with geometric past using negative energy signals.

1. In ZEO unitary M-matrix between positive and negative energy parts of zero energy state defines particular zero energy state. M-matrices characterize zero energy states and are square roots of density matrices reducing to a product of real and diagonal hermitian matrix and unitary S-matrix S common to al of them. M-matrices can be assumed to be orthogonal and form effectively orthogonal basis of matrices.

2. Self corresponds to a sequence of repeated state function reductions in which neither the passive boundary of CD nor states at it is changed. The state function reduction sequence corresponds at the active boundary to a sequence of U-processes each followed by a localization in the moduli of the active boundary but without any state function reduction at it.

   This sequence of state function reductions gives rise to the experienced flow of time and the contributions to consciousness from passive boundary give rise to the experience about static observer, the self and to varying contribution to the experience representing sensory input. Figure-background separation is clearly involved.

   The first state function reduction to the active boundary means death of self and its re-incarnation at formerly active boundary. Self experiences time reversal, and for mental images of self (sub-selves) this change is certainly highly non-trivial and must have effect on how self experiences the sub- self.

   This chapter was written much before the emergence of ZEO based view about self and I have kept the text almost as such trying to add some comments about how the ZEO based view simplifies the situation. For instance, the considerations related to the life-time of self reduce to few lines if ZEO based view is applied.

9.1.2 Geometric And Subjective Memories

The identification of moment of consciousness as quantum jump between histories suggest two kinds of time developments, subjective and geometric, and therefore also two causalities and memories. By the 4-dimensional general coordinate invariance (GCI) of quantum TGD, geometric memories

contain information about entire quantum and classical histories. This means that there is no absolute need to store memories of the geometric past to the geometric now. This has dramatic implications for the modelling of brain and allows to get rid of the basic problem of the memory models, namely the fact that the storage of new memories unavoidably tends to destroy the old memories whereas it seem that childhood memories are actually the most stable ones.

Strong form of holography allows to make more this picture more precise. Information about memories is coded by data assignable to string world sheets and partonic 2-surfaces and the partonic 2-surfaces and strings connecting them would appear as carriers of the basic data. Even more, at the this level only the strings carry the data about Yangian Noether charges of super-sympelectic generating the zero energy states.

To remember geometrically means sending signal to the geometric past and receiving it. In ZEO this means that some sub-self (mental image) dies (or falls a sleep) and re-incarnates so that signals traverse to the direction of geometric past. After than death and re-incarnation (wake-up) occurs again and this means positive energy signal to the geometric future possibly creating the mental image about memory becoming conscious after wakeup of sub-self.

Subjective memories could result from time-like entanglement between sub-selves defined by M-matrix. In this case the square root of the matrix appearing in M-matrix would reduce to a projection operator multiplied by S-matrix having no elements beween the sub-space defined by projection operator and its orthogonal complement. Therefore one would have negentropic entanglement (NE) with a unit density matrix. This kind of memories would be interpreted as sharing of mental images of future and past selves. It is somewhat questionable whether this mechanism is mathematically feasible.

9.1.3 Spin Glass Model Of Memories

One of the relatively early ideas was that the 4-dimensional quantum spin glass property of TGD universe must have fundamental role in the realization of memories. Spin glass property predicts fractal energy landscape in which there are valleys inside valleys inside valleys and memories correspond to self-organization patterns associated with sub-self having interpretation as processes leading to bottoms of various valleys. In TGD framework energy minima are replaced by the maxima of Kähler function defining configuration space geometry as a function of zero modes which are effectively classical variables in the sense that in each quantum jump a complete localization occurs in these variables. One can also consider the interpretation of "energy" as binding energy of bound states as function of zero modes. The higher the value of the binding energy, the deeper the valley, and the higher the probability that system ends up to the bound state and the longer the time spent in the bound state.

Four-dimensionality means in ZEO that 3-surfaces are pairs of 3-surfaces at opposite boundaries of CD connected by a preferred extremals for which classical Noether charges in quantum critical sub-algebra of super-symplectic algebra vanish. This means very strong correlations between 3-surfaces at the boundaries of CD implying that they are analogous to Bohr orbits. This also implies that self-organization can be regarded as occurring for the superpositions of space-time surfaces analogous to representations of behaviors or functions in the sense of biology.

One can also regard life as a process of carving a 4-dimensional statue gradually quantum jump by quantum jump. The longer the extension of the valley in the temporal direction and the larger the number of copies of the valley is, the more reliable the memory recall is. The best way to learn to remember is to remember. The depth of emotion determines how deep and long in temporal direction the valleys representing memories are.

9.1.4 Mirror Mechanism

MEs provide a mechanism of long term memory which differs from ordinary sensory perception only in that the ME giving rise to a geometric memory has much longer duration with respect to the geometric time than the ME giving rise to ordinary sensory perception. To remember something at temporal distance T in the past is to look at a mirror with length $L = cT/2$. The mirrors in question must have astrophysical sizes measured in light years typically and this of course raises obvious objections against the model. Although this mechanism as such is too strong an idealization, it can serve as a starting point. For instance, MEs can be also curvilinear and

could propagate along closed magnetic flux loops of the personal magnetic body serving effectively as wave cavities and suffer few reflections: this would make possible high precision targeting.

At quantum level remembering means sharing of mental images: this corresponds to the quantum entanglement between the sub-selves of the geometric now and of the geometric past. The classical non-determinism of Kähler action is essential in making possible entanglement between systems having time-like separation. This would be the mechanism of episodal memory, For non-episodal memories only the mental image representing the desire to remember would be shared, and the answer from the geometric past could be realized as classical communications using MEs. Commmunication would be based on some code, perhaps memetic code, and would generate a conscious experience in the receiving end, typically verbal memory. Positive energy MEs would propagate with ultra low effective phase velocity inside brain or along magnetic flux tubes of astrophysical size with sub-luminal effective velocity (say alpha wave effective velocity). The most often needed non-episodal memories, say short term memories, could be communicated automatically: in this case the memory recall would be a geometro-temporally local operation, much like taking a sample from a data stream representing particular kind of memories with a particular time span. The option is probably not realized for all non-episodal memories since this would require large energy expenditure.

In this framework synaptic strengths code only cognitive representations and learned associations, not genuine information about the events of the geometric past. Brain can be seen as kind of a collection of standardized features serving as building blocks of sensory and memory representations. Long term memory is coded in the classical em/gravitational fields associated with and in coherent light/gravitons generated by MEs in hologram like way. Any finite space-time region receiving the classical em field of coherent light/gravitons generated by it gets hologram like picture containing info about entire geometric time interval spanned by ME. If vacuum current is localized to some restricted space-time region (it can be!), the hologrammic information is about this region and receiver anywhere along the ME gets more or less the same information since hologram is in question. Note also that the light-likeness of the boundary of ME implies that ME selves have temporal extension defined by the length of ME.

9.1.5 Third Person Aspects Of Memory

Topological quantization implies the notion of field body: field body accompanies any system be it molecule or human body. Field body serves as kind of a manual providing higher level abstract representations about the quantum aspects of the physical body. The model of sensory representations realized at personal magnetic body and at Earth's magnetic body explains both the first and the third person aspects of our sensory experience. Also memories should have third person and transpersonal aspects realized at the magnetic body of Earth. This prediction is testable: moon traveller consciousness should have different third person aspect or this aspect could be even absent. Third person aspect should be crucial for the generation of social structures and the rapid weakening and reversal of Earth's magnetic field predicted to occur within next 2 millenia might have dramatic effects for the future of the civilization.

The sharing of mental images is crucial for the model of the third person aspect of memories. What happens is that sub-self of brain entangles with with the sub-self of the magnetic sensory canvas in the geometric past. One could perhaps interpret spontaneous episodal memories as a basic example of memories communicated by some sub-self of magnetic Mother Gaia to us.

9.1.6 Symbolic And Cognitive Representations Of Memories

Most of our memories are not direct re-experiences. In fact, it would be difficult to tell whether memory is really in question if this were the case. Rather, memories are highly conceptual and based on symbolic representations making possible huge filtering and compression of information. Only in some special cases direct re-experiencing occurs. The inherent nondeterminism of the p-adic field equations and the classical non-determinism of Kähler action make possible to represent sequences of quantum jumps determining the contents of consciousness of self at space-time level in terms of p-adic or real space-time sheets, that is cognitively and symbolically. Symbolic representations are crucial for memories whereas cognitive representations are crucial for intentions. Symbolic representations allow to store information about geometric past to geometric now: history writing

is just this kind of activity. Also brain is doing history writing: to remember is also to form a new memory representation.

It is highly plausible that memory representations are highly abstracted and that the signals from the geometric past do not recreate directly the experience but serve as names for standardized self-organization patterns of neuronal activity, "features" giving charicature of the experience. This means that it is not easy to distinguish between TGD based model and standard model of memories.

9.1.7   Bio-Supercomputers And Memories

The most recent but certainly not the last step in the development of ideas was the realization of a connection between macrotemporal quantum coherence, quantum spin glass property of the TGD universe, classical and quantum gravitation, and the mirror model of geometric memories.

The interpretation of quantum jump as a creation of a totally entangled holistic state $U\Psi_i$ which is then analyzed to pieces allows to interpret self measurement cascade as a conscious analysis. The temporal fractality of consciousness suggest that the lifecycle of any self can be seen as a generation of multiverse of potentialities followed by analysis (and decay) process. One can see the situation also differently. The conscious experience of self is average over moments of consciousness and the eventual thermalization induced by the quantum jump sequence destroys all conscious information. There must be some mechanism hindering this and making macrotemporal quantum coherence possible.

To achieve macrotemporal quantum coherence self must be irreducible self for which self measurements and analysis do not occur. The self must also have large number of zero modes transformed to quantum fluctuating degrees of freedom and this is achieved if self corresponds at space-time level to a join along boundaries condensate. In this process the zero modes of the condensing space-time sheets become quantum fluctuating degrees of freedom. In this "state of oneness" self is able to carry out quantum computer like information processing which is the diametrical opposite of analysis. The decay of this bound state to its components corresponds to the analysis period at the level of self.

Macrotemporal quantum coherence is possible by the quantum spin glass property of TGD universe making the lifetimes of bound states much longer than in the universe obeying standard physics. Different almost degenerate vacuum space-times differ only because they have different classical gravitational energies. The quantum transitions between these almost degenerate states involve emission of MEs representing gravitons. These topological graviton rays are reflected from the curved almost vacuum space-time sheet acting as a gravitational mirror and self energy diagrams involving emission and absorption of the gravitonic ME have interpretation as correlates for the geometric memory recall. The time scale of human memories is between millisecond and 100 years and this time scale characterizes the gravitational energies for systems having sizes between cell size and cell membrane thickness (the number theoretical miracle is that all p-adic length scales in this range correspond to Gaussian Mersennes). Microtubules are excellent candidates for realizing long term declarative memories at bit level so that a connection with Penrose-Hameroff views emerges.

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` [L17].

9.2   Different Types Of Memories

TGD predicts two kinds of memories corresponding to two different time developments. There is deterministic (in generalized sense) time development with respect to the geometric time and the nondeterministic time development by quantum jumps with respect to the subjective time. The memories with respect to subjective time are about previous conscious experiences and "real" whereas geometric "memories" are prophecies giving simulations of the geometric past and future assuming that quantum jumps do not alter the macroscopic properties of the space-time surface. A good visualization is following: each quantum jump represents particular geometric memory whereas the heap of these memories gives rise to subjective memory. The comparison between expectations and reality is obviously a central part of mentality and the heap structure implies

that this comparison is a basic function of conscious mind not reducible to anything simpler. It is well-known that our memories involve a lot of construction and are more like stories consistent with what we actually have experienced than actual documents of what happened. Perhaps geometric memories constrainted by subjective memories give rise to the "story".

One can distuinguish between several memory types such as short term memory and long term memory, episodal memory, procedural memory, implicit memory and associative memory, and it is interesting to try to find whether these memories could be understood in the proposed conceptual framework. In the discussion below concrete mechanisms for the realization of geometric memory are not discussed: the reader interested on this aspect of geometric memory can consult [K39].

9.2.1   Geometric And Subjective Memories

There are two times in TGD: subjective and geometric. In accordance with this there are also two kinds of memories: subjective and geometric[1].

1. The temporal binding of the experiences associated with quantum jumps occurred after the last "wake-up" of the self gives rise to subjective memory defined as memory about earlier conscious experiences and is identifiable as an immediate conscious memory, "psychological now", presumably of duration of fraction of second in case of sensory experiences. There is infinite hierarchy of subjective memories and if long term memories are genuine subjective memories (this need not be the case!), they could correspond to conscious short term memories of higher level selves somehow communicated to the lower level. An essential element is the possibility of sub-selves inside self having much shorter lifetime and organized in a subjecto-temporal sequence: without them the average over the quantum jumps would destroy the information and it would not be possible to remember the digits of a phone number. Various rhythmic actions (such as micro tremor of eyes at 80 Hz frequency and muscle tremor) could generate a sequence of sub-selves with constant duration and thus a clock measuring subjective time.

2. Geometric memories are like a classical physics based model for the universe. They are memories with respect to geometric rather than subjective time and predict what must have happened in the geometric past and what will happen in the geometric future assuming that world is classical (no quantum jumps). The temporal extension of the mind-like space-time sheets and the notion of the association sequence (3-surfaces consisting of a sequence of space-like 3-surfaces with time-like separations providing a simulation of classical history) make possible geometric memories. A natural hypothesis is that the macroscopic space-time associated with the final state of the quantum jump represents the geometric memory. Of course, only part of it becomes conscious and temporal binding implies that self experiences kind of temporal average of the geometric memories associated with the quantum jumps. An attractive possibility is that our long term memories, which have narrative character and are unreliable, correspond to geometric memories. This would mean that there is no need for memory storage mechanisms, four-dimensional brain would take automatically care of memory storage.

Intentionality manifests itself in many ways: as expectations of the future, planning, goals, desires, fears, imagination, intuition etc.. It seems natural, and this is the only possibility given the fact that it is not possible to know anything about future quantum jumps, to identify all aspects of intentionality with the predictions of the expected geometric future provided by the mind-like space-time sheet. Geometry as such contains nothing intentional. Rather, the intentional aspects of the conscious experience reflect the attitudes towards the expectations provided by the geometric memory.

---

[1]The attribute "subjective", as it is used in TGD context, does not have quite the same meaning as it usually has as something non-objective and unreliable: "subjective" derives its meaning from "subjective time" as consciously experienced time as opposed to the geometric time of physics.

"Memories" with respect to geometric time as simulations

Geometric memories are predictions/simulations for what would happen if no further quantum jumps would occur and what would have happened if no quantum jumps had occurred in the past. Simulations and expectations rather than real memories are in question. Geometric memories become reliable in the classical limit, when the effect of quantum jumps becomes negligible. In the deterministic world of classical physics geometric memories would be absolutely reliable. It is indeed possible to predict rather reliably what will happen in the solar system during the next decade. Geometric memories are a prerequisite of the intentionality often regarded as a basic characteristic of conscious mind: beliefs, expectations, plans, etc. involve geometric memory in an essential manner. The computational approach to mind assumes only geometric memories.

The memory with respect to geometric time is possible even assuming that single quantum jump determines the contents of conscious experience completely. However, if the contents of conscious experience are determined completely by the initial and final quantum histories of single quantum jump, it is in principle impossible to have genuine memories about previous conscious experiences. This does not make it impossible to have a model for the most probable subjective life history through simulation. Quantum statistical determinism could make these simulations possible. One must however admit that the hypothesis about subjective memory, naturally identifiable as a short term immediate memory defining the duration of psychological moment, makes things extremely simple and natural. One could also argue that in a universe without subjective memory it would not be possible to discover the notion of quantum jump so that internal consistency of the theory of consciousness requires genuine memory about earlier conscious experiences.

Mindlike space-time sheets and simulations

It is a fact that we can plan future in the time scale of life time. We can also quite reliably extrapolate to the past without direct memory of what happened. The simplest explanation is that the time extension associated with those mind-like space-time sheets, which we have access to, is of the order of lifetime or perhaps even longer. The simplest model for the simulation would be based on an ensemble of thoughts scattered around entire material space-time history defined by, say, my body. Quark sub$-CD$s could realize thoughts as Boolean algebra of statements and could be present everywhere in condensed matter, in particular in water, which is expected to have very rich hierarchy of space-time sheets. Self would experience the sum of the abstracted experiences of ensemble members and experience a simulation about what happens in future and what happened in past assuming that quantum jumps will not occur in future and did not occur in past.

Of course, selves could also do what computers do, namely mimic other selves by building cognitive representations about them at their own space-time sheets. This would make it unnecessary to jump between the levels of the self hierarchy. These representation could have quite different temporal and spatial scales and the presence of the time scaled versions about time development of other selves would realize the fractality aspect related to the idea about Universe as a hologram. DNA could be an example of this kind of simulation of the entire lifespan of individual in molecular length and time scales. Monte Carlo simulation of elementary physics experiment could be also regarded as a simulation of this kind.

The difference between intentions and geometric memories

Intentionality, understood here as time-directedness, manifests itself in many ways: as expectations of future, planning, goals, desires, fears, imagination, etc.. The basic element of mentality is the comparison between the expectations of future and what actually occurred. In TGD framework this tension between potential and actual can be understood. The temporal extension of the mind-like space-time sheet makes possible expectations of what happens in the future assuming that no quantum jumps occur or at least that quantum jumps do not change the macroscopic space-time. Single quantum jump contains information about this kind of expectations. Subjective memory in turn tells what happened actually. Therefore it seems natural, and this is the only possibility given the fact that it is not possible to know anything about future quantum jumps, to identify the predictions of the expected geometric future provided by the mind-like space-time sheet as a basic prerequisite of intentionality.

Subjective memory makes it possible to compare the expectations with what really occurred since subjective memory is kind of a heap of predictions of future arranged with respect to the value of the psychological time. The origin of at least some emotions, which often involve a comparison of what happened and what was expected to happen, is perhaps here. It is quite well possible that all comparisons must be realized as comparisons of the subjective and geometric time developments. It seems that self can also compare its sub-selves, which correspond to simultaneous mental images.

The possibility of this comparison provide a solution to the paradox raised by the innocent question "How do I know that the me of today is the same as the me of the yesterday? How do I even know that I existed yesterday?". The solution might be simple: mind-like space-time sheets have extension which can be much longer than the duration of the subjective memory. Therefore subjective memories contain information about the geometric me of the yesterday and geometric me of today and since these me's resemble each other quite a lot, the conclusion is that also the yesterday's me was a conscious self living in this same body. It is however quite possible that temporal entanglement with higher selves still remembering my past wake-up states is also involved and realized as a formation of join along boundaries bonds between the mind-like space-time sheets of my self and of higher level self. Higher level self could also communicate directly the subjective memories about my existence to me.

What is the temporal extension of mind-like space-time sheets?

With respect to subjective time self and its sub-selves can be characterized by the typical durations of the wake-up state. With respect to the geometric time self (or rather, mind-like space-time sheet) can be characterized by its own duration and the durations of the mind-like space-time sheets which it contains. The time span for the predictions and memories provides an estimate for the duration of mind-like space-time sheets. mind-like space-time sheets can have time-like separations. Mind-like space-time sheets of geometric past could represent memories so that conscious memories could be regarded as multitime experiences and the distances between mind-like space-time sheets could be quite large, of order lifetime.

Zero energy ontology allows to answer this question quantitatively. Space-time surfaces correspond to surfaces inside causal diamonds (CDs) having space-like ends at the boundaries of CDs and the size scale of CD characterized the size scale of self as a geometric entity. The order of magnitude for the size scale is expected to be of the same order of magnitude as duration of life cycle of self.

In ZEO based view about self, the size of CD is not equal to the life-time of self. Rather, the increase of the size scale of self during state function reduction sequences taking place at same boundary of CD and not changing state at it defines the life-time of self.

Life-spans of sub-selves

Sensory experiences seem to correspond to a well defined geometric now having perhaps duration of order .1 seconds. Thus it seems that mind-like space-time sheets representing my sensory sub-selves have rather short time extension, of order .1 seconds. "Ontogeny recapitulates phylogeny principle" (ORP) suggests that the extension is of same order as the duration of the immediate subjective memory, something like .1 seconds. This prediction is certainly consistent with the typical resolution of the sensory experience, say the ability of the visual system to discriminate subsequent pictures as separate pictures. Quite generally, the p-adic time scale $T_p = L_p/c$ characterizing the mind-like space-time sheets gives the first guess for the duration of the mind-like space-time sheet and duration of geometric memory provided by it. Note that .1 seconds gives for the p-adic length scale L_p and estimate which is about circumference of Earth!

The fact is that we have childhood memories, plan future and make reliable predictions. This is not in contradiction with the duration of the mind-like space-time sheets associated with sensory sub-selves. The mind-like space-time sheets representing sub-selves (mental images) can be located in geometric past or future so that multitime experiences with mind-like sheets of past and future contributing to the experience are possible.

The duration of .1 seconds is the duration of typical sub-selves representing our mental images. The geometric duration of the mind-like space-time sheet representing our "main self"

should be much longger since it contains mind-like space-time sheets distributed along entire life span.

The sub-selves which have fallen asleep, wake-up again generating new wave of sensory experience. For instance, mental images (after images) typically re-appear periodically. We are also mental images of larger self in the hierarchy and the periodical appearenc e of of our mental images suggests that also we appear periodically as mental images of this larger self. This would mean reincarnation in the geometric past so that our life would be lived again and again. Entire trains of mind-like space-time sheets could wander through time again and and experience what it is to live in a particular body. Therefore my body could live again and again: by p-adic evolution each life would tend to be slightly better than the previous one. The civilizations of past could be still well and alive and even more civilized! This picture could perhaps explain why persons in their old age sometimes begin to live their childhood again.

As already noticed, the ZEO based view about self allows a precise identification for the life-time of self.

What is the subjective duration of "our" self?

Our conscious experience is some kind of an averaged sum over all conscious experiences associated with the quantum jumps occurred after the last "wake-up". If the averaging is completely democratic, the only possibility is that our sensory sub-selves have duration not much longer than the the time resolution of the sensory experience of order .1 seconds. Contrary to the original beliefs, this does not in principle pose any limitation to the duration of "our" self.

There are thus several options concerning the duration of our self.

1. Our self could have duration not much longer than the duration of immediate short term memories of order .1 seconds. The ability to remember digits of a phone number requires that the duration is indeed longer. For this option it is not at all obvious how the subjective experience of personal continuity is possible.

2. The duration could also correspond to the wake-up period. Also now the problem is how we know that this self existed already yesterday. Note that the gradual thermalization of sub-selves means that subjective memories represented by sub-selves get gradually fuzzy so that the digits of a phone number are forgotten even if our self has duration of order wake-up time.

3. Our self has a duration of order lifetime, or even longer and only the mental image representing our physical body has duration of order lifetime. A possible objection is that the mental image representing our self becomes gradually more and more entropic unless it manages to fight against second law. This might of course correspond to ageing.

Third option deserves a more detailed consideration.

1. The geometric duration of our "main" mind-like space-time sheet should be of the order of life span if geometric memory explains long term memories. "Ontogeny recapitulates phylogeny" principle would suggest that also the subjective duration of our "main" self is of order life time. This option would explain elegantly the fact that we possess subjective identity: this kind of subjective identity would be a logical deduction in case that our main self has duration shorter than life time.

2. This option would mean that we are not actually unconscious during sleep but are only unable to remember anything about what happened during sleep. This would be rather natural since various sensory and cognitive sub-selves are not conscious during sleep periods so that also multitime experiences in which sensory sub-selves wake-up in night time are rare! It might be also possible to remember events occurred during sleep state only during sleep.

3. Note that the claims about near death experiences in which entire life is experienced as a kind of film, could be interpreted as very intensive experiences in which mind-like space-time sheets along the entire life span "wake-up" and give rise to multitime geometric memories. Alternatively, if bodily self with a duration of order lifetime is a sub-self of our self (perhaps

identifiable as the self associated with our magnetic body), the bodily self representing entire life cycle could be experienced as a mental image. Also shorter bodily sub-selves forming a subjectotemporal sequence, "film", could be experienced in the absence of the ordinary sensory input.

ZEO based answer is that our life-time corresponds to the increase of the size scale of CD serving as correlates for us. The simplest expectation is that this size scale is of same order of magnitude as our CD.

9.2.2 Habits, Skills, Associations

The universe of TGD is quantum spin glass [K87]. This provides extremely general conceptual framework for understanding how memories/habits/learned skills/ associations are formed.

1. Mental images (in particular memories) correspond to sub-selves undergoing self-organizing time development by quantum jumps leading to self-organization patterns selected by dissipation. Thus both memes and genes, in particular long term memories, can be regarded as winners in the fight for survival in which dissipation is the ultimate Darwinian selector. Inhibitory and excitatory nerve pulses might physically realize "frustrations" which make possible large number of almost degenerate energy valleys.

2. The universe of TGD is quantum spin glass characterized by a fractal "energy" landscape having valleys inside... inside valleys (directories inside...inside directories). This structure is ideal for a hierarchical representation of memories. Memories must correspond to valleys of the spin glass "energy" landscape into which dissipation takes the system. Memory formation is active process and memories are charicatures rather than photos and deep valleys of the energy landscape represent these charicatures. Hippocampus, known to be involved with the formation of the long term memories, could control the rate of motion in these control variables. The plastic regions of the brain are the most spin-glassy ones and are the most probable seats of the long term memories.

3. System has some territory in the energy landscape. The motion in the zero modes serving as control variables causes a slow shift of the entire territory. Synaptic strengths corresponds naturally to the slow control variables characterizing the position of the territory. In the presence of a metabolic energy feed and sensory input system moves around this territory.

ZEO and NMP provide powerful additional tools, which were not available when the first version of this chapter was written. In ZEO self-organization can be seen as self-organization of 4-dimensional patterns having as space-time correlates space-time surfaces (preferred extremals of Kähler action) connecting space-time 3-surfaces at opposite boundaries of causal diamond. One can say, that basic objects are not 3-D time=constant snapshots but entire time evolutions. Behavioral patterns, functions, habits are the natural basic notions. This has especially interesting implications to morphogenesis, where the notion of magnetic body as kind of morphogenetic field and template for the self-organization of matter around it, becomes the key notion [K55]. Equally interesting are the applications to genetics and neuroscience [?]

9.2.3 Is Genuine Subjective Memory Really Necessary?

For a long time the basic hypothesis of TGD inspired theory of consciousness was that the contents of conscious experience are determined totally by the initial and final states of *single* quantum jump. A heavy objection against this assumption is that the hypothesis makes it impossible to have genuine memories about previous conscious experiences. The concept of self however allows the possibility that the connected series of sequential quantum jumps performed by self after its last "wake-up" integrates to single conscious experience. This hypothesis realizes self as an extended object in subjective time allowing it to have memories about previous conscious experiences rather than only memories with respect to geometric time. An attractive additional assumption is that the conscious experiences of self are kind of subjecto-temporal statistical averages. This would make experiences reliable. In particular, sensory experiences can give objective reliable knowledge

despite the fact that the outcomes of individual quantum jumps are not predictable. The undesired implication is that for long sequences of quantum jumps averaging leads to a total loss of information.

The original vision was that geometric memory is made possible by the finite temporal duration of the what I called mind-like sheets. The emergence of zero energy ontology led to the conclusion that all space-time sheets are mind-like since one can assign them to the interior of CDs. Depending on one's tastes one could of course refer to p-adic space-time sheets as mind-like (or cognitive). p-Adic space-time sheets are identified correlates of intentions, plans, desires, ... whereas real space-time sheets would correspond to sensory experience and sensory memories. Geometric memories are about geometric past and serve as prophecies telling what would have happened if quantum jumps were not constantly replacing macroscopic space-time with a new one. Precognitions which can be only geometric tell what would happen if no further quantum jumps take place. Subjective memory makes it possible to compare what actually happened with what was expected to happen. It might be that this comparison is one of the fundamental irreducible mental acts. There is a sharp difference between ordinary memories on one hand and precognition and memories about time before birth (the region in the geometric past of the CD assignable to the 4-dimensional biological body) since the interior of "personal" CD is in a preferred position. Interestingly, the CD corresponding to a life time of order 100 years corresponds to a primary p-adic length scale of order 10^{-7} meters and the age of the universe to 10^{-4} meters, the size scale of a large neuron.

A natural identification of the subjective memory is as immediate short term conscious memory, or actually a hierarchy of short term memories corresponding to the hierarchy of selves. This identification requires that the subjective durations of our sensory selves are typically of a fraction of second, .1 seconds is suggested by various arguments relating to the ability to experience subsequent stimuli as separate ones and corresponds to the duration of psychological moment. This time scale corresponds to the temporal size scale of the CD of electron. The narrative character of the long term memories suggests their identification as geometric memories: long term memories could correspond to multitime experiences with contributions coming also from the geometric past (say childhood). It turns out that this identification explains basic facts about long term memories. Declarative memories are assumed to involve negative energy signals suffering a time reflection from the brain of the geometric past. The condition that the energies of the corresponding photons are above thermal threshold can be satisfied if the value of Planck constant is large enough. The emergence of long term memory and planned action would involves in an essential manner the emergence of large values of Planck constant [K36].

9.2.4 Spin Glass Model Of Learning And Long Term Memories

The universe of TGD is quantum spin glass [K87]. This provides extremely general conceptual framework for understanding how memories/habits/learned skills/associations are formed.

1. Mental images (in particular memories) correspond to sub-selves undergoing self-organizing time development by quantum jumps leading to self-organization patterns selected by dissipation. Thus both memes and genes, in particular long term memories, can be regarded as winners in the fight for survival in which dissipation is the ultimate Darwinian selector. Inhibitory and excitatory nerve pulses might physically realize "frustrations" which make possible large number of almost degenerate energy valleys.

2. The universe of TGD is quantum spin glass characterized by a fractal "energy" landscape having valleys inside... inside valleys (directories inside...inside directories). This structure is ideal for a hierarhical representation of memories. Memories must correspond to valleys of the spin glass "energy" landscape into which dissipation takes the system. Memory formation is active process and memories are charicatures rather than photos and deep valleys of the energy landscape represent these charicatures. Hippocampus, known to be involved with the formation of the long term memories, could control the rate of motion in these control variables. The plastic regions of the brain are the most spin-glassy ones and are the most probable seats of the long term memories.

3. System has some territory in the energy landscape. The motion in the zero modes serving as control variables causes a slow shift of the entire territory. Synaptic strengths corresponds naturally to the slow control variables characterizing the position of the territory. In the presence of a metabolic energy feed and sensory input system moves around this territory.

One can consider two general models of learning and memory recall in this framework, the TGD version of the neural network model and the genuinely TGD based mechanism on the notion of the geometric memory. Consider first the TGD based version of the neural network model of memory.

1. The possible memories of the system correspond its territory in the "energy" landscape. Learning means slow change of the shape of the territory so that memory valleys get gradually deeper and system ends up to them with larger probability in future.

2. Repeated simulated annealing provides a promising memory recall mechanism. The feed of energy from metabolism kicks the system into a motion and dissipation leads it into some valley. If the valley is quite not correct (correct subdirectory but wrong subsubdirectory), a smaller kick leads the system to the bottom of some nearby valley which might be correct. By applying a sequence of increasingly smaller kicks system finally finds the correct memory valley. The conscious attempt to remember corresponds naturally to an external force forcing the system to move in a correct direction.

There are several objections to this scenario. The first mystery is how system knows that the experience is a memory: there seems to be nothing which would distinguish memory from the experience occurring for the first time. Second problem is that the formation of the new memories tends to destroy the old ones: the new territory is simply not the old one. Even if one could circumvent this paradox, it is difficult to understand why the lively episodal memories of childhood are the most stable ones.

If long term memories are geometric memories then memory recall mechanism corresponds to multitime experiences involving generation of mind-like space-time sheets in both geometric now and past.

1. Learning by repetition means keeping some subsystem in some deep valley for a long period of geometric time (system is still in that valley in the geometric past!). This corresponds to reverberating patterns in neuronal circuits generated automatically or by learning by repetition. In this picture the modification of synaptic strengths is not learning of memories but just what it seems to be: a modification of responses to sensory inputs necessary for survival.

2. The attempt to remember creates mind-like space-time sheets located in the geometric past. The probability that a newly created mind-like space-time sheet is located in the memory valley of long time duration is high and thus conscious memory recall becomes probable. Also very emotional and "catchy" experiences generating long lasting memory valleys are easily remembered. Childhood memories are often very emotional ones and therefore also the most stable ones.

No final vision about what memories are in TGD framework exists yet. What is certain is that one can distinguish between geometric and subjective memories. The idea that episodal memories are ordinary sensory experiences with the object of the perceptive field in the geometric past is very attractive and speculative hypothesis which might work in TGD Universe, but more conventional explanation sounds more realistic in the context provided by the standard neuroscience. What is lacking still is a clear vision about the precise physical realization of long term memories.

9.2.5   Long Term Memories

An important question is whether our long term memories correspond to either geometric or subjective memories or whether they involve both aspects somehow.

Long term memories as geometric memories?

The unreliability and narrativeness of the long term memories would support strongly the interpretation of at least episodal long term memories as geometric memories, that is multitime experiences involving active mind-like space-time sheets scattered along entire life span. This option is consistent with the short duration of subjective memories, which can be even of order .1 seconds characterizing the duration of immediate sensory memories.

Geometric memories could be realized as multitime experiences involving mind-like space-time sheets located around several moments of the geometric time, provide the simplest realization for the long term memories.

1. The model solves the basic difficulties of the neural net models of long term memory. In the neural net models long term memories are represented by synaptic strengths. The problem is that the learning of new memories destroys old memories. In particular, the stability of the childhood memories is difficult to understand. It is also hard to understand how brain knows that the experience represents memory. One cannot avoid the difficulty by saying that novelty detection tells that experience occurs for the first time since the notion of novelty does not make sense if conscious experience contains only information from single moment of geometric time.

2. TGD model is consistent with neural net models and actually generalizes them. Neural net in the spirit of TGD corresponds to brain as system moving in spin glass energy landscape. Self-organization by quantum jumps leads the system to a bottom of an energy valley representing memory. This model is consistent with the fact that there is no upper bound for autobiographical memory. One can also understand how learning occurs. The repetition of an experience means that energy valley becomes a canyon in time direction so that mind-like space-time sheets in the geometric past have a large probability to end up to the region representing memory. In particular, reverberating nerve pulse patterns are ideal for representing long term memories.

3. Highly emotional experiences generate deep valleys and increase the probability of the system of the geometric past to stay at the bottom of valley. This explains why cildhood experiences are so stable. In fact, one could identify primitive emotions of pleasure and pain as related to the motion in the spin glass energy landscape. Pleasure and pain could even directly correlate with the sign of the increment of the Kähler function in the hopping motion in the spin glass energy landscape. Note that primitive pleasure and pain are are very much like sensory experiences and one could regard them as sensory experiences of brain about its own motion in spin glass energy landscape. This leads to the generalization of the notions of sensory experience and motor action to include the motion in spin glass energy landscape and to a considerably new insight about the meaning of the brain architecture.

There are also perinatal experiences, memories about previous lives and transpersonal experiences having natural explanation in terms of geometric memory realized as multitime experiences associated with mind-like space-time sheets located at different values of the geometric time. Transpersonal experiences suggests that self is dynamical: if prenatal experiences, memories about previous lives and transpersonal experiences are really what they seem to be, the geometric time extension of self should dramatically increase during these experiences.

If "our" self has duration of order lifetime, also subjective memories can contribute to our long term memories. As already found, this option does not exclude the possibility that our long term memories correspond to subjective memories.

Geometric memories as sensory experiences with the object of the perceptive field in the geometric past?

The general theory of qualia to be developed in [K39] leads to the conclusion that geometric memories could be regarded as special kind of sensory experiences for which some objects of the perceptive field located in the geometric past. One also ends up with a concrete models for the mechanism making long term memories possible by "waking up" sub-selves of the geometric past in selective manner by EEG frequencies. The unavoidable conclusion is that massless extremals

(MEs) with durations of order lifetime, and hence with sizes which are measured in light years, are necessarily involved. Needless to say, one must give up the idea that we are nothing but our brains.

The fact that the light-like boundaries of MEs serve as quantum holograms and have gigantic information storage capacities by the almost degeneracy of the states fits nicely with view. Lightlikeness means that 3-dimensional time=constant slice of Minkowski space is replaced with a slice which can have arbitrary long temporal duration so that memories become indeed possible. The fact that at least vision represents directly information about outer surfaces of 3-dimensional objects rather than objects themselves but contains information about time development over an interval of order .1 seconds fits nicely with this view.

The realization of long term memories in terms of magnetic quantum phase transitions induced by ME frequencies requires incredibly high frequency resolution. The resolution is of order $\Delta f/f \sim \Delta T/T$ giving $\Delta f/f \sim 10^{-9}$ for time resolution of about $\Delta T = 1$ seconds. An unrealistically high frequency resolution is required if temporal coding by EEG frequencies is assumed. There is also another problem: if the signal to the geometric past and back is between parts of brain, one cannot avoid zigzag type MEs effectively representing a repeated reflection between two mirrors. In the p-adic context these zigzag MEs are allowed by conservation laws (this might relate with the fact that long term memories are mostly cognitive) but not in the real context.

These observations suggests that one should allow MEs and magnetic flux tube structures with length scales of order light lifetime and try to invent a more elegant mechanism of long term memory. One might start from the mirror idea and consider the possibility that memory recall involves a question sent to the geometric past as a classical signal reflected back to brain in a mirror formed by a magnetic flux tube: perhaps passive MEs are involved at this stage. Thus MEs with lengths of order of light lifetime ($L = cT$) would be required. The answer could involves a transformation of passive MEs to active em MEs and the generation of quantum entanglement unless it is present already: the recalled experience is shared by the experiencer now and experiencer in the geometric past. The mechanism involves several purely TGD based features: the light-like character of the boundaries of MEs making possible light-like selves; space-time sheets with a negative time orientation allowing classical signals to propagate backwards in time; the magnetic flux tube structures associated with brain having sizes of order light years making possible MEs to form mirrors. Precognition is the temporal mirror image of this mechanism.

If long term memories are in some sense sensory experiences with the object of the perceptive field in the geometric past, the notion of the magnetic canvas should work also in these astrophysical length and time scales. Consider first the constraints on this mechanism.

1. The sensory experiences at different levels of the magnetic hierarchy cannot be identical. This means that standard sensory representation using magnetic canvas must be applied to realize the episodal memory. This leaves only two possibilities. Either the experience is coded to a light-like vacuum current and this information, when sent into future, regenerates the sensory experience there. Alternatively, future self could entangle with the self of the geometric past and share its experience.

2. Since MEs correspond to 3-surfaces moving with light-velocity, the only possible realization of the communications between geometric past and geometric now is in terms of "laser mirrors" connected by MEs representing geometrically the light reflected in the mirror. The length of ME is given by $L = cT$: $2T$ is the moment of the geometric past which gives rise to the memory. Interestingly, Peter Gariaev has suggested that laser mirrors are involved also with DNA [I30]. This means that a ME extending from the brain of the geometric now to the geometric past and the ME from the brain of the geometric past fuse with the same magnetic flux tube to form a representation for light reflected in a cosmic mirror. The MEs and magnetic flux tube structures associated with the relevant parts of brain must form pre-existing, tightly correlated structures since the probability for the formation of this kind of mirrors accidentally is extremely small and there is no guarantee that they connect parts of the same brain. Second mirror would be obviously defined by the join along boundaries contact/flux tubes of ME with the magnetic flux tube. Hippocampus is a natural candidate for the brain structure, at which the first mirror is located. The fact that MEs represent channelled energy means that distance is not a problem as far as energetics is considered.

3. Active memory recall must involve a question sent to the geometric past followed by an answer communicated to future in some manner. There must be some difference between precognition and memory recall so that the question and answer cannot be realized in the same manner. This serves as an important guideline. Various arguments lead to the view that the desire to remember is communicated to the geometric past by sharing and fusion of mental images made possible by entanglement. In the case of episodal memories also the memory recall would result in this manner. For non-episodal memories the memory would be communicated from the geometric past using classical communications.

Sharing of mental images if time-like quantum entanglement is generated between the selves of the geometric past and geometric now. This is possible in TGD framework, thanks to the non-determinism of Kähler action making also MEs quantum holograms in quantum gravitational sense. The fact that MEs represent light-like selves, would be essential for this realization. The beauty of this realization is that the information need not be transferred classically. This realization is actually a special case of the realization in terms of zigzag ME in much shorter length scale: in this case a huge number of reflections in the mirror pair would be required and it is difficult to understand how one could control the temporal position of the self of the geometric past in this kind of situation.

This picture deserves some further comments.

1. If the higher levels of the magnetic self hierarchy are intelligent as one might expect (and even more intelligent than us), one can also consider the possibility that the step in which the interaction of ME representing a question sent to the geometric past with the magnetic flux tube at the higher level of the hierarchy is far from a mechanical interaction. Rather, the magnetic flux tube structure could act as an intelligent conscious system rather than a mechanical relay station.

2. The process could also have interpretation as an exchange of two virtual MEs between brain and magnetic flux tube structure: kind of a very low frequency counterpart of self energy Feynman diagram realized as a generalized Bohr orbit. The Feynman diagrams for the emission of parallel photons are infrared divergent. This encourages the expectation that the probability for the presence of MEs parallel to the magnetic flux tubes is very high and increases with the increasing length of ME. The spontaneity of the episodal memories is in accordance with this view. An interesting question is how these MEs relate to $1/f$ noise.

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

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

This represents a frequency coding for the temporal location but in a way different from the one proposed originally. In particular, this coding does not require ME frequencies to be in EEG range and defined with a relative accuracy of order $E - 9$. In standard physics the idea about brain generating MEs with a frequency scale of the order of the inverse of lifetime does not make sense: in TGD context situation is different since this process occurs in subjective time.

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

Long term memories as memories of higher level self?

The natural identification of the immediate short term memory as subjective memory predicts that the life time of a human sensory self cannot be much longer than .1 seconds, the duration of psychological moment of time. Our long term memories correspond to much longer time interval and cannot thus correspond to our subjective memories. Entire hierarchy of subjective memories is however predicted and a possible model for *genuine* long term memories is as resulting from temporary entanglement with selves belonging to the higher level of the hierarchy. Also this identification is consistent with the fact that there seems to be no upper bound on autobiographical memory. Summation hypothesis implies that our genuine long term memories would be sums over a large number of wake-up periods of self in the subjective past of the self. Therefore one could perhaps understand how ageing self gains gradually wisdom from experience: also the identification of the long term memories as geometric memories explains this.

Higher level selves could communicate their subjective and geometric memories as well as the emotions generated by their comparison to us. The first idea to come into mind is that communications occur during totally entangled state, sleep or trance. For this option it is not at all clear how the experiences of the higher level selves during entangled state could be ours! In fact, we should lose our selves during entanglement with self characterized by larger p-adic prime. For instance, during sleep without dreams entanglement with some higher level self should occur and we do not remember anything about this. Trance is a second example of this: subject person does not remember anything about the trance state. Thus it seems that this mechanism cannot give rise to conscious long term memories. This does not however exclude the possibility that cognitive representations are formed during the communication and lower level self experiences them later as memories. One function of sleep might be the generation of the entanglement with higher selves making in turn possible the communication of genuine memories of subjective past to our mind. This communication could realize these memories as thoughts about the experiences of past realized as nerve pulse patterns regenerating these thoughts.

The so called semitrance mechanism [K91] avoids the objections against communications occurring in totally entangled state. During semitrance parts of brain are entangled with some higher level self. These selves can communicate their memories to that part of brain which is awake (communication means generation of mental images). Ancient men received these communications as sensory hallucinations ("God's voice"), very much like schizophrenics, whereas modern man experiences them as thoughts and emotions which are often "hallicinatory" in the sense that they are not automatic reactions to the sensory input. The TGD based vision for the development of language and civilization modifies Jaynes's vision about bicameral man as a schizophrenic of modern society and relies on the notion of semitrance. Semitrance mechanism is extremely general and could be present in all length scales. For instance, semitrance could provide the inhabitants of cell societies (organisms) and protein societies (cells) with a personal self narrative (genetic determination of cell as self narrative!).

Semitrance mechanism survives the most obvious counter arguments.

1. The general objection is that the memories of the higher level selves are rather abstract. The assumption communication mechanism is restricted to thoughts and emotions is however consistent with the abstract nature of the non-episodal long term memories. The most natural identification of episodal memories is indeed as personal geometric memories or possibly as artificially generated sensory hallucinations stimulated by higher level self during semitrance.

2. Since semitrance mechanism is only a communication method, geometric and subjective memories remain the fundamental memory mechanisms. Therefore the nice features of the geometric memory are not lost. For instance, one can understand learning and the role of emotions and repetition in learning.

More complicated scenarios

One can consider also more complicated scenarios for realizing long term memories.

1. Ensemble of mind-like space-time sheets could generate continuously cognitive representations remaining in ideal case unchanged and memories as ability to re-experience would be

carried by mind-like space-time sheet when it wanders to the direction of future. This would require that mind-like space-time sheets replicate just as material space-time sheets (DNA, cells, members of species) do. If mind-like space-time sheets responsible for memories of this kind have finite lifetime, say of order one second, short term memories could be realized in this manner without cognitive population explosion. In fact, cell division might realize long term memories in cell populations. Perhaps also DNA replication might be regarded as this kind of memory.

2. The realization of long term memory and communication relying on replication is rather primitive and the fact is that neurons do not replicate. A natural explanation is that neurons have discovered procedural memory, which means that long term memories could be realized dynamically: standardized nerve pulse patterns generate standardized temporal patterns of quark magnetization. This implies ability to regenerate the thought stimulated by the primary experience and associative learning would associate memories to experiences as thoughts. This picture would correspond to that of ordinary associative nets and is subject to the standard counter arguments such as the loss of old memories caused by the learning of the new ones.

3. Sustainment of the mental images is indeed one of the basic mechanisms behind human intelligence and can be also seen as a way to enhance the probability that a geometric memory in the past is recalled. Sustained mental images are analogous to the icons of the computer screen, which in fact supports the idea that the evolution of computers mimics in many respects the evolution of the brain. At program level icons correspond to program loops. At neural level to periodic neural process generating again and again the same mental image (not necessarily directly conscious to us).

4. Written language and symbols are the next step to the internal sustainment and make possible to achieve a given sensory and cognitive experience in a controlled manner. Program files are obviously analogous to the written language (the electronic control systems preceding the computer era were effectively computer programs but were not written as computer code, externalized). DNA could be seen also as ROM type memory of living systems.

9.2.6 Implicit Memories

A possible definition of implicit memories is as memories which exist but are not created in conscious experience of the subject person. Also implicit learning could be defined in this manner. A good example of implicit memory is provided by a situation in which unaesthetized patient can quite accurately remember what has been said during the operation [J113]. An example of implicit learning is the learning of grammatical rules without any explicit (conscious) representation for them. The status of the implicit memories and learning is not established. A possible reason for this is that it is not easy to understand them in computational paradigm of consciousness. Connectionism explains implicit learning and memories as unconscious formation of associations and mathematically modelled by the dynamics of the neural networks.

In TGD framework implicit learning and memories could correspond to learning and memories at the lower levels of the self hierarchy not usually conscious to us. In case that the mind-like space-time sheet corresponding to our sub-self forms flux tube with a lower level self so that lower level self fuses with the sub-self in question, its memories can become our conscious memories. ORP suggests that this process involves also the formation of quantum entanglement and this indeed must occur. Biofeedback could be understand as a special case of this process. In the TGD based model for the quantum correlates of the sensory qualia this process is key role. The memories communicated by semitrance mechanism can indeed be and probably often are implicit.

One can consider also formation of flux tubes between our sub-selves and sub-selves of other persons. This is quite possible if our sub-selves indeed correspond to topological field quanta representing ELF photons associated with the EEG frequencies having size of even size of Earth. Formation of flux tubes between topological field quanta of this size would make for us to experience the memories of other persons. This kind of mechanism could explain the memories of anesthetized patient about what happened during the operation as memories of sub-selves of the persons participating the operation. An open question is whether the mechanism could also explain

also out-of body experiences, in which patient looks himself from outside, sometimes involved with this kind of situations.

Implicit learning could also correspond to the development of various cognitive skills realized as self-organized self cascades so that no explicit representation of the skill is needed: when initial value self wakes up, the cascade proceeds with highly predictable manner due to quantum statistical determinism. Even the ontogeny could be regarded as this kind of skill implicitely coded in DNA!

9.2.7   Procedural Memories

Procedural memories seem to be mostly stabilized sequences of thoughts and mental images and the proposed model for cascade like generations of selves provides therefore a model for procedural memory. Procedural memories could be simple cognitive acts occurring again and again as a reaction to some specific stimulus. mind-like space-time sheet would carry them while drifting into the future. For an ensemble of selves with each self initiating cognitive acts is in question, reliability of memories would result.

Quantum spin glass model of brain explanains for formation of the procedural as resulting from quantum self-organization. Dissipation caused by quantum jumps would automatically select skills, habits and eigen behaviours as surviving self-organizing patterns. These patterns would correspond to deep valleys in the fractal energy landscape of the spin glass landscape, which is effectively four-dimensional. Repetition would automatically lead to the learning of procedural memories since it would extend the valleys in time direction so that mind-like space-time sheets would have larger probability to enter to the valley and give rise to memory. For instance, reverbrating nerve pulse patterns in the memory circuits of brain would realize this repetition.

9.3   Model For Long Term Memories

In the following an attempt is made to understand how long term memories could be realized at neuronal level. I hope that my fragmentary knowledge about the details of brain science would not mask from the reader the beauty and simplicity of the general mechanism. The model is constructed first at general level and then basic facts about long term memory are discussed in the framework of the model.

9.3.1   General Ideas

In TGD framework one can make a precise distinction between genuine memories and apparent memories such as procedural and implicit memories, associations, feature recognition, and standardized neuronal "features" serving as building blocks of memories. The basic question is whether the representations of the long term memories are realized in the brain geometrically now or in the brain of the geometric past. In TGD the latter option is allowed by time-like quantum entanglement made possible by the non-determinism of Kähler action. The very fact that the memory storage of past memories to the geometric now is not needed, means that there is no need to carve long term memories to associative structures so that geometric now would contain representations about moments of the geometric past. Only the representation of the event at time when it occurred is needed. For example, this implies that long term potentiation (LTP) is just learning and adaptation to a new situation and can only be related to the modification of memory representations and possibly the construction of new standardized features.

Mirror mechanism

Mirror mechanism is the simplest quantum mechanism of episodal memories and involves only a sharing of mental images by time-like entanglement. p-Adic physics suggests that the entanglement should be negentropic. Negentropic time-like entanglement is indeed possible and would correspond to density matrix which is projector. The corresponding entanglement matrix would be unitary.

Another mechanism is based on communications in time direction giving rise to the analog of reflection in time direction. The brain hemisphere sends a negative energy ME to the geometric past reflected at a large distance and returning back to the hemisphere and induces a sharing of mental images. The desire to remember something and the memory of the past fuse to a single

mental image shared by the brains of the geometric past and now. The desire to remember would be communicated to the geometric past also in case of non-episodal memories whereas memory itself would be communicated classically by positive energy MEs.

In a more realistic situation multiple reflections for a curvilinear negative energy ME along a closed magnetic flux loop would occur and guarantee precisely targeted communications to the geometric past. The sizes of these loops would be measured in light years. MEs and magnetic flux loops associated with the personal magnetic body are the most realistic candidates since in this case the interaction with matter is minimized.

The notion of memory field supports this idea. Retrograde amnesia leads to a selective loss of memories in some time interval, and the notion of memory field provides a possible explanation. This means that brain structures with a given memory field entangle with those events of the geometric past which are located in some time interval ΔT at temporal distance T in the past. A closed magnetic flux tube with a given length $L(T)$ would obviously be a correlate for a memory field with a given time span T.

The sharing of mental images mechanism (see **Fig. http://tgdtheory.fi/appfigures/ sharing.jpg** or **Fig. ??** in the appendix of this book) requires only that gravitational MEs take care of only quantum entanglement and because it allows arbitrary kinds of episodal long term memories. The electric stimulation of neurons can induce complex episodal memories. This can be understood if the episodal memory recall involves only the entanglement by the negative energy ME and the field pattern associated with ME does not matter at all. The unique experimental signature of the quantum entanglement mechanism is that no direct correlates for the memories themselves are necessary in the brain geometrically now. One can wonder what distinguishes the resulting experience from precognition by the self of the geometric past: could it be that to precognize now is to remember in the geometric future?

The direct sharing of sensory experience is non-economical in the sense that the amount of the irrelevant information is very high. The conceptualization involved with the symbolic representation allows to represent only the absolutely essential aspects. In case of classical communications symbolic representations is of course the only practical possibility. Since the brain of the geometric past serves as a passive entangler and does not have the possibility to process the communicated information, the sharing of the mental images is not flexible enough and does not allow an active precisely targeted memory recall. It is also very difficult to tell whether sensory experience represents memory or a genuine experience.

Classical communications and non-episodal memories

For non-episodal memories classical communication mechanism suggests itself as a more appropriate mechanism. Classical signalling requires the coding of the data to the shape of the field pattern propagating along positive energy ME, which could be curvilinear and analogous to a radiation propagating in a wave cavity defined by a magnetic loop of the magnetic body.

MEs are indeed optimal for the coding of the classical signal since the vacuum current for given moment of geometric time is non-deterministic. Classical communications would allow and also require the minimization of the data communicated. These memories would not be sensory unless back-projection to the sensory organs is involved at the receiving end. The formation of the symbolic representation is subject to errors: for instance, temporal order of events can change. It is known that declarative memories can often involve changes of the temporal order. It must be emphasized that declarative need not be synonymous with non-episodal. Declarative memories could be also episodal and correspond to sharing of a symbolic mental images of the geometric past. The "features" of Freeman [E2] having during of about .1 seconds are good candidates for the representation of the classical signals and the time scale suggests that electron's causal diamond is involved as also quark CDs with time scale of 1 ms. If EEG MEs are involved, the modulation of hippocampal theta frequency is a candidate for the representations of classical signal.

In ZEO this mechanism corresponds to a process in which sub-self representing mental image dies and re-incarnates at the opposite boundary of CD. This corresponds to a negative energy signal travelling to the geometric past. Also this self dies and re-incarnates at original boundary of CD: this corresponds to the positive return signal from the geometric past. Mental image simply falls asleep and wakes up and after that represents the memory as a conscious information.

There are are two basic options for how the classical communication could occur.

1. Positive energy ME would not leave brain at all and would therefore have ultra slow effective phase velocity along the brain structure in question, say axon, so that it would not leave brain during its travel to the geometric future.

2. Positive energy ME would be curvilinear and parallel with magnetic flux loop of the personal magnetic body serving effectively as a wave guide. In this case the reduction of the phase velocity to EEG wave phase velocity would be enough. For instance, for the phase velocity of alpha waves propagating along loops with the size of the order of the Earth's circumference, the time span of the memory would be of the order of one year. In this picture one of the functions of the part of EEG representing evoked responses could be classical communications making possible non-episodal memories. Only part of these memories would be conscious to us. The length of the magnetic loops is expected to directly correlate with the period of EEG frequency involved with the classical communication via the relationship $L = vT$ would provide a second correlate for the notion of the memory field. There are indeed reasons to expect that the structures communicating signals to the geometric future are specialized to communicate signals to a certain distance.

The most plausible neurophysiological excitations associated with the received signal are Ca^{++} waves known to have extremely wide velocity spectrum. For the option a) the required velocity would be of order neuronal sizes per year, and this is perhaps unrealistically low velocity. It is also difficult to see how the neuronal noise would not spoil the signal. For the option b) the positive energy ME entering brain at the moment of memory receival would induce Ca^{++} waves in turn inducing neural activity.

For classical signalling the transformation of the classical signal to a conscious experience is needed. MEs could directly generate membrane oscillations and nerve pulse patterns via the general mechanism of nerve pulse and EEG discussed in [K81]. EEG MEs could in turn induce cyclotron transitions at the magnetic flux tubes of the Earth's magnetic field in turn affecting nerve pulse generation. Also a transformation of the signal to Ca^{++} waves could be possible. The conscious experience does not involve sensory component unless there is back-projection to the level of sensory organs involved.

Interesting questions relate to the interpretation of the ultraslow effective phase velocity of MEs acting as bridges connecting two space-time sheets.

1. The classical fields from a larger space-time sheet A can be transferred to a smaller space-time sheet B topologically condensed on A by inducing the motion of the wormhole contacts, which in turn generate classical fields at the smaller space-time sheet. The fields can also penetrate along flux tubes connecting the boundaries of two space-time sheets.

2. Quite generally, the "topological" half of Maxwell's field equations implies that tangential component of E and normal component of B are continuous at the junctions connecting the boundaries of two space-time sheets. One could assume that quantum effects can be modelled phenomenologically by introducing the phenomenological D and H fields introduced also in the Maxwell's theory. In the Maxwell's theory the discontinuity of the normal component of the D field equals to the density of the free surface charges and the discontinuity of the tangential component of the H field equals to the free surface current. These conditions can be assumed also now, at least as the first approximation.

3. One could model the propagation of MEs topologically condensed at a space-time sheet labelled by a p-adic prime $p \simeq 2^k$, k prime or power of prime, by introducing the di-electric constant $\epsilon(k)$ and the relative permeability $\mu(k)$ satisfying the condition $\epsilon(k)\mu(k) = 1/v^2 > 1/c^2 = 1$, where v is the effective phase velocity of ME depending in general on its fundamental frequency. The fields D and H would be defined as $D = \epsilon(k)E$, $H = B/\mu(k)$: this condition generalizes to that for the Fourier components of the fields. The reduction of the effective velocity for the propagation of the topologically condensed MEs to say alpha wave phase velocity does not seem plausible.

4. The propagation of MEs which serve as bridges between boundaries of two space-time sheets (say cell membrane space-time sheet and cell exterior space-time sheet) must be modelled differently. One could introduce a generalized di-electric constant $\epsilon(k_1, k_2)$ and permeability

$\mu(k_1, k_2)$ characterizing the pair of space-time sheets such that the effective phase velocity $v(k_1, k_2)$ of MEs acting as bridges satisfies $\epsilon(k_1, k_2)\mu(k_1, k_2) = 1/v^2(k_1, k_2)$, and also now depend on the fundamental frequency of ME. A very large value of $\epsilon(k_1, k_2)$ implying the needed very small value of the effective phase velocity would mean that the orthogonal component of the electric field does not appreciably penetrate inside ME from either space-time sheet. Since MEs are the fundamental topological field quanta, this looks a natural assumption. The extremely low effective phase velocity should be due to the replacement of the wormhole contact coupling with the join along boundaries coupling causing the "sticking" of MEs. Note that the join along boundaries coupling is topological sum coupling for boundaries whereas wormhole contacts represent topological sum coupling for interior. Furthermore, join along boundaries contacts can have a macroscopic size whereas wormhole contacts are CP_2-sized: this could explain the huge reduction of the effective phase velocity for the boundary MEs.

Negative energy MEs as ideal entanglers with the geometric past?

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

The requirement that the entanglement process is highly selective suggests a resonance mechanism. This requires that receiving and sending structures are similar and generate ULF MEs with fundamental frequencies measured typically in cycles per year. If negative energy energy ME is in question, as suggested by the idea that a classical communication to the geometric past is involved, it cannot be emitted unless there exists a receiver absorbing the negative energy and in this manner providing energy for the sender by buy now-let others pay mechanism. For negative energy MEs resonance mechanism plus a simple classical signal serving as a a password could also guarantee that correct part of the brain receives the signal.

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

Since the generation of negative energy MEs does not require energy feed, the memory recall to the geometric past occurs more or less spontaneously, and the scanning of the geometric past becomes possible. The intentionality of the memory recall would be realized as generation of a p-adic ME transforming to a negative energy ME, when the real system jumps to a higher energy state. This process makes possible precisely targeted intention also in the case of memory recall since the transitions in question cannot occur spontaneously. In the case of precognition precognizer must intentionally receive negative energy MEs from the geometric future so that energy feed is needed. This perhaps explains why precognition is so rare. Note that p-adic variant of pre-cognition having interpretation as intentionality occurs easily since p-adic energy is conserved only in a piecewise manner.

The most often needed non-episodal memories, say short term memories, could be communicated automatically: in this case the memory recall would be a geometro-temporally local operation, much like taking a sample from a data stream representing particular kind of memories with a particular time span. The option is probably not realized for all non-episodal memories since this would require large energy expenditure.

9.3.2   Could Gravitation Have Something To Do With Long TermMemories?

Penrose has proposed that quantum gravitation might be crucial for understanding consciousness. In TGD framework the hierarchy of Planck constants labelling a hierarchy of quantum criticalities and the prediction that quantum gravitation gives rise to quantum coherence in astrophysical scales replaces this vision [K97, K70].

The quantitative formulation is in terms of the gravitational Planck constant characterizing the flux tubes of two-body system and having the expression $\hbar_{gr} = GMm/v_0$, where v_0 corresponds to a characteristic velocity associated with the system. The hypothesis $h_{eff} = n \times h = h_{gr}$ relates h_{gr} to the large Planck constant h_{eff} characterizing the cyclotron condensates of charged particles in living matter.

Gravitational Compton length does not depend on the mass of the particle and cyclotron energy spectrum proportional to h_{eff} is universal (no dependence on the mass of charge particle) and in visible and UV range. The dark photons in question can transform to ordinary photons identifiable as bio-photons and defined fundamental communication and control tools in living matter. This implies that they are crucial also for the memory. This vision is discussed in [K73, ?, K12].

The text below was written much before this vision but I have left it essentially as such.

Could classical gravitation stabilize irreducible bound state entanglement?

Bound state entanglement gives rise to a "state of oneness", in which quantum computing system is totally bound-state entangled and does not decay into sub-selves in self measurement process and can thus behave effectively as a non-dissipating system and quantum compute. The estimates for the duration of this kind of bound states tend to be much shorter than required [J111]. The question is whether classical gravitational interaction could somehow stabilize these bound states.

The extremely low value of the gravitational binding energy is an objection against the view that gravitational interaction could help to stabilize the bound states. The huge degeneracy of the bound states could however change the situation.

1. Suppose that spin glass degeneracy gives rise to a huge number of almost degenerate bound states for which only the classical gravitational energy is different and that for non-bound states this degeneracy is much smaller. The dominant part of the binding energy is of course something else than gravitational. If this is the case, the number of the bound states is so large as compared to the number of unbound states that the branching ratio for the decay to unbound state is very small and bound state entanglement can last for much longer time as usually. Although the lifetime of an individual bound state need not increase, the time spent in bound states and defining de-coherence time become much longer than predicted by standard physics.

2. If the flux tubes are sufficiently near to vacuum extremals, they indeed allow immense spin glass degeneracy with slightly different gravitational interaction energies and the desired situation can be achieved.

3. This argument can be refined by using unitarity. If the net rate for the transitions to bound states is enhanced by the degeneracy of the bound states, probability conservation implies that the probability for the occurrence of de-cohering decays is reduced correspondingly.

A rough order of magnitude estimate for the gravitational binding energy for a cubic blob of water (that is living matter) having size given by p-adic length scale $L(k)$ is

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

Gravitational binding energy is larger than the p-adic energy $2\pi/L(k)$ for $L(k = 179) \simeq .169$ mm. In the range $L(163) = 640$ nm and $L(167) = 2.56$ μm gravitational binding frequency varies between 1 Hz and 1 kHz, that is over EEG range up to the maximal frequency of nerve pulses. If

the binding energy gives estimate for the lifetime of the gravitationally bound states, this might fit nicely with EEG energies in typical cell length scales!

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

One can perform a similar estimate for linear structures. Parametrizing the microtubular transversal area to be $d = x^2 L^2(151)$, $L(151) = 10$ nm, one has

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

This gives for $L(k) \sim 1$ meter, the frequency of $.1 \times x^5$ Hz. The time scale varies between $10/x^5$ seconds and $32/x^5$ years and certainly covers the time scale for human long term memories. Of course, this rough estimate involves numerical factor which can increase the upper bound.

Note that the increments of the gravitational energy between transitions between almost degenerate bound states are some fraction of the gravitational binding energy. Also the gravitational interaction energy associated with the classical em fields could contribute significantly to the density of the gravitational energy in TGD framework and tend to increase the overall energy scale. The reason is that the gravitational constant associated with classical fields is roughly 10^8 times larger than the ordinary gravitational constant [K11]. Thus, if the energy of classical fields is more than $10^{-8}m_p \sim 10$ eV per proton the classical field energy of, say, flux tubes becomes significant factor. Since hydrogen ground state binding energy is about 13 eV, this kind of energy density per atomic volume looks quite reasonable in case of water.

TGD universe is quantum critical system in the sense that space-time sheets representing magnetic and electric fields with arbitrary large sizes are present and correspond to two phases in equilibrium (compare with ice and water at melting point). Electric-magnetic duality is second fundamental symmetry of quantum TGD. Magnetic flux tubes carrying constant magnetic field (in lowest order approximation) have as their duals space-time regions carrying electric fields (constant in lowest order approximation). In biosystems various electrets and magnetic flux tube structures are the concrete realization of these two phases. Classical gravitational effects generate vacuum 4-currents near the boundaries of these structures serving as sources of magnetic resp. electric fields. The boundaries of these structures are singularities of the classical gravitational fields and these gravitational fields are good candidates for generating gravitional MEs responsible for long term memories.

Spin glass degeneracy corresponds in the formulation of hierarchy of Planck constants in terms of hierarchy of quantum criticalities [K36, **?**] to the existence of space-time surfaces, which can be regarded as many-sheeted singular coverings of space-time surface such that the sheets coincide at the ends of the space-time surface at boundaries of CD. The number of sheets corresponds to the value of $h_{eff}/h = n$. There are deep connections with p-adic length scale hypothesis and its generalization, with the notion of negentropic entanglement, with strong form of holography, and the vision about hierarchy of algebraic extensions of rationals as correlate for evolution [K119].

Long term memory and gravitational MEs

Interestingly, MEs (topological light rays) with fundamental frequencies with time scale measured using year as a unit are needed in the mirror model of long term memories (to remember event at a distance of T in past is to look in mirror at a distance $L = cT/2$). The gravitational transitions between huge number of almost degenerate spin glass states could be coded to the fundamental frequencies of MEs. In particular, structures with sizes slightly above cell membrane thickness, such as microtubules, could generate these MEs as the topological correlates of graviton emission with frequency equal to the increment of the gravitational binding energy in quantum jump involved. Thus there would be a direct correlation with long term memories and microtubules: microtubule conformations could code for long term memories.

The mirror mechanism of long term memory has beautiful interpretation in terms of topological correlates for virtual graviton exchange with vacuum.

1. The light reflected in mirror corresponds to topological light rays assignable to gravitons and is reflected from the curved vacuum. Topological counterpart of virtual graviton is emitted by (say) tubulin, absorbed by vacuumandemitted again by vacuum, and finally absorbed by tubulin. Curved vacuum acts as a mirror for gravitons and you see yourself in this mirror.

2. Why gravitons are the only possibility in time scale of years is simply that they interact so weakly that they can propagate light years before absorbed by curved vacuum. Time scales come out correctly and microtubules are known to be crucial for long term memories (Altzheimer's disease involves changes at microtubular level).

3. There are also genuine vacuum extremals interpretable as topological graviton rays. These graviton rays could reduce to vacuum MEs except in the turning point. This would mean "self-reflection" without scattering from background and interpretable as an absorption and emission of a virtual graviton. In case of non-vacuum extremals, classical momentum conservation however requires that the topological graviton exchanges momentum with the background space-time surface and thus is mirrored from it.

4. One could interpret the low energy topological graviton rays responsible for long term memory as a particular kind of $1/f$ noise accompanying all critical systems, in particular TGD Universe, which can be regarded as a quantum critical quantum spin glass. Gravitonic $1/f$ noise would be emitted in the transitions between almost degenerate spin glass states and would be kind of analog for gravitational brehmstrahlung.

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

   While writing the above piece of text I did not known about the hierarchy of Planck constants. A photon with given energy can have arbitrary long wave length so that the minimum scale for macroscopic quantum coherence given by the wavelength is scaled up dramatically. For instance, the scaling by a factor 10^{12} can quite well be considered, and in the case of visible photon means scale of thousand kilometers- the scale of Earth.

9.3.3 Is The Right Brain Hemisphere The Quantum Entangler?

There are some reasons to suspect that the quantum communications with the geometric past occur more dominantly in the right brain hemisphere whereas classical communications would occur in the left hemisphere. This would explain among other things the holistic aspects of right brain consciousness. Left brain hemisphere is specialized more to symbolic processing of information and would indeed be more suitable to classical communication of this information.

   Clearly, right brain would be passive receiver whereas left brain would be active expresser. DNA strands would be an example of this dichotomy at molecular level. This dichotomy would be realized also at the level of gene expression using MEs as the model of bio-photons involving in essential manner negative and positive energy MEs suggests. Of course, this statement must be take only in the spirit of fractality and would hold true only in certain range of p-adic time scales.

   The following arguments lend some support for the proposed division of labour between right and left brain hemispheres.

Synesthesia as a key to the mechanism of episodal memory

What forces brain region to send negative energy MEs and thus to remember? "Hunger!" is the possible answer! During synesthesia the metabolism in the left cortex is reduced by by 18 per cent due to the abnormally high metabolism in memory circuit (for the model of synesthesia see [K89]). Perhaps the generation of the negative energy MEs is forced by the starvation of the neurons of the left cortex induced by the over-activity of the neurons of the memory coordination circuit. The starving cortical neurons of the left hemisphere would send massive amounts of negative energy

MEs to the direction of the geometric past inducing entanglement bridges by the mirror mechanism with the brain of the geometric past in turn inducing episodal long term memories by the sharing of the mental images. Thus the miraculous ability of synesthetes to remember episodally could be understood to result as a by-product of a neuronal emergency reaction.

There are good reasons to expect that same mechanism might be at work also in the normal situation but involve a less dramatic artificial starvation of the neurons of the right brain hemisphere. Clearly, the role of hippocampus is dramatically different from what is usually believed and also forces to question the naïve belief that neuronal activity is a measure of the contribution of brain area to the conscious experience. While building long term memory representations as classical signals hippocampus and memory circuit would steal energy from certain areas of cortex, and the resulting metabolic starvation would force them to send negative energy MEs to gain energy in this manner. This in turn would lead to the generation of long term episodal or non-episodal memories as a side product. Quite generally it is known that limbic brain and cortex tend to work in complementary modes: when the cortex is in a high state of arousal, limbic brain is in a state of low arousal and vice versa. Perhaps the passive brain region is involved with memory recall and the active one with the construction of sensory or memory representations.

Left-handedness and episodal memory

It is known that persons with many left-handed family members have better ability for episodal memory recall and that this probably relates closely to the communication between left and right hemispheres. We begin to have verbal memories only after the age of four: at this time also the connection between right and left hemispheres has matured. The proposed mechanism of non-episodal memories requires that the right brain hemisphere shares the mental image representing the desire to remember and the left brain hemisphere communicates the memory classically. Als the communication between right and left hemisphere is necessary for this process to occur. Children before the age of four could live in a kind of a dream time experiencing mostly sensory episodal memories and presumably not being able distinguish memories from genuine experiences. This would also explain why we do not have declarative memories dating to the time before the age of four.

How could one understand the tendency of persons with many left-handed family members to have better episodal memory recall? The ability to have sensory memories can appear also when a damage occurs to the regions of the left hemisphere. It could be that classical communications between the hemispheres are worser than usually when episodal memory recall is favoured, and are replaced by quantum communications. The mental images in the left brain hemisphere would entangle with those in the right hemisphere entangling in turn with the geometric future and give rise to episodal memories. Thus the quantum communications between hemispheres might be better than usually. This kind of persons would be more "holistic" than ordinary persons.

NDEs and long term memories

That negative energy MEs could be responsible for episodal long term memories is supported by near death experiences. Persons having near death experiences are clinically dead: in particular, EEG is absent. If these persons indeed have conscious experiences and if they are able to remember them as it seems, and since EEG signals are out of question, only MEs generated during NDE remains as a viable alternative in TGD framework. Brain or possibly body should be involved with the receival of geometric memories if spin glass degeneracy is essential for the time-like entanglement by MEs.

Life review is one important aspect of the NDE experiences: entire 4-dimensional body is experienced simultaneously. The starvation of neurons forcing them to generate negative energy MEs could explain the episodal memory feats of synesthetes and the eidetic memory, and would naturally be at work also during NDE experience. This is not the only possibility. This experience might also be partially due to the absence of the volitional actions. This life review memory could be interpreted as geometric memories not masked by the normal contributions to the contents of consciousness. An interesting possibility is that this contribution is generated by theta and delta bands of EEG during lifetime and is present also normally but, being strongly masked, is not recognized.

Dejavu experiences and memory feats

Dejavu experiences provide a challenge for any realistic model of memory. In Dejavu the sensory experience is accompanied by the feeling "I have experienced this already earlier".

A natural working hypothesis is that purely sensory memories, sensory re-experiences, do not contain information about the value of the geometric time associated with the sensation. This means that sensory memories cannot be distinguished from real experiences. On the other hand, cognitive and symbolic memories differ so radically from the sensory experiences that there is no difficulty of distinguishing them from genuine experiences. Therefore one knows that the experience represented by this kind of memory occurred in geometric past or represents an expectation of future. Symbolic (real) and cognitive (p-adic) representations are very probably continually transformed to each other. If this view is correct, then the simultaneous occurrence of the sensory and cognitive memories implies dejavu experience. The event giving rise to the sensory and cognitive memories might have occurred only few seconds earlier.

This view has some nontrivial implications concerning the character of conscious experience of children. Cognitive abilities are thought to appear only after the age of four or five years. If also symbolic memories are absent, small children might live in a kind of dream time, as also members of primitive cultures, such as aboriginals, are believed to live in. Also dream consciousness could involve in an essential manner sensory memories as suggested by temporal acontinuity of dream consciousness. One could also see dreams as transformations of cognitive representations to sensory ones and such reverse to what occurs in wake-up consciousness so that surreal dream logic could basically result from p-adic non-determinism. The back projection to the sensory organs would be an essential element of the mechanism.

The absence of a temporally organized consciousness would explain why we do not possess memories from the age before four. Perhaps also the bicameral consciousness, which according to Jaynes preceded modern consciousness, was kind of dream time consciousness in which memories were direct sensory experiences, like voices experienced as voices of gods and visual hallucinations. According to Jaynes, also schizophrenics are modern bicamerals.

Some time ago I saw a TV document about some autistic persons, who have very serious cognitive defects like inability count the number of objects if it exceeds two, are capable of miraculous memory feats. One of these fascinating individuals was an artist who could draw in full detail a picture about an area of London containing thousands of buildings after having seen the area once from a helicopter. Another autistic artist, virtuoso pianist, could reproduce every piece he had heard with highly personal style. Perhaps also great musical wunderkinds like Mozart have had similar direct sensory memory for music. Also a brain damage spoiling cognitive abilities can lead to the blossoming of exceptional artistic gifts. If the neuronal metabolic starvation forces the generation of negative energy MEs in turn giving rise to long term episodal memories then one could indeed understand how brain damage could have this kind of positive consequences.

The explanation suggesting itself is that the loss of cognitive memory is compensated by sensory memory in this kind of situations. A plausible reason for why average human being has dominantly cognitive memories is simple. Sensory memory contains huge amounts of un-necessary data: symbolic and cognitive memories have much higher survival value since only the relevant data are stored. Sensory genii have very hard time in the modern society unless they work as artists!

In light of foregoing, the poor cognitive abilities of animals suggest that also animals remember predominantly sensorily and live in dream time (note however that rats have hippocampal theta). For instance, dogs might have sensory memory dominated by odours. The challenge is to invent tests for this hypothesis. One could also try to device a non-destructive method leading to a temporary loss of cognitive consciousness and making possible to spend a day as a dog.

9.3.4   Going To The Neuronal Level

The following attempt to develop the model of long term memory at the neuronal level is made involves many uncertainties and must be taken as an exercise in order to get accustomed with the ideas involved.

Which parts of the brain are the quantum entanglers?

It is known that the electrical stimulation of amygdala, hippocampus, and temporal lobes can generate lively sensory memories. The simplest explanation is that quantum entanglement with the sensory representations of the geometric past is in question. The role of the electric stimulation would be only the generation of time like entanglement, not providing any information characterizing the memory. This would mean that large portions of brain can participate to the generation of episodal memories.

The fact that the part of body must be able to generate negative energy MEs with a proper ULF time scale, poses constraints on the system involved. Cellular sub-systems and microtubules are good candidates in this respect since the transition frequencies for the transitions involving change of classical gravitational are in the required range. Since resonance mechanism is probably involved, there are good reasons to believe that similar system is is involved with both the receival and sending of the message. Microtubular structures are good candidates adn accompany both neurons and glial cells.

Energetics poses also constraints. The receivers of negative energy MEs should have an easy access to the metabolic energy resources compensating the negative energy. In fact, the receiver must be in an excited state, which decays when negative energy ME is received (dropping ions to a larger space-time sheet could be also involved). Glial cells serve as metabolic resources of the brain and interact with neurons via Ca^{++} waves and are the first guess for the system entangling with negative energy MEs. Other parts of brain and body, even sensory organs, can get metabolic energy by entangling with astrocytes via negative energy MEs so that the desired sharing of mental images would indeed result.

The notion of memory field [J125] was derived from the study of short term memory and applies to the neurons of the frontal lobes at least. The span T of the memory field is essentially the time span of the long term memory. T correlates strongly with the fundamental frequency associated with the negative energy ME if quantum entanglement is involved, and the length of magnetic loop and curvilinear negative energy ME satisfies $L \sim cT = c/f$, where f is a frequency related to a transition in which gravitational energy of the system is question changes.

When f is expressed in terms of the size of the water blob generating gravitational negative energy ME in spin glass transition this gives $T \propto L^{-5}$, where L is the size of the water blob serving as a gravitational quantum antenna. MEs with T varying in the range 8.5 hours- 32 years in the length scale range 80 nm-10 nm are generated. One day (24 hours) would correspond to a length scale 33 nanometers: 3.3 times the thickness of the cell membrane. In case of neurons only the intracellular structures having much larger sizes and much higher gravitational binding energies might serve as entanglers (larger space-time sheets would be in question) and give rise to short term memory. The time scale of 1 minute corresponds to about .3 micrometers, millisecond corresponds to $L(167) \simeq 2.3$ micrometers, whereas $L(163)$ corresponds to a time scale of 1 second. This would suggests that sub-neuronal water blocks larger than the size of cell nucleus could generate short term memories which need not be conscious-to-us. Perhaps the flux loops of the magnetic body of the cell nucleus are involved.

For linear structures like microtubules one has $T \propto 1/L$. Even in this case a rather strong dependence on the time span of the long term memory on the system generating negative energy MEs results. The fact that microtubules are ideal for representing conscious information symbolically, suggests that neuronal/astrocytic microtubules serve as the entanglers at sending/receiving end of the quantum communication line responsible for long term memories. This picture also suggests that the magnetic flux loop of a given astrophysical length scale is associated with a microtubule of a given length.

Where the classical signals are generated and received?

There are several bits of information helping to guess how long term memories might be realized.

1. The damage of the hippocampus leads only to a loss of the ability to generate new declarative memories but does not lead to a loss of long term memories from the period when hippocampus was intact. Thus it seems that hippocampus plays essential role in the communication of our non-episodal declarative memories to the geometric past and that at least a dominant part of the receivers are somewhere else than in hippocampus. Since the stimulation of both

amygdala, hippocampus and temporal lobes induces long term episodal memories, it would seem that all these structures can serve as quantum entanglers.

2. New neurons and glial cells are regenerated in hippocampus and the regeneration is especially intense during ischemia which can destroy a lot of neurons [J103]. This would suggest that both glial cells and neurons are essential for the realization of long term memories.

These pieces of data give some guide lines in the attempt to build a more detailed model of long term memories.

1. The generation of classical signals requires metabolic energy and this suggests that the generation occurs as near as possible to energy resources. Glial cells are known to be the providers of the metabolic energy. Synchronously firing neuron groups are accompanied by astrocytes forming gap junction connected structures. For a long time it was believed that astrocytes play only the role of passive energy storages but it has become clear that there is signalling between astrocytes and neuronal groups based on Ca_{++} waves. Astrocytes couple also strongly to sounds: for instance, it is known that very mild blow in head inducing sound waves can lead to a loss of consciousness. Perhaps the astrocyte structures associated with hippocampal neurons generate positive energy MEs responsible for the classical communications making our non-episodal memories possible.

2. The receival of the classical signal does not require metabolic energy. If astrocytes are involved with the sending of the classical signal, then neurons would be naturally the receivers of the signal and the energy received with the signal would partially explain why synchronous firing of neuronal groups seems to require less metabolic energy than expected. Of course, quantum entanglement by negative energy MEs wither energy sources could also explain this.

Is memetic code used to code declarative long term memories?

Memetic code is a good candidate for the coding of declarative long term memories. The duration of single memetic codeword would be about .1 seconds and the duration of a single bit would be about 1 millisecond. This hypothesis fits nicely with the facts that many cyclotron frequencies are around 10 Hz and the frequency of neuronal synchronal firing is about kHz.

Quite recently it became clear that TGD predicts counterpart of Tesla's scalar waves as two sheeted structure defined by pairs of massless extremals having different directions of light-like four-momenta [K34, K72, K71]. These waves represent a pulse of electric field propagating with a velocity of light and an electric field in the direction of propagation. These waves corresponds in TGD to space-time sheet of finite length and duration ($L = cT$) carrying constant electric field and propagating with velocity of light to the direction of the field. This solution type is extremely general and dual to the magnetic flux tubes. Electrets are one manifestation of these structures in living matter (membrane potential is one example of this kind of structure).

One could consider the hierarchy of MEs representing geometrically a hierarchical structure of commands and that memetic code corresponds to the lowest level with bit represented by a electric pulses whose polarity determines whether "1" or "0" is in question: very much like in case of computers. Electret sequences would ultimately give atomic nuclei kicks in a direction depending on the value of the bit.

What about other synchronous EEG frequencies?

Genuine theta (hippocampal theta which spans both theta and alpha bands) and delta bands could correspond to more abstract levels of consciousness not directly experienced by us usually. During slow wave sleep theta and delta bands dominate and the interpretation in terms of the binding of the mental images to memory representations is highly suggestive. Hence these bands would contribute to our consciousness in the geometric future rather than in the geometric now.

1. Theta band might relate to long term memory consolidation by a construction of temporal replicas of ordinary long term memory representations generated already during the wake-up period. Sleep state is certainly ideal in this respect.

2. naïve extrapolation suggests that delta band memories correspond to a rather long temporal distance T (that is very low frequency $f = 1/T$ for gravitonic MEs). Delta band memories would be therefore generated by structures with sizes below the thickness of cell membrane. One could understand why delta band is strongest in childhood and weakens towards old age. If delta band memories correspond to very long temporal distances T, it is useless to generate these memories at the old age since there would be no brain receiving these memories. The long time span of the delta band memories would explain why childhood memories are stable and why some persons "return" to their childhood at the old age. The return to the sensory world of childhood at old age suggests that delta band memories must be sensory memories. Delta band representations might even give rise to transpersonal memories experienced during the later lives. The absence of ordinary sensory input masking delta band memories would explain why earlier life cycles can be recalled in meditative states.

3. The contribution of theta and delta band memories to our consciousness could also relate to the third person aspect of consciousness. Theta and delta waves could be associated with the magnetospheric sensory representations giving rise to multi-brained selves. The entanglement between sleeping brains inducing a loss of personal consciousness would induce a kind of collective stereo consciousness in which a large number of individual views about world fuse together would be in question. The search for correlations between the EEGs of sleepers having a close personal relationship might be rewarding. For instance, DNA could quantum entangle and give rise to conscious memories in very long time scale at the level of species.

Note that the presence of synchronous or asynchronous EEG correlate of memory generation is present also during memory recall does not seem to be necessary since the memory is indeed in the geometric past.

Questions

One important question is whether positive energy EEG MEs are involved with long term memories or only with sensory representations (assuming that sensory representations are realized at the magnetic body). The idea that MEs take care of memories and EEG MEs of sensory representations is attractive idea at least.

Fascinating questions relate to cognitive representations since these involve p-adic physics. Frontal lobes are known to be the seat of planning, volition and cognition. Therefore p-adic cognitive representations, p-adic entanglement and the p-adic selves characterized by positive entanglement negentropy should be realized in the neural circuits involving frontal lobes. These circuits have been even proposed to be "conscious circuits" but this probably reflects the erratics identification of consciousness as cognitive consciousness only. Cognitive representations could be realized at magnetic cognitive canvas using beta frequencies as resonant frequencies and beta MEs would entangle with the points of the cognitive magnetic canvas p-adic mental images representing intentions and plans. The transformation of these p-adic mental images to real ones would somehow generate generalized motor actions, in particular ordinary motor actions. That frontal lobes contain motor areas conforms with this view.

9.3.5   Hippocampus And Long Term Memories

The findings about hippocampal system provide a good test for the general ideas about long term memory. For a review about the role of hippocampus in long term memory see [J102].

Anatomy of hippocampal system

The anatomy of hippocampus is discussed in [J11]: here only very rough summary is given: possible inaccuracies are due to my amateurish knowledge of brain science.

Hippocampus is located with the inferior medial wall of the temporal lobe posterior to the amygdala. Hippocampus decomposes into anterior and posterior regions. Hippocampus consists of a number of subcomponents, and adjoining structures, such as the parahippocampal gyrys, perirhinal and peritorhinal cortex and uncus. The main body of the hippocampus consists of the

dentate gyrus (here brain cells are regenerated), the subiculum and the sectors referred to as CA1, CA2, CA3 and CA4. The uncus is a bulbar allocortical protrusion located in the anterior-inferior medial part of the temporal lobe.

There are three major neural pathways leading to and from the hippocampus. These include the fornix-fimbrial fiber system, and a supracallosal pathway which passes through the cingulate, and via the entorhinal area: this is the mesocortical gateway to the hippocampus. Through the fornix-fimbrial pathways hippocampus makes major interconnections with the thalamus, septal nuclei, medial hypothalamus, and exerts either inhibitory or excitatory influences on these nuclei.

The entorhinal cortex acts to relay information to and from the hippocampus. The hippocampus maintains via the entorhinal cortex interconnections with the neocortical multi-modal associations areas of the temporal, frontal, and parietal lobes, including surrounding structures, e.g., the parahippocampal gyrus, and allocortical tissues, the perirhinal cortex, septal nuclei and amygdala. The parahippocampal gyrus, entorhinal and perirhinal cortex, being directly interconnected with the hippocampus and the neocortex, act to relay input from the neocortical association areas to this structure.

The entorhinal cortex consists of 7 to 8 layers rather than only 6 layers. The entorhinal cortex maintains massive interconnections with all multi-modal neocortical association areas (as well as with the amygdala, hippocampus, septal nuclei, olfactory bulb, etc.) but none of the primary sensory areas which presumably relates to the fact that hippocampus is responsible for declarative rather than sensory memories.

Memory deficits and hippocampus

Memory deficits provide important information about the role of hippocampus with respect to the memory. In anterograde amnesia the ability to generate new long term declarative memories is lost and it is known that a damage to the hippocampus can cause this defect. Thus it seems that hippocampus is crucially involved with the construction of long term memories. Also the damage to the medial temporal lobes and subcortical structures such as medial thalamus and mammillary bodies can destroy the ability to generate long term memories. This supports the view that hippocampus is kind of a central entangler binding together mental images from various parts of brain: most naturally entanglement occurs along the three neuronal pathways going through hippocampus and presumably associated with torus-like magnetic flux tubes.

In retrograde amnesia memories about some period of time in past are lost. It seems that this deficit does not correlate with the damage of hippocampus. Thus the cautious conclusion is that long term memory recall occurs also elsewhere in brain. The selectivity of the retrograde amnesia suggests that the notion of the memory field applying in the case of short term memory [J125] generalizes. The brain structures responsible for the receival of long term memories are specialized in the sense that they entangle with the mental images of the geometric past located only in an interval around certain temporal distance T. If the memories involve only few reflections along a closed magnetic flux loop, the corresponding MEs have fundamental frequency $f = 1/T$ and correspond to spin glass transition for microtubules or for 3-dimensional sub-neuronal structures at a length scale between cell size and cell membrane thickness if the simplest estimate makes sense. This kind of resonant selectivity might be possible to achieve if the receiving system is driven to the bottom of the spin glass landscape with a depth which corresponds to the gravitonic energy $E = 2\pi f$ If memories involves large number of reflections, it is difficult to imagine, how this kind of selectivity could be achieved.

Hippocampus and declarative memory

It is known that there are several memory types and hippocampus is responsible for the construction of only declarative memories, which are verbal and highly symbolic representations of the geometrical aspects external world. Hippocampus is not essential for the recognition of familiar objects nor for procedural/motor memories which are implicit memories. The natural identification of declarative memories is as memories communicated classically using some coding but one cannot exclude sharing of mental images. Memetic code or its scaled up/scaled down is a good candidate in this respect. The modulation of hippocampal theta might provide the coding.

Sensory memories can be induced by the electric stimulation of both hippocampus, amygdala and temporal lobes. This suggests that lower levels of self hierarchy which we do not experience directly can have sensory memories. The entanglement by negative energy ME with the geometric past giving rise to an episodal memory is the most natural interpretation for the effect. Neural loops are the geometric correlates for entanglement at the level of CNS, and time-like quantum entanglement of parts of the electrically stimulated structures with primary sensory areas with the mediation of these loops should be involved. If the stimulation is too strong, hallucinations result. In this case the sensory representations in the brain geometrically now are presumably activated and back projection to the sensory organs would occur. An interesting possibility is that the strength of stimulation correlates with the temporal distance of the sensory representation in the geometric past activated in the stimulation.

Hippocampus provides spatial and temporal context

The right hippocampus of the taxi drivers in London is enlargened. This supports the view that hippocampus provides kind of a symbolic map of the spatial layout of the environment. Studies in animals suggest that hippocampus adds a spatial context to the mental images from cortex entangled with mental images in subhippocampal structures entangled with the mental images in hippocampus. The spatial map is based on various spatial cues serving as landmarks. Left hippocampus is in turn involved with the verbal memories and this suggests that it is responsible for providing a temporal context and time ordering of events. This suggests that hippocampus is responsible for the temporal and spatial organization of conscious experience besides generating memory representations. Perhaps a high level sensory representations at the magnetic body is in question.

Hippocampus is known to contain place cells providing cognitive representations for the objects of perceptive field. These place cells are pyramidal cells containing magnetic crystals which suggests that they act as projectors to the magnetic memory canvas. All kinds of features could be associated with these landmarks, and more generally, with the symbolic objects of the memory field.

Long term potentiation (LTP) does not occur in hippocampus but hippocampus is highly dynamical with synaptic contacts being generated all the time and even the size of hippocampus continually changing. It would seem that hippocampus provides by its own dynamical structure a context for various data coming from cortex, kind of a geometro-symbolic model for the external world. The mental image associated with this model of external world quantum entangles with the mental images in cortex, amygdala, hypothalamus, etc...

Not only spatial but also temporal context is important and hippocampus should provide also this. Purely sensory memories do not carry any information about whether memory is in question or not. For symbolic representations the situation is different. Symbolic representations would be realized as association sequences, perhaps in the time scale of hippocampal theta such that each 3-surface of association sequence contains lower level association sequences contains.... Memetic code words of duration .1 seconds would be at the lowest level and perhaps correspond to mesoscopic features of Freeman [E2].

The intronic portion of DNA could provide the fundamental hardware representation of memes in terms of sequences of 21 DNA triplets: spoken language would be only a tip of an iceberg if this picture is correct [K41]. Positive energy em and MEs could realize these memes in the shape of vacuum current, which at given moment of time is non-deterministic and therefore optimal in this respect. Memetic code realized in terms of magnetization direction for quark sub-CDs is a further candidate for realizing the symbolic representations. This highest level representation adding context to the other data located in the geometric past would entangle via MEs with the brain of the geometric now in case of episodal memories. The fact that hippocampus is thought to be involved with the transfer of items in short term memory to long term memory in cortex conforms with the mirror mechanism.

Entorhinal cortex serves as some kind of a relay station between hippocampus and neocortex. Entorhinal cortex has very special structure being 7-to-8 layered rather than 6-layered. Entorhinal cortex maintains rich connections to various multimodal regions in temporal, parietal and frontal cortices but not to the primary sensory areas. This is consistent with the idea about three-leveled hierarchy *multimodal areas→ entorhinal → cortex-hippocampus*, with the fact that the mental

images associated with hippocampal memory representations are symbolic rather than sensory, and with the assumption that multimodal areas, entorhinal cortex, and hippocampus entangle.

Hippocampal theta corresponds to EEG frequency range varying from about 4 Hz to 12-14 Hz and thus spans both theta and alpha bands. Hippocampal theta can be seen as a correlate for the binding of various cortical and subcortical mental images to a single mental image representing both that aspect of consciousness which makes possible organized view about space and time and declarative memory. MEs at hippocampal theta frequencies could project to the magnetic memory canvas providing an abstract representation about world analogous to sensory representation but without sensory qualia. It must be emphasized that the memory representation should provide an essential part of our everyday consciousness making possible space and time categories of everyday conscious experience. Novel and painful stimuli indeed induce hippocampal theta as well as orienting reactions, learning, selection and discrimination.

Remote emotions and associations?

Amygdala seems to be responsible for the formation of emotional aspects of the memories in accordance with entanglement paradigm. Amygdala is known to be sensitive to emotional contextual cues which can trigger perceptive experiences similar to previous ones. Associative memories seem to be in question.

Whether the associative memory is in the geometric now or past is not obvious and time-like quantum entanglement might perhaps allow to induce remote associations in the geometric past. If the cue is entangled with the cue in the geometric past, the activation of this cue by quantum entanglement could activate neural process generating the memory in the geometric past. This kind of mechanism would provide a general mechanism of active memory retrieval. The active scanning of memory neurons with memory fields characterized by different values of T would be a second mechanism of this kind. In fact, there need not be any sharp difference between ordinary associations and associations in past.

Memory consolidation and long term potentiation

The notions of memory consolidation and long term potentiation relate to the more standard views about long term memory and it is interesting to try to interpret them in TGD framework. Memory consolidation means the strengthening of memories by "replaying" them. Certainly a repettiion of mental image provides a manner to learn and establishing a long term memory also in TGD. The mere generation of gravitational MEs associated with a given mental image means consolidation: no modification of the existing neural connectivity is needed. Of course, standardized mental images are probably generated but this is not construction of memories in the strict sense of the word.

Memory consolidation involves hippocampal theta. In TGD framework hippocampal theta is a correlate for that part of consciousness which gives rise to an organized view about space and time: not necessarily in the geometric now however. Mirror mechanism implies that this process defines automatically memory representations about the state of brain so that memory consolidation is an automatic side effect.

It has been proposed that during REM sleep hippocampus is "replaying" the memories unconsciously [J149]. The fact that there is no sensory input at night time would suggest that sleeping brain is like an empty magnetic tape freely usable for the memory construction. Theta and delta bands could relate to the memory representations replayed during sleep period but could be also responsible for the construction of higher level sensory representations important for non-episodal memories.

There are however objection against the idea that REM sleep is specialized with the replaying. First, hippocampal theta, believed to be crucial for the formation of long term declarative memories, is not synchronous during REM sleep. Secondly, during dreams only the posterior portion of the hippocampus is active whereas during learning the active part is the anterior portion of the hippocampus.

TGD based vision suggests a first principle explanation for the activity of hippocampus during sleep and dreams. Both classical communications to the geometric future and the receival of negative energy MEs from the geometric future require metabolic energy feed. Since the

metabolism related to the motor activity and sensory preception is absent during sleep, the optimal realization of the long term memories is based on the entanglement with the sleeping brain of the geometric past. This would also explain why we do not have conscious experiences about memory recalls from the geometric future. Sleeping brain can also help the situation by performing memory recalls itself. REM sleep would not be in any special role except that it could make possible episodal sensory memories.

The memories about dream experience fade out rapidly after wake-up. This suggests that the lengths of the magnetic flux tubes along which classical communications occur during dreams, are short and therefore also the time span of the resulting declarative memories is brief. This as it should be since otherwise dreams would make possible pseudo memories. We could be conscious during dreams but would not remember it since long term memories would not be generated during this period. Alternatively, dream memory representations could be generated by the larger self to which we are fused during sleep. The above mentioned findings about the hippocampal activity during dreams could mean that magnetic flux loops of declarative memory get longer in posterior-anterior direction: this would mean a concrete identification for the neurophysiological correlates of the declarative memory fields. Also the dominating frequency of EEG/ZEG would become lower in this direction.

The basic question relates to the interpretation of the hippocampal theta. There are two options.

1. Hippocampal theta is associated with the MEs responsible for the classical communications to the geometric future making possible long term memories.

2. MEs take care of the classical communications to the geometric future (memetic code) whereas hippocampal theta contributes to the conscious experience of the geometric now by generating high level sensory representations at the personal magnetic body.

For the latter option hippocampal theta could be also involved with the generation of entanglement between various parts of brain crucial for the construction of long term memories making possible an organized view about space and time. This assumption conforms with the idea that EEG rhythms are responsible for the synchrony and entanglement. This would not happen during REM sleep since hippocampal theta is asynchronous during dreaming and during cortical synchrony (not much sensory input). Visual dream consciousness is indeed sensory consciousness without an organized view about space and time categories. This applies also to the non-REM verbal dreams. Furthermore, the de-synchronization of both hippocampal and cortical EEGs implies a confused state of mind. This would suggest that hippocampus indeed contributes also to our consciousness in the geometric now, and makes possible the organized view about space and time by constructing higher level sensory representations.

Long term potentiation (LTP) has been suggested as a mechanism by which hippocampus generates long term memories by strengthening the synaptic communications between neurons. In TGD framework this interpretation does not make sense: rather LTP can be seen as a special case of associative learning which is just gradual modification of the brain structure as a response to the conscious experience. Of course, LTP modifies gradually memory representations but these memory representations do not contain information about past.

As noticed, LTP does not occur in hippocampus itself. Instead, hippocampus grows rapidly in neuron number and synaptic connections during long term memory generation. This conforms with the view that hippocampus is more or less a real time dynamical representation for what might be called changing context. In particular, new neurons generated in hippocampus could be essential in representing the context and could generate gravitonic MEs crucial for the entanglement.

Relationship between cortical and hippocampal EEGs

Cortical de-synchronization accompanies hippocampal synchronization and vice versa. The simultaneous de-synchronization of cortical and hippocampal EEGs involves distractability and hyper-responsiveness so that person becomes owerwhelmed, confused, and may orient to and approach several stimuli.

These findings can be understood in TGD framework.

1. During cortical asynchrony there are good reasons to build long term memories so that hippocampus should be in synchronized state and bind various mental images to long term memories.

2. During cortical synchrony there is nothing to represent as long term memories and hippocampus can do something else. Perhaps participate in imagination and day dreaming as suggested by the fact that also during REM sleep hippocampal theta is asynchronous.

3. When both cortical and hippocampal theta are de-synchronized, not only the long term memory representations fail to be generated but also the construction of spatial and temporal context and this leads to confusion and difficulties with orientation to various stimuli.

9.3.6 Microtubuli And Long Term Memory

When I began consciousness theorizing whole-daily around about 1994, I became deeply fascinated about microtubuli (as probably most others in the field of quantum consciousness). I launched off by developing a rudimentary model about how microtubuli could act as quantum antennae in the TGD universe: massless extremals were the key element of the model. Needless to say, too much of the general theory of consciousness and of biosystems as macroscopic quantum systems needed for a deeper understanding was unconscious-to-me at that time.

After the rapid self-organization of the theory during this year and still continuing (I am living last days of August 2002 while writing this), it occurred to me that it might be a good idea to take a fresh look on the role of the microtubuli. While re-reading the wonderfully inspiring article of Nanopoulos dating back to 1995 [J59], I realized that the TGD based view about macrotemporal quantum coherence, the mirror mechanism of long term memory, and the quite recent discovery of cognitive codes and their physical realization, provide the tools for developing a view about the role of microtubuli in long term memory.

What made me somewhat skeptic about the importance of the microtubuli for *our* consciousness was the naïve view that the size L of the system system generating the memory increases when the geometrotemporal distance T of the long term memory increases. Microtubuli would be conscious but from our point of view this would represent something analogous to bit level in computers.

The understanding of how the macrotemporal quantum coherence is generated however challenged this view. TGD Universe is quantum spin glass and spin glass degeneracy is broken only by the classical gravitational binding energy. Quantum transitions between almost degenerate quantum spin glass states correspond to frequencies defined by the differences of the classical gravitational binding energy and generate gravitational MEs responsible for the quantum mirror mechanism. Gravitational binding energy increases with the system's size and this means an effective inversion of the length scale hierarchy, so that systems like microtubuli can contribute to our conscious experience much more significantly than some subsub....sub-self level at the bottom of the self hierarchy might be expected to do.

Basic findings about the correlation between long term memory and microtubuli

A basic difference between ordinary cell and neuron is that the microtubuli associated with the T shaped centriole in case of the ordinary cell, are in neuron replaced by long microtubule bundles starting in a region near nucleus and connecting it to dendrites and axonal ends. The natural guess is that at least these microtubuli are closely involved with the brain consciousness.

What happens in microtubuli is indeed very intimately related to what happens in synapses. The minimal modification of the standard neuroscience belief system is that microtubuli control how synapses, still assumed to be responsible for the memory representations, are modified during learning identified as generation of long term memories. In [J59] a lot of basic facts about microtubuli plus the evidence for the correlation between microtubuli and long term memory is discussed and references can be found in this article. Here I just summarize the basic points of the discussion of [J59].

1. The production of tubulin and MT activities correlate with peak learning, memory and experience in baby chick brains. Experiments with baby rats show that when they first open they eyes, neurons in their visual cortex begin producing vast quantities of tubulin.

2. The experiments with trained goldfishes show that the drug colchicine produces retrograde amnesia. The interference with MTs responsible for the structural modification of certain synapses is believed to affect memory fixation. In TGD framework one must carefully distinguish between learning and memory: microtubuli could provide both the long term memory representations and also control learning by controlling synaptic strengths.

3. The selective dysfunction of animal brain MTs by the drug colchicine causes defects in learning and memory which mimic the symptons of Alzheimer's disease (AD). It has been reported that in rats a continuous MT disruption induced by a chronic colchicine administration results in a dose-dependent learning deficit, and memory retention is also impaired. It has also been stressed that these colchicine-induced cognitive defects resemble those of AD, e.g., amnesia of the recent learning and loss of formerly established memories. These findings encourage to think that microtubuli are involved both with the generation of the memory representations and long term memory recall by mirror mechanism in accordance with the idea that microtubuli act as both receiving and sending quantum antennae in the sense that they generate MEs making possible time-like quantum entanglement. MEs generate coherent photons or gravitons according to the original definition of quantum antenna [K68]. Certainly, the antenna which sends is also optimal for receiving.

4. It has been suggested and also supported by detailed experimental studies that the impairment of MTs, leading to tangled and dysfunctional neural cytoskeleton, may be one explanation for the pathogenesis of AD.

5. In specific hippocampal regions of the brain of schizophrenic patients, distorted neuronal architecture has been found due to a lack of 2 MAPs. This suggests that the splitting of consciousness characterizing schizophrenia has a geometric correlate already at the microtubular level: macroscopic bound state entanglement responsible for the binding to long-lived holistic microtubular mental images and the generation of memory representations would not occur as they should.

How microtubuli could relate to declarative long term memories?

For several reasons microtubuli are tailor-made for the realization of long term declarative memories in TGD Universe (the structure of microtubuli is discussed in some detail in [K64], where the realization of cognitive codes is discussed). Microtubuli are however not the only candidates: also 2-D membrane like structures and genuinely 3-D structures could be involved and correspond to different types of long term memories.

1. Microtubuli can entangle with each other and with the surrounding world in conformational degrees of freedom to yield macrotemporal quantum coherence. Microtubule associated proteins (MAPs) can mediate naturally bound state entanglement between conformational patterns of different microtubuli. This makes possible macrotemporal quantum coherence and processes resembling quantum computation when bound states are formed. MAPs can act as switches initiating quantum computation and halting it. The simplest possibility is that MAP protein becomes just disconnected at some levels of the hierarchy of space-time sheets.

2. Tubulin dimers allow two different conformations and the patterns of tubulin conformations are ideal for binary representations of data natural for the representation of long term declarative memories. In [K64] a cognitive code explaining the numbers associated with microtubular geometry is discussed and a model for how the conformational patterns are coded into conscious experience in the phase transition in which spontaneous electric polarization occurs and forces all tubulin dimers to the ground state conformation. That microtubuli allow the realization of the symbolic counterparts of cognitive representations realized using cognitive neutrinos and possibly also by p-adic MEs, conforms with the fact that colchicine which affects MTs, induces cognitive defects characteristic of Alzheimer's disease. The linearity of microtubuli would be obviously essential and at least parts of the sensory pathways could be responsible for the representations of these memories.

3. In the standard view about long term memories one cannot identify microtubuli as seats of long term memory representations. The reason is simply that microtubule conformations are quite too short-lived for this purpose. This leaves only the identification of the synaptic strengths as a representation of long term memories. In TGD the situation is just the reverse and flexibility requires fast enough dynamics. The time scale defining sensory resolution is obviously a bottle neck time scale. The time scale for the phase transition leading to ground state of tubulin dimer in an external electric field and the time scale related to the control of the external electric field at the microtubular space-time sheet are the most obvious guesses. The first time scale should be of order of the time scale of conformational dynamics, about nanosecond. The latter time scale would be basically the duration of nerve pulse if nerve pulses are responsible for the phase transition in question. In TGD framework the modification of synaptic strengths can be more naturally seen as representing generation of new "habit routines" rather than memory representations which are much more involved and information rich.

4. Microtubuli are ideal for quantum mirror mechanism of long term memories. As already found, in case of spherical structures the dependence of gravitational binding energy on size of the structure is $E_{gr} \propto L^5$, whereas the gravitational binding energy depends on the length L of a linear structure as $E_{gr} \propto L$. For membrane like structures $E_{gr} \propto L^3$. Since microtubule lengths vary in the range 10 nm- 1 mm, this means that the temporal distance $T \propto 1/L$ of long term memory varies between 32 years 2.8 hours (very roughly; increase of the overall time scale due to the fact that increment of the gravitational binding energy in the transition is smaller than the gravitational binding energy itself). Inside axons microtubuli can bind to longer structures by MAPs and even meter sized structures associated with sensory pathways are possible. This lowers the lower bound for the time span to 10 seconds. The longest microtubuli are responsible for the representation of the shortest term memories realizable in this manner. Of course, memory circuits should regenerate again and again microtubular memory representation and in this sense synaptic strengths become an essential part of the memory representation.

5. Colchicine affects both memory recall and memory generation. This inspires the working hypothesis that microtubuli of a given length $L \propto 1/T$ in the geometric past entangle with a microtubule of same length in the geometric now during memory recall. For instance, the receiver in the geometric now could correspond to a postsynaptic microtubule whereas the sender in the geometric past corresponds to a presynaptic tubule. This is not the only alternative, receiving cells could be even glial cells.

6. That the memories of childhood are the most stable ones could be interpreted as reflecting the fact the microtubuli act both as receiving and sending quantum antennae, and that the long microtubuli responsible for generating the short term memory representations and for receiving them deteriorate towards the old age with much higher probability than the shorter ones. It could be possible to induce selective amnesia restricted to memories with a temporal distance $\sim T$ by a treatment which affects microtubuli of given length $\sim L \propto 1/T$.

7. Microtubuli could be also ideal for the communication of non-episodal memories involving classical communication by ultra slow MEs perhaps accompanied by Ca^{++} waves known to have an extremely wide velocity spectrum. Ca^{++} ions are associated with the outer surface of the microtubuli and dynamically comparable to a crop field in a wind. Ultra-slow orientational waves for these Ca^{++} ions representing sensory inputs and propagating along axons could make possible a classical communication of data from the geometric past as declarative memories. For sensory pathways the sequences of microtubuli could have a total length of order one meter. For the average length $L_0 = 10 \ \mu m$ of the microtubule in brain, the time span $T_0 = 10$ seconds would give $v_0 \sim 1 \mu m/s$, a typical velocity of in cellular level. In this case 10 nm length of microtubule would correspond to 10^{-2} seconds of time. This would mean that roughly 13 parallel sequences of 13 bits of information about 10 millisecond period. The bit rate of one bit per millisecond corresponds to the information storage capacity of the memetic code. For longer time intervals T and microtubule lengths L the bit rate would scale like $(L/L_0) \times (T_0/T) = v/v_0$. For $T = 1$ year and $L = L_0$ one

would have roughly one bit per hour. It seems that this mechanism can be at work only for short term memories whereas long term memories would involve closed magnetic loops.

Relation to the general model of long term memories

It is interesting to relate the proposed model with the general model of long term memories.

1. Long term memory is lost when tubulins return to ground state unless there is some mechanism regenerating the conformational state. In brain the function of neuronal loops generating the nerve pulse patterns repeatedly would take care of regenerating the memory representation. If this view is correct, then also memories of childhood involve this kind of continual regeneration. Sensory pathways do give rise to long term memories unless the feedback from brain to primary sensory organs (oto-acoustic sounds and the movement of eyes during REM sleep) regenerates these memory representations. During dream long term memories correspond to small value of T: does this allow to conclude that the feedback to the primary sensory organs during dreams results in long term memories with T about few minutes? The maximization of the lengths of the sensory pathways (left side of the body is connected to right brain hemisphere and vice versa) would relate to the maximization of the representational capacity if this mechanism is at work. The most natural assumption is that sensory representations are regenerated for time interval of order T so that the maximal values of T and stablest memories correspond to relatively short microtubuli in the interior of neuron.

2. Hippocampus is believed to be crucial for the generation of long term declarative memories and responsible for spatio-temporal organization of perceptive field. Hippocampus could act as a kind of entanglement center entangling with "features" at various brain areas and project them to the sensory magnetic canvas (the episodal component representing spatial relationships might accompany also non-episodal memories!). Feature sub-selves would have microtubular selves as sub-selves: this would mean entanglement between hippocampal and other microtubular memory representations. The microtubuli acting as central entanglers in hippocampus should be relatively short, with lengths not much longer than the length determined by the lower bound for temporal distance T for long term memories. The maximal length L of hippocampal axons should correspond to this T and $L \sim 10^{-2}$ meters from the size of the hippocampus might be a reasonable guess giving a time scale of about 15 minutes (these estimates are just orders of magnitude).

3. The recall of long term memories could basically correspond to a transition of a neuronal microtubule to a higher energy state by an emission of negative energy ME. The process would be preceded by the emission of a p-adic ME representing the intention to remember and transformed to a real negative energy MEs in the jump to a higher energy state. The neuronal/astrocytic microtubules of the right brain hemisphere could be specialized to send/receive negative energy MEs, whereas the astrocytic/neuronal microtubules of the left hemisphere would be specialized to send/receive positive energy MEs. Of course, this is just a naïve guess inspired by the right/left–holistic/reductionistic dichotomy. What is however clear that microtubuli with abnormally small metabolic energy feed would be responsible for generating long term memory recalls and those with abnormally large energy feed responsible for generating long term memories.

4. Tubulin dimers correspond to the Mersenne prime $p = M_k = 2^k - 1$, $k = 13$, and the n-ary 13-adic time scale nearest to p-adic prime nearest to .1 second time scale of the memetic code word is $T(20, 13) \simeq .8$ seconds whereas single bit lasts for $T(20, 13)/13 \simeq 61$ milliseconds. .8 seconds is rather natural time scale from the point of view of human consciousness. Corresponding frequencies are 1.25 Hz in delta band, and 16.25 Hz in the lower end of the beta band which conforms with the fact that cognition correlates with the beta band activity of EEG. That delta frequency alone does not give rise to conscious experience would be due to the fact that no phase transition giving rise to a conscious experience occurs if all tubulins possess same ground state conformation. The facts that delta band weakens during ageing and also memory generation mechanisms deteriorate towards the old age, conform with the

idea that this band is responsible for the generation of memory codewords. If this view is correct, hippocampal theta should be responsible for the binding of mental images rather than coding of our long term memories. Of course, also a lower level representations in time scale of hippocampal theta could be in question.

5. At this stage it is not possible to answer the question whether microtubuli correspond to sub-selves or subsub....selves. If the entangled microtubuli correspond to our sub-selves, the microtubuli belonging to different neurons should be able to entangle with each other. This requires the presence of flux tube contacts between pre- and postsynaptic microtubuli. MEs with lengths of neuron length scale could serve as this kind of contacts and generate time like entanglement between the microtubuli of neurons along the neural pathway.

What about effectively 2-D and 3-D memory representations?

Microtubuli need not be solely responsible for our long term memory representations. The fact that microtubuli seem to correlate with cognition and declarative memories which involve typically representations linear with respect to time suggests that the effective dimension D of the structure involved determines the character of the long term memory and also that of sensory experience. Moreover, it is quite possible that a large number of entangled neurons results in a kind of "stereo consciousness" fusing a large number of slightly different views about the same sensory input. This would mean large number of entangling Grandmother neurons.

1. Cell membranes consist of a large number of parallel rather than serially ordered units. Hence cell membranes could be responsible for the storage of sensory memories, which are 2-dimensional at the basic level, say visual images. The neuron size of 10^{-4} meters corresponds to the lower bound of about millisecond for $T \propto L^3$.

2. Three-dimensional blobs of biomatter in length scale range 1 micron-10 nanometers span the range 1 millisecond-32 years for temporal distance T. This allows to consider the possibility that 3-D structures could be also responsible for long term memory representations. If one takes seriously the dimensional rule, 3-D structures should give to genuinely three-dimensional sensory memories and make 3-D spatial imagination and sensory experience possible. It is not obvious whether neurons contain any 3-D lattice like structures besides liquid crystal blobs of ordered water. Effectively 3-D structures could also result as composites of 2-D structures.

9.4 Hyper-Finite Factors Of Type Ii$_1$, Dark Matter Hierarchy, And Long Term Memories

This section is devoted to the progress that has occurred during since 2004 and represents new material which has not yet been fully integrated with the older material. The realization that the von Neumann algebra known as a hyper-finite factor of type II$_1$ is tailor made for quantum TGD has led to a considerable progress in the understanding of the mathematical structure of the theory and these algebras provide a justification for several ideas introduced earlier on basis of physical intuition. One of the most important outcomes is a prediction of a hierarchy of quantum phases with arbitrarily large values of quantized Planck constant identified as dark matter and assumed to be the quintessence of living matter.

9.4.1 Hierarchies Of Algebraic Extensions Of Rationals, Quantum Criticalities, Planck Constants, Dark Matter, And Of Hyperfinite Factors

Quite recently (2004-2005) the hierarchy of Planck constants labelling hierarchy of dark matters was understood as labelling a hierarchy of quantum criticalities giving a precise content for the vision that TGD Universe is quantum critical and direct connection with super-symplectic symmetries of TGD emerges.

This hierarchy accompanies an even deeper hierarchy of algebraic extensions of rational numbers allowing to realized number theoretical universality by fusing reals and various p-adic number fields to anadelic structure inducing adelic counterparts at the level of space-time, embedding space, and WCW. This approach allows to identify preferred p-adic primes as ramified primes of algebraic extension.

In strong form of holography p-adic continuations of 2-surfaces to preferred extremals identifiable as imaginations would be easy due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K64]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes. Whether these primes correspond to p-adic lengths scale hypothesis or its generalization to small primes, is an open question.

The hierarchy of algebraic extensions realized abstractly at the level of WCW in terms of parameters characterizing space-time surfaces so that one avoids problems with symmetries. In the adelic approach cognition having p-adic space-time surfaces as its correlates is a basic aspect of existence in all length scales in this vision. Strong holography allows to reduced the intersection of realities and p-adicities to string world sheets and partonic 2-surfaces.

The fractal hierarchy of sub-algebras of super-symplectic algebra isomorphic to algebra itself realizes the quantum critical hierarchy. These algebras have conformal structure and for sub-algebra the conformal weights are n-ples of those for the entire algebra.

The Clifford algebra spanned by gamma matrices of WCW defines standard example about a von Neumann algebra known as hyper-finite factor of type II$_1$. Hyper-finite factor of type II$_1$ has a canonical realization as an infinite-dimensional Clifford algebra and the obvious guess is that it corresponds to the algebra spanned by the gamma matrices of the WCW ("world of classical worlds"). The hierarchies of inclusion sequences for sub-algebras of super-symplectic algebra labelled by $n_i = m_i \times n_{i-1}$ define excellent candidates for hierarchies of inclusions of hyper-finite factors. The measurement resolution increases along this sequence since at each phase transition $n_i \to n_{i+1}$ gauge degrees of freedom are transformed to physical ones. This hierarchy also relates naturally to evolutionary hierarchy. According to the arguments of [K119] the value of n relates closely to the dimension of algebraic extension of rationals and ramified primes are factors of n: this however only by physical argument. Number theoretically the dimension of extension and ramified primes are independent.

9.4.2   Dark Matter Hierarchy

The identification of dark matter as phases having large value of Planck constant [K97, K120, K32] led to a vigorous evolution of ideas still continuing while I am writing this addendum to the original text. Entire dark matter hierarchy with levels labelled by increasing values of Planck constant is predicted, and in principle TGD predicts the values of Planck constant if physics as a generalized number theory vision is accepted [K120]. Also a good educated guess for the spectrum of Planck constants emerges. The implications are non-trivial already at the level of hadron physics and nuclear physics and imply that condensed matter physics and nuclear physics are not completely disjoint disciplines as reductionism teaches us. One condensed matter application is a model of high T_c superconductivity predicting that the basic length scales of cell membrane and cell as scales are inherent to high T_c superconductors.

Living matter 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 [J60] [K33]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [K51, 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.

1. The argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of h_{eff} at all.

2. 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.

3. The phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

4. The recent view about quantum criticality allows to identify the space-time counterpart for $h_{eff} = n \times h$ as space-time surface, which is singular n-sheeted covering with the branches of the covering fusing to single 3-surface at the boundaries of CD. The very essence of quantum criticality is that n distinct space-time sheets collapse to single space-time sheet at the ends of CD. This identification replaces the earlier proposal that singular n-sheeted coverings of embedding space are in question. This view serves however still as a convenient auxiliary tool. The non-determinism associated with n-sheeted covering corresponds to the four-dimensional spin glass degeneracy.

Jones inclusions and quantization of Planck constant

The Clifford algebra spanned by gamma matrices of infinite-dimensional space defines standard example of a von Neumann algebra known as hyper-finite factor of type II_1. The characteristic property of this algebra is that unit matrix has unit trace. Jones inclusions of hyperfinite factors of type II_1 combined with simple anyonic arguments turned out to be the key to the unification of existing heuristic ideas about the quantization of Planck constant [K36].

1. Quantum TGD emerges from the infinite-dimensional Clifford algebra extended to an analog of a local gauge algebra with respect to hyper-octonionic coordinate [K120]. In particular, the notions space-time as a hyper-quaternionic four-surface of embedding space emerges.

2. This predicts automatically arbitrarily large values of Planck constant and assigns the preferred values of Planck constant to quantum phases $q = exp(i\pi/n)$ expressible using only iterated square root operation: these correspond to polygons obtainable by compass and ruler construction with integer n expressible as $n = 2^k \prod_i F_{s_i}$, where $F_{s_i} = 2^{2^{s_i}} + 1$ are distinct Fermat primes: the lowest Fermat primes are given by $3, 5, 17, 127, 2^{16} + 1$. In particular, experimentally favored values of h_{eff} in living matter should correspond to these special values of Planck constant. This model reproduces also the other aspects of the general vision. The subgroups of $SL(2, C)$ in turn can give rise to re-scaling of $SU(3)$ Planck constant. I have proposed that the most general situation can be described in terms of Jones inclusions for fixed point subalgebras of number theoretic Clifford algebras defined by $G_a \times G_b \subset SL(2, C) \times SU(2)$.

3. These inclusions (apart from those for which G_a contains infinite number of elements) are represented by ADE or extended ADE diagrams depending on the value of index. The group algebras of these groups give rise to additional degrees of freedom which make possible to construct the multiplets of the corresponding gauge groups. For $\beta \leq 4$ the gauge groups A_n, $D_2 n$, E_6, E_8 are possible so that TGD seems to be able to mimic these gauge theories. For $\beta = 4$ all ADE Kac Moody groups are possible and again mimicry becomes possible: TGD would be kind of universal physics emulator but it would be anyonic dark matter which would perform this emulation.

Dark matter hierarchy and the notion of self

The introduction of dark matter matter hierarchy forces to also reconsider the definition of self and in the following the original definition and modified definition are discussed. The vision about dark matter hierarchy as a hierarchy defined by quantized Planck constants leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [K32, K33].

The hierarchy of dark matter levels is labelled by the values of Planck constant having quantized but arbitrarily large values. The hierarchy comes as $h_{eff} = n \times h$, n integer. There are indications for important sub-hierarchies such as hierarchies, for which n is power of prime. In particular, for the hierarch for which one has $n = m^r$, $m = 2^k$. The first guess about Planck constants was $m = 2^{11}$, which corresponds roughly to the ratio of proton and electron masses. The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T(k) \propto 2^{kn}$ of the quantum jump.

Dark matter hierarchy suggests a modification of the notion of self, in fact a reduction of the notion of self to that of quantum jump alone. Each self involves a hierarchy of dark matter levels.

The averaging of mental images over quantum jumps would occur only for the mental images sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

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

If one accepts the hypothesis that CP_2 time defines the typical geometric duration of quantum jump then moments of consciousness with duration longer than CP_2 time would be associated with dark matter. This would require quite huge value of n for human consciousness and does not seem a plausible option since the time scale of .1 seconds corresponds to integer $n \simeq 2^{256} \simeq 10^{38}$. A more reasonable looking option is that n-ary p-adic time scales $T(n,p)$ for a given value $h_{eff} = m \times h$ define the typical geometric duration so that for a given prime p one would have the hierarchy $T(m,n,p) = mT_p(n) = m\sqrt{p}^n T_{CP_2}$ of geometric durations of moment of consciousness, with favored values of m given by $m = 2^k \prod_i F_{s_i}$: as already explained, $F_{s_i} = 2^{2^{s_i}} + 1$ are distinct Fermat primes and the lowest Fermat primes are given by $3, 5, 17, 127, 2^{16} + 1$. T_{CP_2} corresponds to CP_2 time about 10^4 Planck times. The geometric durations give a natural first guess for the duration of long term memories. Second interpretation is as the increase of geometric time coordinate in single quantum jump in the drift towards geometric future which should accompanying quantum jump making possible to understand the experience about flow of time.

9.4.3 The Time Span Of Long Term Memories As Signature For The Level Of Dark Matter Hierarchy

If one accepts the hypothesis that CP_2 time defines the typical geometric duration of quantum jump then moments of consciousness with duration longer than CP_2 time would be associated with dark matter. This would require quite huge value of n for human consciousness and does not seem a plausible option since the time scale of .1 seconds corresponds to integer $n \simeq 2^{256} \simeq 10^{38}$. A more reasonable looking option is that n-ary p-adic time scales $T(n,p)$ for a given value $h_{eff} = m \times h$ define the typical geometric duration so that for a given prime p one would have the hierarchy $T(m,n,p) = mT_p(n) = m\sqrt{p}^n T_{CP_2}$ of geometric durations of moment of consciousness, with favored values of m given by $m = 2^k \prod_i F_{s_i}$: as already explained, $F_{s_i} = 2^{2^{s_i}} + 1$ are distinct Fermat primes and the lowest Fermat primes are given by $3, 5, 17, 127, 2^{16} + 1$. T_{CP_2} corresponds to CP_2 time about 10^4 Planck times. The geometric durations give a natural first guess for the duration of long term memories. Second interpretation is as the increase of geometric time coordinate in

single quantum jump in the drift towards geometric future which should accompanying quantum jump making possible to understand the experience about flow of time.

Higher levels of dark matter hierarchy provide a neat quantitative view about self hierarchy and its evolution [K33]. EEG frequencies correspond at this level dark Josephson photon energies above the thermal threshold so that thermal noise is not a problem anymore. Various levels of dark matter hierarchy would naturally correspond to higher levels in hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question. The level in the would determine also the time span of long term memories as discussed in [K33].

The emergence of these levels must have meant evolutionary leaps 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 [K51, 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.

Quantum classical correspondence predicts that the arrow of subjective time is somehow mapped to that for the geometric time. The detailed mechanism for how the arrow of psychological time emerges has however remained open. Also the notion of self is problematic.

9.4.4   Remote Metabolism, Long Term Memory, And Zero Energy On- tology

The notion of negative energy signals and time mirror mechanism (see **Fig. `http://tgdtheory. fi/appfigures/timemirror.jpg`** or **Fig. ??** in the appendix of this book) emerged before zero energy ontology. Since the mechanisms of remote metabolism, of memory, and of intentional action rely on time mirror mechanism, one should check that this mechanism is indeed consistent with zero energy ontology. Zero energy ontology could also yield new insights to these mechanisms.

Zero energy ontology

Zero energy ontology states that physical states have vanishing net conserved quantum numbers and states decompose to positive and negative energy state and that the latter one can be said to be located in the geometric future with of the positive energy state at the time-like boundary of the space-time sheet representing the system. It is possible to speak about energy of the system if one identifies it as the average positive energy for the positive energy part of the system.

The matrix ("M-matrix") representing time-like entanglement coefficients between positive and negative energy states unifies the notions of S-matrix and density matrix since it can be regarded as a complex square root of density matrix expressible as a product of real squared of density matrix and unitary S-matrix. The system can be also in thermal equilibrium so that thermodynamics becomes a genuine part of quantum theory and thermodynamical ensembles cease to be practical fictions of the theorist. In this case M-matrix represents a superposition of zero energy states for which positive energy state has thermal density matrix. As a matter fact, M-matrices for an orthonormal basis and it is now possible to construct unitary U-matrix relating various M-matrices in terms of S-matrix and the basis of hermitian square roots of density matrices [K61].

1. If the positive energy parts of zero energy states appearing in the superposition have only single value of energy, the notion of remote metabolism is certainly well-defined. Even in the case that the system is thermalized, remote metabolism makes sense since average energy can be increased by remote metabolism. One can even imagine a statistical variant of the process in which the temperature increases.

2. The critical question is whether crossing symmetry prevails in the sense that the positive energy signal propagating to the geometric future is equivalent to a negative energy signal propagating to geometric past.

The recent view about quantum measurement theory in ZEO allows to formulate the notion of negative energy signal propagating to geometric past in rigorous manner. State function reductions at both boundaries of CD are possible and the sequence of repeated reductions at fixed boundary gives rise to self as a conscious entity (Zeno effect). The first reduction to the opposite boundary means the death of self and re-incarnation at opposite boundary as time reversal of the original for which geometric time is opposite to that in original situation.

Time mirror mechanism and metabolism

Energy conservation and geometric arrow of time poses strong conditions on the mechanism. If positive energy part of state sends negative energy signal, then negative energy part of state must send a compensating positive energy signal. Furthermore, positive (negative) energy signals propagate towards geometric future (past).

1. If only single space-time sheet is involved, either negative energy signal S_-: $X_-^4 \to Y_-^4$ or positive energy signal S_+: $X_+^4 \to Y_-^4$ is possible. The energy of both states is reduced in magnitude. For instance, this process tends to reduce destroy long term memories represented as bit sequences with bit represented by population inverted laser system.

2. Second possibility is that X^4 are Y^4 are disjoint and X^4 is in the geometric future of Y^4.

   The first possibility is S_+: $X_+^4 \to Y_-^4$ and negative energy signal S_-: $X_-^4 \to Y_-^4$: the energy of both X^4 and Y^4 is reduced in this case.

   Second possibility is S_-: $X_+^4 \to Y_+^4$ and S_+: $Y_-^4 \to X_-^4$. X^4 would suck energy from Y^4 in the geometric past. This option could correspond to both remote metabolism, memory recall, and intentional action. The presence of topological light ray connecting two systems would be also a correlate for time-like quantum entanglement making possible sharing and fusion of mental images and creating a sensation about flow of time just like it creates sensation of depth in stereo vision by fusion of right and left visual fields. Depending on the sign of the energy of the signal one would have memory or precognition. Precognition would require use of metabolic energy and this might be one reason for why it is rather rare.

3. Suppose next that the zero energy space-time sheet, call it X^4, is inside larger space-time sheet, call it Y^4: $X^4 \subset Y^4$. In this case one can have S_-: $X_+^4 \to Y_+^4$ accompanied by S_+: $X_-^4 \to Y_-^4$. $X^4 \subset Y^4$ would suck energy from a larger system Y^4. It is of course possible to replace signals with signals of opposite energy in opposite time direction.

   A possible interpretation is as a metabolic charging of smaller space-time sheets by sucking energy from longer scales or by active pumping of energy to shorter scales. The transformation of long wavelength photons with large Planck constant to short wavelength photons with smaller Planck constant is an analogous process and might realize metabolic charging in biology. For instance, Sun-Earth system could correspond to Y^4 and biosphere to X^4.

To sum up, zero energy ontology completes the picture in the sense that it also provides a process making possible metabolic charging.

Thermodynamical considerations

It is not at all obvious whether the proposed picture is consistent with the standard thermodynamics. The transfer of energy from long to shorter length scales making possible to gain metabolic energy and realize the mechanism of long term memory indeed seems a genuinely new element. This process resembles dissipation in the sense that energy is transferred from long to short length scales. In an approach to thermal equilibrium temperature gradients are however reduced whereas remote metabolism favors the active generation of "hot spots".

These considerations relate closely to the notions of entropy and syntropy by Italian mathematician Luigi Fantappie [J97] assigned with the two arrows of time. I learned from the work of Fantappie in SSE conference held in Röros from Antonella Vannini [J29] and Ulisse Di [J146] [J146].The discovery of Fantappie was that in living systems entropic processes seem to be accompanied by syntropic processes which seem to be finalistic. He assigned these processes to the advanced solutions of wave equations.

It would seem that entropy and syntropy do not relate directly to the notion of remote metabolism.

1. Syntropy growth would indeed be the mirror image of entropy growth associated with negative energy mirror image of positive energy dynamics. This dynamics could be seen as sequences of downwards scalings leading from long time scale to short time scale. This sequence would define time sequences proceeding in opposite directions of time for positive and negative energy parts of states. Thus entropy growth would be accompanied by syntropy growth.

2. Syntropy growth could be also seen as a consequence of generalized second law applying with respect to subjective time and growth of syntropy would be growth of entropy but manifesting itself at space-time level in reversed direction of geometric time. For instance, the spontaneous assembly of bio-molecules from their parts could be seen as a decay process in the reverse direction of geometric time controlled by phase conjugate control signals.

3. Remote metabolism as generation of "hot spots" does not seem to reduce to these notions and might represent a genuine breaking of standard thermodynamical view about the world.

One must also distinguish the notions of entropy and syntropy from the notion of number theoretic entanglement negentropy N assignable with quantum entanglement with algebraic entanglement probabilities.

1. N is defined as the maximum of the p-adic entanglement negentropy $N(p)$ as a function of the p-adic prime p and thus assigns to an entangled system a unique prime p_{max}. $N(p)$ is obtained by replacing in the definition of the Shannon entropy the argument of logarithm with its p-adic norm. N is in general positive and thus defines a genuine measure of information.

2. The non-negative negentropy defined in this manner characterizes entanglement as a carrier of information rather than the state of either of systems and has nothing to do with the ordinary (non-positive) entropy characterizing the lack of knowledge about the state of either subsystem. Negentropy Maximization Principle [K56] favors the increase of the number theoretic negentropy and thus formation of entanglement quantum systems and generation of quantum coherence. Depending on the character of entanglement negentropic entanglement might be interpreted as a correlate for some conscious experience with positive content: say experience of understanding (time-like entanglement implying causal structure), of love (space-like entanglement), etc...

It is not obvious to me whether the remote metabolism as a way to build hot spots and diversity could be reduced to NMP or whether it should be regarded as something completely independent.

9.4.5 Applying Computer Analogy To The Model For Long Term Memories

The general model for long term memories does not say anything detailed about how memory recall can take place effectively. Taking seriously the idea that we made computers as our images, one can try to see whether the basic facts about memory storage and recall in the case of computers could help to guess how the memory recall is realized in TGD Universe.

The basic metaphor is 4-D brain as a kind of magnetic tape in time direction carrying memories as a text consisting of letters with fixed width (temporal duration) and decomposing into paragraphs, sections, etc... just like written text. Rhythms of generalized EEG would realize the decomposition to letters, and larger sub-units.

Computer analogy suggests also the analog of directory system allowing an easy and rapid access to a particular record in a particular file. Fractality would automatically make possible fractally scaled down variants of the system with life span scaled down to a second but details absent or not visible in the cognitive resolution available.

Web suggests a link system in temporal direction realizing temporal associations automatically and topological light rays which would be vacuum extremals in passive state could realize the link system.

The two kinds of memories seem to be closely related

There are two kinds of memories. The proposal is that the sharing of mental images of the geometric past gives rise to episodal memories, re-experiences. These memories would correspond to mental images identified as quantum jumps containing quantum jumps containing... for zero energy states. This hierarchy would correspond to dark matter hierarchy and hierarchy of Planck constant.

One can criticize this idea.

1. Does the quantum entangled zero energy state of the magnetic body and brain of the geometric past really give rise to the episodal memory as sharing of mental images? The sharing aspect would certainly give rise to experience of time as analog for the depth experience in stereo vision assumed to result from the sharing of left and right visual mental images. But why not interpret this kind of state as a representation for a "law of nature" telling that state pairs in the superposition of states are causally related? Isn't state function reduction reducing entanglement necessary to experience sharp sensory qualia? The answer to these questions is that it is entangled system whose qualia are in question, not either of the individual systems. In quantum context this would mean that the sum of observables giving rise to the qualia of separate systems are measured in quantum jump.

2. What it really means to have an episodal memory? For sharing of mental images by space-like entanglement of sub-selves the space-time correlate is the flux tubes connecting the space-time sheets condensed at larger disjoint space-time sheets. In the case of episodal memories it would seem that the experiencer-now and and experiencer-then must correspond to disjoint space-time sheets and containing smaller space-time sheets connected by a topological light ray. Hence also classical communications would be an essential part of the mechanism of memory and the distinction between episodal and declarative memories does not seem so sharp as thought originally.

3. The mere re-experiencing of events of the geometric past by quantum entangling with a subsystem representing sensory mental image is not very effective mechanism. A more effective manner to remember is to represent memories symbolically as bit sequences with bits represented as population inverted state and ground state of laser (say many-sheeted laser). In this case metabolism is required to keep the representations intact.

Memory recall as communications between magnetic body and brain of geometric past

Memory recall would be communications between magnetic body and brain of the geometric past. Magnetic body can be visualized as a kind of onion with several layers: the larger the radius of layer the longer temporal distance T to the geometric past it corresponds. In memory recall the size of the active layer would correspond naturally to the temporal distance to the brain of the geometric past where the memory is stored. The frequencies of large Planck constant photons involved with communications would correspond to this distance ($f \sim 1/T$) and a de-coherence to photons with much shorter wavelength would take place in the process.

Neuroscience suggests that theta waves, which still have wavelength of order Earth size scale, are involved. They could result in de-coherence of waves with wavelength of order $\lambda = cT$ reducing the value of Planck constant.

The most primitive memory recall would rely on the scanning of brain of geometric past by using negative energy signal with a slowly varying carrier frequency. One can however consider MEs which are present permanently as vacuum extremals and activated to non-vacuum extremals during memory recall: this would mean a realization of a link system.

How could one realize links in time-like direction?

Links are certainly one of the most powerful functions of the web. Links are always present and activated when used. The obvious counterpart for the web link would be a topological light ray connecting two subsystems with a time-like separation. Topological light rays can also reduce to vacuum extremals and the activation of the link could correspond to a feeding of energy to a

topological light ray deforming it to a non-vacuum extremal. This kind of links would be naturally associated with long term memories and would make it un-necessary to scan the entire geometric past in the search of a particular episodal or declarative memory.

Dreams and building up of copies of memories

Important memories should be stored in several copies since would increase the probability that the scanning of the geometric past allows to build ME bridge to the subsystem representing the memory mental image. Memories represented as bit sequences can be also lost in a repetitive recall since they might fail to receive metabolic energy feed.

Dreams might be a way to build this kind of copies. The copies built up in this manner can involve a considerable processing and it could even happen that for painful memories large number of less painful variants are constructed. Also the original memory could be transformed to less painful during the period of time-like entanglement. When it is important that memory remains unchanged, PS might in fact be not favorable and it is known that PS deprivation can help of keeping memory intact [J67].

There is a lot of evidence that memory processing indeed occurs during sleep (memory consolidation): in particular during paradoxical sleep (PS, REM periods with dreams) and during periods of deep slow wave sleep (SWS) preceding them. The sequential model for memories [J67] assumes that both periods are necessary. The first guess is that dreams and preceding SWS periods could build copies of both episodal and declarative memories.

The sensory experience associated with a dream possibly resulting partially by sharing of sensory mental image of geometric past (say previous day) could give rise to a symbolic representation realized as a kind of record. If also a copy of sensory mental image is created, the dream would involve virtual visual input generated by sending signals from brain to retina and other sensory organs involved (in TGD sensory organs carry fundamental sensory qualia). This back projection is present also during wake-up state and essential part of building sensory representation from the raw sensory data. The fact that dreams are by no means direct copies of the sensory inputs of the geometric past suggests that an active buildup of sensory mental images indeed takes place. One could however stretch the limits of imagination and argue that the dreams could be composed of sequences of shared mental images from different times: this would conform with the short time range of "dream logic".

If the brain can be regarded as a kind of magnetic tape in the temporal direction, SWS period might be interpreted as a kind of empty interval in the tape telling that a memory record comes next (kind of silence before concert). Second function of SWS pattern would be to divide the time axis to frames analogous to letters appearing as units in computer memory. The SWS interval might also contain a temporal pattern defining among other things what might be regarded as a name of the record in question. The temporal pattern of the negative energy signal used in memory recall should have such a pattern that it would "resonate" with this pattern. Note that vacuum extremal MEs could define "static" links to memory mental images activated during memory recall to non-vacuum extremals and one can imagine also sequences of these extremals building a sequence of links.

Directory system, holograms, and p-adic fractality

Directory system is necessary in order to handle computer memory effectively. Basically the directory would be a scaled down fractal variant of the geometric past with a reduction of details leaving only titles of sections and subsections, so to say. These directories would make possible an effective scanning of the brain of the geometric past by going directly to the correct directory coded roughly by the temporal distance. The fact that we can construct mentally fractally scaled down memory representations about what happened during day and even during lifetime without effort suggests that this kind of fractal representation indeed is there.

The obvious idea is that the items of directories serve as links to subdirectories so that it is possible to active link in each directory item leading to a subdirectory associated with that item.

The fact that p-adically small is large in the real sense would automatically realize small time scale representations of long temporal intervals. This would suggest that the memory storage mechanism is hologram like so that copies of memories in various time scales are present. Effective

p-adic topology would indeed suggest the presence of this kind of representation with various copies appearing as p-adically scaled variants of basic pattern for given p. For this option declarative memory recall would not require a precisely targeted signal to a particular moment of geometric past whereas sensory memories would require it (note however the possibility that dreams build more or less faithful copies of sensory memories).

One could imagine a fractal coding of names of directories and subdirectories by temporal distances in various p-adic length scales. Here effective p-adic topology giving rise to a hierarchy of p-adic length scales might play key role in the coding. Also dark matter hierarchy and hierarchy of Planck constants would be involved in an essential manner and code for various scales of long term memory. The fact that favored value of Planck constants and p-adic length scales come in octaves suggests a close interaction between the two hierarchies.

The p-adic view about cognition suggests that p-adic numbers give a representation for the addresses of records and that effective p-adic topology for real space-time sheets is essential. Their space-time counterparts would be discrete intersections field bodies and p-adic space-time sheets having literally infinite size. The density of points of intersection would reduce as one moves away from biological body both in temporal and spatial direction and the fact that p-adic numbers correspond always to non-negative real numbers would conform with the fact that memories are about geometric past and the memories of nearest past are the most precise and for time scales which are fractions of second become sensory experiences which are actually very short term memories as findings of Libet demonstrate.

What is the role of generalized EEG rhythms from the point of view of memory?

TGD predicts entire hierarchy of EEG rhythms which are predicted to correlate with various biorhythms. One challenge is to understand the precise role of EEG rhythms, in particular theta band known to be involved with memory consolidation. Functional magnetic resonance imaging led to the discovery of so called so called spontaneous fluctuations in BOLD (blood oxygen level dependent) signal having 1/f spectrum in average sense [J73] (I am grateful for Vesa Kiviniemi (who is also working in this field [J69]) for sending me this review article). The frequency spectrum of these fluctuations is in the range range $.1 - .001$ Hz.

This activity is regarded as spontaneous in the sense that it is not induced by stimulus, motor output, or task but is something independent and thus conflicts with the paradigm that EEG corresponds directly to the brain state dictated by the input to brain and motor output and by cognitive tasks. For this reason spontaneous BOLD fluctuations were originally interpreted as noise but it has become clear that the fluctuation patterns possess both spatial and temporal coherence and that it is possible to assign regions of spatial coherence with brain functions in various brain areas.

The variation of spontaneous BOLD fluctuations explains also the variation of responses in experimental situations involving fixed stimulus or tasks. Spontaneous BOLD fluctuations seem to superpose linearly with the effect due to stimulus or task. BOLD fluctuations seem correlate with the slow fluctuations in EEG known to modulate the power spectrum in various EEG bands. Interestingly, there are also ~ 1 Hz slow fluctuations of membrane potential, which could be related to the cyclotron frequencies of DNA nucleotides (carrying constant negative charge density).

These findings conform with the fact that TGD predicts a fractal hierarchy of EEGs corresponding to the hierarchy of values of Planck constant. A further prediction would be that scaled variants of alpha band and its harmonic should appear in BOLD fluctuations as also the counterparts of beta and theta bands whose positions cannot however predicted without further assumptions.

EEG and its generalization would allow to interpret EEG rhythms as dividing the magnetic tape in time direction to a linear lattice of separate frames which each could represent a record in turn containing further records. This would be much like a fractal variant for the decomposition of a written text to letters with an approximately constant width. SWS would define kind of empty lines between paragraphs in this text and during wake-up state similar empty lines might be present.

Of course, the strict linear lattice is an idealization. It could be perturbed by insertions just like written text by pictures. These insertions could represent sensory mental images due to sensory input. Another analogy for sensory input would be as external force inducing kicks to the

harmonic oscillator changing the amplitude of oscillation and inducing phase increments.

9.5   A Proposal For Memory Code

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?*" [J75] (see `http://tinyurl.com/7dcgjwf`).

9.5.1   Basic Ideas Of The Model Of Memory Code

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 α and β. 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.

   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.

What does one mean with memory?

Before proceeding one must make clear what one means with memory in the recent context. The articles of New Scientists with - almost as a rule - sensationalistic titles, do not pay too much attention for the fact this kind of proposals are always based on some philosophical assumptions which might be wrong.

1. What one means with "memory" in the recent context? The memory in question is behavioral memory. Conditioning producing reflect like reaction is a typical example of behavioral memory and need not have anything to do with conscious memory such as episodal memory in which one literally re-lives an event of past. Electric stimulation of some regions of temporal lobes can indeed induce this kind of memories. The idea about coding would suggest the identification of this memory with a highly symbolic computer memory based on "carving in stone".

2. The proposal is inspired by the idea of brain or cell as computer and can be criticized. There is no pressing need for coding since behavioral memory can be reduced to the formation of associations and associative learning by computers is standard example of this kind of behavioral memory. One can of course consider the coding for declarative and verbal memories and genetic code provides an attractive candidate for a universal code. This kind of code might be behind the natural languages as a kind of molecular language.

3. Behavioral memories can be defined as changes of behavior resulting from a continued stimulus. The understanding of behavioral memory relies on the notions of synaptic strength, synaptic plasticity, and long term potentiation. Synaptic strength tells how strongly the postsynaptic neuron responds to the nerve pulse pattern arriving along pre-synaptic axon and mediated by neurotransmitter over the synaptic gap. For instance, glutamate acts as excitatory neurotransmitter and binding to receptor. At neuronal levels long term potentiation means increase of the synaptic strength so that post-synaptic neuron becomes "more attentive" to the firing of pre-synaptic neuron.

   Hebb's rules [J10] (see `http://tinyurl.com/y7q2gueo`) - not established laws of Nature and plagued by exceptions - state that the effectiveness of synaptic receptors increases, when the two neurons fire simultaneously: it is important to notice that these firings need not have any causal connection with each other. The simultaneous firing activates NMDA receptors in the post-synaptic neuron and generates Ca^{+2} flux which correlates with the increase of the synaptic strength. NMDA obeys same chemical formula $C_5H_9NO_4$ as glutamate: in fact, glutamate and asparagin the two acidic amino-acids. It is also known that the presence of CaKMII is necessary for the increase of the synaptic strengths.

4. There is however an almost-paradox involved with this view about memory if assumed to explain all kinds of memories - in particular episodal memories. Long term conscious memories can be lifelong. Synaptic structures are however highly unstable since the synapses and proteins involved are cycled. To my view this argument is somewhat naïve. There could be a flow equilibrium. The flow pattern of fluid flow in flow equilibrium can be stable although the fluid is replaced with new one all the time. The proposal of authors is that memories are stored to some more stable structures and that microtubules are these more stable structures making possible short term memories. Post-synaptic microtubules, which differ from presynaptic microtubules in several ways are indeed stabilized by MAPs. Authors also propose the thin filaments associated with the cytoskeleton are responsible for long term memories.

   Authors believe on computationalism and they apply standard view about time so that their conclusion is that long term memories are stored elsewhere and remain able to regulate synaptic plasticity. In this framework the notion of memory code is very natural.

LTP and synaptic plasticity

From Wikipedia one can read that synaptic plasticity [J21] (see `http://tinyurl.com/cn7724o`) means possibility for changes in function, location and/or number of post-synaptic receptors and ion channels. Synapses are indeed very dynamical and synaptic receptors and channel proteins are transient, which does not seem to conform with the standard view about long term memory and indeed suggest that the stable structures are elsewhere.

Long term potentiation [J13] (see `http://tinyurl.com/djmhrp`), briefly LTP, involves gene expression, protein synthesis and recruitment of new receptors or even synapses. The mechanism of LTP is believed to be following. The glutamate from pre-synaptic neuron binds to post-synaptic receptors, which leads to the opening of Ca^{+2} channels and influx of Ca^{+2} ions to dendritic spines, shafts and neuronal cell body. The inflow of Ca^{+2} induces activation of multiple enzyme including protein kinase A and C and CaMKII. These enzymes phosphorylate intra-neuronal molecules.

It is known that the presence of CaMKII is necessary for long term potentiation. This supports the proposal of authors that microtubules are involved in an essential manner in memory storage and processing and regulation of synaptic plasticity. The observation about the correspondence between the geometries of CaMKII and microtubular surface is rather impressive support for the role of MTs. To my opinion, the hypothesis about memory code is however un-necessary.

Microtubules

Quite generally, microtubules (MTs) are basic structural elements of cytoskeleton. They are rope like polymers and grow as long as 25 micrometers long. They are highly dynamical. The standard view identifies their basic function as maintaining of cell structures, providing platforms for intracellular transport, forming the spindle during mitosis, etc..

Microtubules [J14] (see `http://tinyurl.com/ya6rm9r`) are extremely rich in eukaryotic biology and brain neurons. They are believed to connect membrane and cytoskeletal levels of information processing together. MTs are the basic structural elements of axons and MTs in axons and dendrites/neuronal cell bodies are different. Dendrites contain antiparallel arrays MTs interrupted and stabilized by microtubule associated proteins (MAPs) including MAP_2. This difference between dendritic and axonal microtubules could be relevant for the understanding of the neuronal information processing. Microtubules are associated also with long neural pathways from sensory receptors, which seem to maximize their length.

For these reasons it would not be surprising if MTs would play a key role in the information processing at neuronal level. Indeed, the more modern view tends to see microtubules as the nervous system of the cell, and the hexagonal lattice like structure of microtubules trongly suggests information processing as a basic function of microtubules. Many information processing related functions have been proposed for microtubules. Microtubules have been suggested role as cellular automatons and also quantum coherence in microtubular scale has been proposed.

The proposal of the article is that short term memory is realized in terms of a memory code at the level of MTs and that intermediate filaments which are much more stable could be responsible for long term memory.

CaMKII enzyme

According to the proposal the key enzyme of memory would be Calcium/calmodulin-dependent protein kinase II: briefly CaMKII [J8] (see `http://tinyurl.com/6x4toa3`). Its presence is known to be necessary for long term potentiation.

In passive state CaMKII has snowflake shape. The activated kinase looks like double sided insect with six legged kinase domains on both sides of a central domain. Activation means phosphorylation of the 6+6 legs of this "nano-insect". In the presence of Ca^{+2} or calmodulin flux CaKMII self-actives meaning self-phosphorylation so that it remains permanently active.

There are however grave objections against phosphate=1–no-phosphate=0 coding.

1. Only the fluxes of Ca^{+2} and/or calmodulin matter so that it is very difficult to imagine any coding. One would expect that the fraction of phosphorylated legs depends on these fluxes in equilibrium but it is very difficult to image how these fluxes could carry information about a specific pattern of phosphorylation for legs. If all legs are phosphorylated the coding to microtubular phosphorylation would require that 6 bits of information is fed at this stage by telling which leg actually gives its phosphate to tubulin. This does not look two plausible but one must be very cautious in making too strong conclusions.

2. Since metabolic energy is necessary for any information processing, the more plausible interpretation would be that phosphorylation makes bit active. Bit itself would be represented in some other manner. The 6+6 leg structure of CaMKII is very suggestive of a connexion with 6 incoming bits and 6 outgoing bits - possible same or conjugated. The interpretation in terms of DNA codon and its conjugate is what comes first in mind.

One should not however throw away child with the wash water. The highly interesting discovery discussed in the article [J75] (see `http://tinyurl.com/7dcgjwf`) is that the spatial dimensions, geometric shape, and electrostatic binding of the insect-like CamKII and hexagonal lattices of tubulin proteins in microtubules fit nicely together. The authors show how CaMKII kinase domains can collectively bind and phosphorylate MTs. This alone could be an extremely important piece of information. There is no need to identify bit with phosphorylation state.

9.5.2 TGD View About The Situation

TGD based view about memory could have been developed by starting from the paradox related to long term memories. Memories are long lasting but the structures supposed to be responsible for their storage are short-lived. TGD based solution of the paradox would be based on new view about the relationship between geometric time and experienced time.

1. According to this view brain is 4-dimensional and primary memories are in the time-place, where the neural event took place for the first time. In principle there would be no need to store memories by "carving them in stone". To remember would be to see in time direction: this view is indeed possible in zero energy ontology. Time-like entanglement and signalling to the geometric past using negative energy signals would be the basic mechanisms of memory.

2. Stable memories require copies also for another reason. The negative energy signal to geometric past is not expected to allow a precise targeting to a one particular moment of time in past. To circumvent the problem one must make the target large enough in time direction. The strengthening of memory would mean building up large number of copies of memory. These copies are produced in every conscious memory recall and learning would be based on this mechanism. The neuronal mechanism would produce large number of copies of the memory and one can ask whether CaMKII indeed generates phosphorylated sections of MT somehow essential for the representation of long term symbolic memories as names for experiences rather than experiences themselves.

3. Metabolism must relate also to conscious memory recall. Since negative energy signals are involved, there is great temptation to assume that de-phosphorylation liberating metabolic energy corresponding to the absorbed negative energy accompanies memory recall. Large $\hbar$ for the photons involved would allow very low frequencies -expected to characterize the time span of memory recall - and make communications over very long time intervals possible. This would mean that the original memory representation is destroyed in the memory recall. This would conform with the spirit of quantum no-cloning theorem [B3] (see `http://tinyurl.com/2dhl4oe`). Several copies of the memory representation would be needed and also feed of metabolic energy to generate new copies. In this framework conscious memory recall would be dynamical event rather than stable bit sequence in accordance with the vision about quantum jump as moment of consciousness.

Braiding as a universal model for memory

This leaves a lot of freedom to construct more detailed models of symbolic memories.

1. Braiding of magnetic flux tubes would make possible not only topological quantum computation [K2] (see `http://tinyurl.com/ybyscdpt` but also a universal mechanism of long term memory. In the model of DNA as topological quantum computer) the flux tubes connect DNA nucleotides and lipids of cell membrane. It turned out that the flux tubes carrying dark matter - identified as ordinary particles but with non-standard value of Planck constant [K36] - could connect all kinds of biomolecules and that braiding and reconnection could serve as basic quantum mechanisms in the functioning of biomolecules. Flux tubes could also connect the tubulins of microtubules and lipids of axonal or dendritic membrane.

2. Two kinds of braidings are present: the lipid flow defines braiding in time direction as the analog of dance and the fact that lipids are like dancers with threads from shoes the wall - now microtubule surface - so that the dance induce braiding of these threads storing the dynamics of the dance to memory. The presence of both space-like and time-like braiding and the fact that they are in well-defined sense dual has become central idea of quantum TGD itself. Originally it was however discovered in the model for DNA as topological quantum computer [K2].

3. Both active memory recall by sending negative energy dark photon to geometric past and spontaneous memory recall by receiving a positive energy photons from geometric past require metabolic energy. Therefore the presence of phosphate in braid strands is necessary. The

flux tubes defining braid strands can be therefore assumed to be active only if they have phosphate at the other end. A more appropriate TGD based interpretation is that this makes possible negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book), which is one of the basic predictions of the number theoretic vision about life. High energy phosphate bond would thus a signature of negentropic entanglement, which could serve as a correlate for the experience of understanding. One could relate ATP-ADP process as a basic process of life directly to cognition. The presence of phosphate would tell that there is magnetic flux tube - actually pair of them- beginning from the molecule.

TGD variant of the microtubular model for memory

The finding of the authors inspires a more detailed formulation for the vision for how memories could be realized at microtubular level.

1. The phosphorylation of tubulins would generate active braids strands and their presence would make possible memory recall. Note that memories as such could be stored to the braiding in any case if the microtubule-lipid flux tubes are present always. Every nerve pulse pattern would induce a flow of lipids at neuronal membrane if the membrane is in a phase corresponding to 2-D liquid crystal. This flow pattern would be stored to the braiding of the flux tubes.

2. In the model of DNA as topological quantum computer one assigns to braid strands connecting DNA nucleotides to lipids 4 different states representing the nucleotides A, T, C, G. In the original model the A, T, C, G were mapped to four states defined by quarks u, d and their antiquarks at the ends of braid strands. This proposal can be of course accused of being quite too science fictive. TGD however predicts the possibility of scaled up variants of QCD type physics even in the scale of living matter and there are some indications for this.

   A more down-to-earth realization of the genetic code proposed quite recently [K46] is that braid states correspond to pairs of magnetic flux tubes. To the ends of both flux tubes one assigns electron so that the electrons form spin triplet and spin singlet state defining 3+1 states representing A, T, C, G. This gives also a connection with electronic super-conductivity which is fundamental assumption in the model of nerve pulse based on Josephson currents: nerve pulse corresponds to a simple perturbation of the ground state in which all Josephson current along axon are oscillating in the same phase. Mathematically the phase difference behaves like gravitational pendulum [K81].

   The 6=2+2+2 legs could correspond to flux tube pairs and each flux tube pair would represent DNA nucleotide in terms of the spin state of electron pair. Phosphorylation would activate the braid strand by making possible negentropic entanglement and information storage and recall. This conforms with the fact of life is that metabolic energy is needed for all kinds of information processing including also information storage.

   If all 6 tubulins to which bits are assigned are indeed phosphorylated in the active state and if the memory recall involves use of metabolic energy as proposed, then the reading of the memory would mean complete de-phosphorylation of 6-tubulin sequences. The prediction would be the presence of phosphorylated 6-tubulin sequences at microtubular surface and their disappearance in memory recall. I do not know whether there is any manner to test these predictions.

3. For this proposal LTP would involve a generation of active braid strands. The post-synaptic neuron would be in "wake-up" state and would pay attention to the nerve pulse patterns arriving from the pre-synaptic neuron. This activation would be induced by simultaneous firing of post-synaptic and pre-synaptic neurons. As a consequence, the lipid flow would generate braidings providing memory representations and defining in temporal domain quantum computation like processes.

4. This does not yet explain why CaMKII is necessary for LTP. There is a high temptation to regard the increase of the synaptic sensitivity as a property of synaptic connection. One can imagine several mechanisms.

(a) For instance, active flux tube connections between presynaptic lipids and postsynaptic microtubuli could be generated by phosphorylation, and the flux tubes might increase the flow of glutamate between pre- and post-synaptic neurons and in this manner increase synaptic strength. Flux tubes might make possible a continual flow of dark particles between pre- and post-synaptic neurons. They could also make possible negentropic entanglement between the two neutrons binding the neurons to single coherent quantum whole.

(b) The strength of this connection could be affected also by the presence of active braid strands making possible quantum memory and topological quantum computation. Also more complex processes assigned with LTP would become possible since microtubules might be seen as conscious intelligent structures able to modify their nearby environment.

Part III

INTELLIGENCE, INFORMATION, AND COGNITION

Chapter 10

Conscious Information and Intelligence

10.1 Introduction

This chapter is a fusion of two separate parts, the first one devoted to information measures for conscious experience and second summarizing a quantum model for intelligent systems. This reflects in its own way the fact that the development of the related ideas has not been a linear process and has involved many weird twists typical for a mathematical thinking without strong connection with empiria.

The motivation for the recent updating are the developments in basic quantum TGD and in TGD inspired theory of consciousness (I am writing this towards the end of March, 2015). In the following I try to summarize TGD inspired view about information, intelligence and consciousness. Some of the memes of the previous updated version prepared around 2003 have lost the game and new memes - or rather an overall vision about conscious intelligence - has emerged. This is also due to the unification of about decade old ideas related to TGD proper to form single coherent whole.

One of the most notable losers is the hypothesis about the quantum jump replacing p-adic space-time sheet with a real one as a realization of intentional action. The hypothesis was inspired by the idea that p-adic space-time sheets are correlates for both cognition and intentionality. In adelic vision about TGD space-time surfaces are correlates both for the sensory and cognitive aspects and intentional action are assigned state function reduction. Intention is assigned with the sequence of repeated state functions defining self and subselves as mental images of self. Quite generally, p-adic and real aspects integrate to form an adelic view at all levels rather than being thought to be something separate.

The earlier vision identifying evolution at basic as a generation of number theoretic complexity of algebraic extensions of rationals becomes rather concrete in the adelic vision about TGD, and the strong form of holography leads to an elegant unification of real and p-adic physics in terms of number theoretic universality in the intersection of real and p-adic worlds defined by string world sheets and partonic 2-surfaces and serving as the seat of life. This intersection carries also the cognitive and sensory representations and for the parameters characterizing extension take physical meaning.

The new elements relate to the progress in the understanding of the notion of self implied by a generalization of quantum measurement theory based on Zero Energy Ontology (ZEO). In particular, the precise definition of Negentropy Maximization Principle and role of negentropic entanglement (NE) leads to powerful predictions consistent with what is known about biology and consciousness and very relevant for the notion of evolution of conscious intelligence. Also the realization that the hierarchy of Planck constants corresponds to a hierarchy of quantum criticalities realized in terms of symmetry breakings has strong implications central for understanding evolution and intelligence.

10.1.1   Magnetic Body As Intentional Agent And Experiencer

The notion of magnetic body has a central role in TGD inspired biology. Magnetic body has an onion-like fractal structure and astrophysical size with wavelength of EEG wave defining the size scale of the magnetic body with which it is associated. Magnetic body acts as as an intentional agent using biological body as a motor instrument and sensory receptor. Magnetic body receives sensory and other information from biological body through EEG and its fractal counterparts and controls biological body via EEG type signals sent to the genome, where they induce chemical or electromagnetic gene expression. This allows to imagine also a mechanism of collective learning. The spatio-temporal nerve pulse patterns defining topological quantum computations are mediated via EEG and its fractal counterparts to the magnetic body of organism and from it to the magnetic body of another organism [K33].

The magnetic body of Earth - magnetic Mother Gaia- could serve as a relay station and Schumann resonances and alpha band could allow broadcasting of the nerve pulse pattern to a large number of magnetic bodies of organisms. From the latter magnetic body the field representation of nerve pulse pattern would induce via EEG type signal from magnetic body to the receiver genome the original nerve pulse pattern in the brain of the receiver. Nerve pulse patterns would be quite generally induced by magnetic bodies via appropriate part of the intronic genome as electromagnetic gene expression. This mechanism could be also involved with telepathy and remote mental interactions.

Magnetic flux tubes and flux sheets are basic building bricks of the magnetic body and DNA as topological quantum computer hypothesis assumes that DNA nucleotides are connected to cell membrane by flux tubes defining braids playing a key role in topological quantum computation [K2]. Therefore magnetic body is essential for realizing the software of biological intelligence. The essential assumption is that magnetic body carries dark matter consisting of ordinary with a non-standard value of Planck constant. The phase transition changing the value of Planck constant change the size scale of the flux tube and this process together with reconnection of the flux tubes would define mechanisms of bio-catalysis.

Magnetic bodies - or rather their time evolutions connecting two space-like 3-surfaces at the opposite boundaries of causal diamond (CD) in ZEO - are natural space-time correlates for memes and the replication of magnetic bodies completely analogous to what happens in 3-particle vertex makes possible the replication of memes and is assumed to induce biological replication. 4-D character of the quantum self-organization and of the space-time correlates of zero energy states can be seen as an essentially new element allowing to understand how behaviors and function emerge.

10.1.2   What Is Conscious Intelligence

The following summary tries to give a brief summary about how conscious intelligence could be understood in TGD Universe. The vision about life and conscious information and intelligence as something in the intersection of real and p-adic worlds is certainly the most important aspect in this respect. ZEO (ZEO) and the notion of causal diamond (CD) lead to the modification of quantum measurement theory allowing to define the notion of self and explaining basic aspects of consciousness. The hierarchy of Planck constants as an explanation of dark matter and energy as macroscopic quantum phases even in astrophysical scales and implying that dark matter is a key actor in the drama of life is the third key element.

Zero energy ontology and intelligence

In zero energy ontology (ZEO) physical states are replaced by pairs of positive and negative energy states assigned to the past *resp.* future boundaries of causal diamonds (CDs) defined as pairs of future and past directed light-cones ($\delta M^4_\pm \times CP_2$). The net values of all conserved quantum numbers of zero energy states vanish. Zero energy states are interpreted as pairs of initial and final states of a physical event such as particle scattering so that only events appear in the new ontology.

ZEO combined with the notion of quantum jump resolves several problems. For instance, the troublesome questions about the initial state of the universe and about the values of conserved quantum numbers of the Universe can be avoided since everything is in principle creatable from

vacuum. Communication with the geometric past using negative energy signals and time-like entanglement are crucial for the TGD inspired quantum model of memory and both make sense in ZEO. ZEO leads to a precise mathematical characterization of the finite resolution of both quantum measurement and sensory and cognitive representations in terms of inclusions of von Neumann algebras known as hyperfinite factors of type II_1 [K120]. The space-time correlate for the finite resolution is discretization which appears also in the formulation of quantum TGD in terms of the Kähler-Dirac action.

At the embedding space-level CD is the correlate of self whereas space-time sheets having their ends at the light-like boundaries of CD are the correlates at the level of 4-D space-time. The hierarchy of CDs within CDs corresponds to the hierarchy of selves.

ZEO implies that 3-D objects are replaced by pairs of space-like 3-surfaces at opposite boundaries of CD and holography implies that space-time surfaces replace 3-D objects. Spatiotemporal patterns or actually their quantum superpositions become the basic objects. Behavior and function matter rather than the state of system, say brain, at given moment. This has important implications for the view about morphogenesis in biology and behavior in neuroscience. Self-organization becomes evolution of 4-D rather than 3-D patterns. Identifying magnetic bodies as counterparts of memes, one can even speak about replication of memes inducing that of living matter. Obviously these aspects are central also for understanding of intelligence.

The original interpretation of the space-time correlates of mental images was as mind-like space-time sheets identified as space-time sheets with a finite temporal size. In ZEO all space-time sheets have a finite size and serve as correlates for zero energy states, which could be interpreted as representations of laws of physics as superpositions of pairs of initial and final states given by M-matrix. In state function reduction process these states are reduced to states for which only negentropic time-like entanglement is possible and one might say that the negentropy measures the conscious information associated with the final state of the reduction process. One can interpret negentropic quantum states as memes or morphogenetic fields [K87] [I63].

ZEO based quantum measurement theory leads automatically to the notion of self predicting that self has a finite life-time [K54, K89]. The highly non-trivial prediction is that in death caused by a state function reduction to the opposite boundary of CD self re-incarnates at the opposite boundary of CD as a time-time reversed version: at the level of sub-selves this means replacement of mental image with its time-reversed mental image. The experience flow of subjective time finds a simple explanation and the question why the contents of sensory consciousness is restricted to such a narrow time interval (located near the future boundary of CD) [K116, K7].

The decomposition of contents of consciousness of self to a static part coming from the passive boundary of CD at which state function reduction sequences has no effect and to part coming from the active boundary of CD, which changes and for which the state changes suggest interpretation as an analog of figure-background or experiencer-experienced division. The time reversal would change the roles of figure and background and vase-faces illusion could be an example about time reversal of mental image. Time reversed writing and time-reversed speech [K89] could be also examples about directly experienced time reversal of mental images. This aspect of self-ness is certainly crucial for understanding intelligence: since figure back-ground divisions is what intelligent systems perform routinely. For instance, right and left brain might be specialized to produce time reversed views about same sensory input.

Also first and third person views might correspond to time reversed mental images. In near death experiences person sees himself as an outsider: could this be interpreted as the change of the roles of figure and background interpreted as first and third person perspectives?

Weak form of NMP

The precise form of NMP has chrystallized only gradually. The strong form of NMP states that negentropy gain in state function reduction is maximal. This would fix completely the sub-system complement pair of system for which the reduction takes place and if negentropic entanglement is present also the final state as negentropically entangled state with density matrix which is projector to subspace which has dimension which can be also higher than $d = 1$. In standard quantum theory one has $n = 1$ and one can argue that the density matrix in practices has only non-degenerate eigenvalues in real context. In TGD framework quantum criticality changes the situation and quantum critical states have the property that $d > 1$ is possible.

It has however turned out that strong form of NMP does not allow genuine morally responsible free will. We would live in best possible world which does not seem to be the case. This leads to the proposal that weak form of NMP is more appropriate formulation. Again NMP would select the sub-system-complement pair which can produce the maximal negentropy gain but the continuation is different.

1. Suppose that $n > 1$-dimensional projector would produce maximum negentropy gain and would be thus forced by strong form of NMP. The weak form of NMP allows self associated with the CD containing the CD of self as sub-CD to choose also lower-dimensional subspace of sub-space of dimension $n - k$, $0 \leq k < n$.

   For $k = n - 1$ one has ordinary state function reduction destroying NE and isolating the self from the rest of the world. This means free will. Note that self does not itself decide what as it dies and reincarnates: it is self above who decides! One can also understand the quantum correlates of ethics and moral if the generation of NE is what good deed means. The death of self is like picking a fruit from tree and the self picking it decides how much NE is created.

2. If one has fixed base for n-dimensional sub-space (this might be questioned) one the resulting subspaces have dimension in the range $1, ..., n$ and their number is $2^k - 1$: this like putting $n - k$ balls in distinct boxes in all possible way and the number is given by binomial coefficient: the 0-dimensional final state space is not allowed. This would suggest that the choices are in 1-1 correspondence with the basis of Boolean algebra of k bits. Since the amount of negentropy generated should measure the degree of positive emotional coloring of the choice, it is possible that one has kind of emotional realization of of Boolean logic with one statement thrown away (in set theoretic realization this would be the statement represented by an empty set). Since the p-adic prime appearing in the definition of number theoretic negentropy is a factor of $n - k$, those values of $n - k$ near to n, which correspond to powers of single prime produce largest negentropy gain and would be favored so that powers of prime are favored by selection implied by weak form of NMP.

3. An interesting question is whether this "emotional" realization of logic can be mapped naturally to the realization of Boolean logic by many-fermion states in ZEO (many-fermion state and its counterpart with opposite quantum numbers at opposite boundary of CD in a fixed basis realize the Boolean statement). This realization could be fundamental for understanding the correlates of emotional intelligence at quantum level.

One can represent an objection against the proposed emotional realization of Boolean logic. One is choosing from the discrete set of sub-set of a fixed basis for n-dimensional space. Why not to choose from the continuous set of sub-spaces? This would be the classical option. There is a continuum of choices for $n - k$-dimensional sub-space and the choices are parameterized by complex Grassmannian $G(n, k)$ (appearing in twistor Grassmann approach to scattering amplitudes!) and now one can talk about probabilities only. The probability for a choice of $n - k$-dimensional subspace would be naturally proportional to the volume of Grassmannian $G(n, k)$. The first problem is that this volume is vanishing for $k = 0$ so that the choice with maximal dimension would have zero probability. The second problem is that volume of $G(n, k)$ is proportional to a scale parameter R raised to the dimension $d(k) = k(n - k)$ of $G(n, k)$ and the condition that probabilities for various choices depend on the choice of R. It seems that the classical option cannot make sense and will not be discussed in the sequel.

Boolean mind and fermions

The connection of fermionic Fock space basis with Boolean algebra was one of the first ideas related to the quantum modelling of intelligent systems. The state basis for the fermionic Fock space has a natural interpretation as Boolean algebra (fermion number $=1/0\leftrightarrow$ yes/no). In this way ordinary Boolean algebra is extended to a vector space spanned by fermionic states. Fermion number conservation poses an obvious problem for this scenario in positive energy ontology. ZEO resolves this problem quite generally and zero energy states resulting as an outcome of state function reduction process represent Boolean statements of type A$\rightarrow$ B in terms of time-like NE in fermionic degrees of freedom.

The original proposal was to use cognitive fermion pairs instead of fermions with fermion and anti-fermion located at the opposite throats of wormhole contact. In the recent formulation of quantum TGD bosons and their super counterparts correspond to wormhole contacts. An interesting question is whether one could consider ordinary Boolean logic as some kind of limit for the complex quantum logic and whether our logical mind could have something to do with Boolean algebra. For instance, could primary "this is true" experiences correspond to Boolean qualia having increments of fermionic quantum numbers as physical correlates. Boolean truth values could also correspond to spin directions of fermions. In this case fermion number conservation does not pose any constraints and the macroscopic realization replacing single spin as a representative of bit with a magnetized ensemble of fermions, makes the realization robust.

Negentropic entanglement (NE) means that qubits are always fuzzy and the fuzziness depends on the situation. The positive aspect is that the quantum superposition gives rise to an abstraction, rule about pairing of say initial and final states represented as positive and negative energy parts of zero energy state with the pairs of superposition representing the instances of the rule. p-Adic-real entanglement with positive definite number theoretical entanglement entropy in the intersection of real and p-adic worlds could give rise the experience of understanding and makes possible cognitive quantum computation like processes.

A new element is the realization that spinor modes and thus fermions are localized to string world sheets and partonic 2-surfaces by the condition that em charge is well-defined. There are many other reasons for this localization. By strong form of holography these 2-surfaces define kind of space-time genes. The natural assumption is that they are in the intersection of reality and various p-adicities in the sense that the parameters characterizing them belong to an algebraic extension of rationals and are therefore discretized.

This makes possible an elegant correspondence between real and p-adic space-time sheets. They are not mapped to each other directly but obtained by holography from the fundamental 2-surfaces in the intersection by the condition that they are preferred extremals of Kähler action for which the classical Noether charges for a sub-algebra of super-symplectic algebra with conformal weights coming as n-ples of those for the full algebra vanish. No discretization at space-time level is required and problems with the general coordinate invariance (GCI) are avoided. By conformal invariance the parameters in question are general coordinate invariant conformal moduli. The vanishing of classical Noether charges for the sub-algebra of super-symplectic algebra characterizes partially the preferred extremals.

Fermions would reside in the intersection and be number theoretically universal. Indeed, the anticommutations relations are number theoretically universal, even in the case that they involve quantum group phase.

The hierarchy of algebraic extensions of rationals defines the fundamental hierarchy defining also evolutionary hierarchy. The higher the complexity of the extension, the higher the level in the evolutionary hierarchy. p-Adic primes are identified as ramified primes of algebraic extension and the large the p-adic prime the higher the level of cognition. The higher the dimension $n = h_{eff}/h$ of extension, the longer the scale of quantum coherence, and the higher the intelligence of the system. What distinguishes ramified p-adic primes from the others that the prime ideals of of integers of extension define by ramified primes are such that the action of Galois group is trivial. The interpretation is that for ramified primes n space-time sheets co-incide at their ends at boundaries of CD. This would be one way to interpret quantum criticality and consistent with the adopted interpretation. This brings in n "dark" discrete degrees of freedom which are crucial for intelligence and this is what makes corresponding p-adic primes so special.

Weak NMP supports the generalization of p-adic length scale hypothesis stating that ramified/p-adic primes near but below powers or primes are of special importance. Primes near powers of 2 appear in the original form of p-adic length scale hypothesis and should be central for understanding intelligence in TGD Universe. Finite fields associated with $p = 2, 3, 5$ can be realized as finite geometries representable by Platonic solids. Also other finite fields can be realized as finite geometries realized as regular polygons. This suggests that powers of primes near but below p^k, $p = 2, 3, 5$ are of special importance. The model of music harmony and genetic code based on icosahedral geometry supports this view: icosahedron corresponds to $p = 5$ finite projective geometry [K80]. Music scales involve both 2-adicity (octave equivalence) and 3-adicity (quint cycle) and the finding that powers of 3 define time scales at which sudden jumps in biological evolution have occurred [I50] support this view. Cyclic group Z_5 defines one particular Galois group with 5

elements and corresponds to angle $2\pi/5$,whose cosine involves $\sqrt{5}$ defining an algebraic extension containing $\sqrt{5}$ and appearing in Golden Mean, which is fundamental in biology.

String world sheets and partonic 2-surfaces would be characterized by $n = h_{eff}/h$ and the ramified primes. Number theory alone does not predict any correlations between them. The generalization of AdS/CFT correspondence to TGD framework realizes quantum classical correspondence and suggests that the p-adic primes identified as ramified primes must divide n. This assumption would mean that even elementary particles would carry surprisingly large number of discrete dark degrees of freedom. For instance, electron would correspond to $n = M_{127} = 2^{127} - 1$ and carry 126 bits of information, and would be ideal for realizing memetic code that I proposed for two decades ago with inspiration coming from Combinatorial Hierarchy [K41]. The secondary p-adic time scale of electron is .1 seconds and corresponds to a fundamental bio-rhythm. The corresponding p-adic length scale corresponds to the size of Earth. Hence - in sharp contrast with standard physics expectations - elementary particles -also quarks - could be crucial for understanding conscious intelligence. Neutrinos correspond to p-adic length scale possibly longer than that associated with Gaussian Mersenne $M_{G,127} = (1 + i)^{167} - 1$. There are actually 4 Gaussian Mersennes in biologically relevant length scale range 10 nm- 2.5 μ m corresponding to $k = 151, 157, 163, 167$. This number theoretical miracle must have some deep meaning. That Gaussian Mersennes are in question might have some deep meaning. They represent primes of algebraic extension containing i possible for primes $p = 3 \ mod3$. Do

p-Adic physics as physics of cognition and imagination

The vision about p-adic physics as physics of cognition has gradually established itself as one of the key idea of TGD inspired theory of consciousness. There are several motivations for this idea.

The strongest motivation is the vision about living matter as something residing in the intersection of real and p-adic worlds. One of the earliest motivations was p-adic non-determinism identified tentatively as a space-time correlate for the non-determinism of imagination. p-Adic non-determinism follows from the fact that functions with vanishing derivatives are piecewise constant functions in the p-adic context. More precisely, p-adic pseudo constants depend on the pinary cutoff of their arguments and replace integration constants in p-adic differential equations. In the case of field equations this means roughly that the initial data are replaced with initial data given for a discrete set of time values chosen in such a way that unique solution of field equations results. Solution can be fixed also in a discrete subset of rational points of the embedding space. Presumably the uniqueness requirement implies some unique pinary cutoff. Thus the space-time surfaces representing solutions of p-adic field equations are analogous to space-time surfaces consisting of pieces of solutions of the real field equations. p-Adic reality is much like the dream reality consisting of rational fragments glued together in illogical way or pieces of child's drawing of body containing body parts in more or less chaotic order.

The obvious looking interpretation for the solutions of the p-adic field equations would be as a geometric correlate of imagination. Plans, intentions, expectations, dreams, and cognition in general could have p-adic space-time sheets as their geometric correlates. A deep principle could be involved: incompleteness is characteristic feature of p-adic physics but the flexibility made possible by this incompleteness is absolutely essential for imagination and cognitive consciousness in general.

The original idea was that p-adic space-time regions can suffer topological phase transitions to real topology and vice versa in quantum jumps replacing space-time surface with a new one is given up as mathematically awkward: quantum jumps between different number fields do not make sense. The new adelic view states that both real and p-adic space-time sheets are obtained by continuation of string world sheets and partonic 2-surfaces to various number fields by strong form of holography.

The idea about p-adic pseudo constants as correlates of imagination is however too nice to be thrown away without trying to find an alternative interpretation consistent with strong form of holography. Could the following argument allow to save p-adic view about imagination in a mathematically respectable way?

1. Construction of preferred extremals from data at 2-surfaces is like boundary value problem. Integration constants are replaced with pseudo-constants depending on finite number pinary

digits of variables depending on coordinates normal to string world sheets and partonic 2-surfaces.

2. Preferred extremal property in real context implies strong correlations between string world sheets and partonic 2-surfaces by boundary conditions a them. One cannot choose these 2- surfaces completely independently. Pseudo-constant could allow a large number of p-adic configurations involving string world sheets and partonic 2-surfaces not allowed in real context and realizing imagination.

3. Could imagination be realized as a larger size of the p-adic sectors of WCW? Could the realizable intentional actions belong to the intersection of real and p-adic WCWs? Could the modes of WCW spinor fields for which 2-surfaces are extandable to space-time surfaces only in some p-adic sectors make sense? The real space-time surface for them be somehow degenerate, for instance, consisting of string world sheets only. Could imagination be search for those collections of string world sheets and partonic 2-surfaces, which allow extension to (realization as) real preferred extremals? p-Adic physics would be there as an independent aspect of existence and this is just the original idea. Imagination could be realized in state function reduction, which always selects only those 2-surfaces which allow continuation to real space-time surfaces. The distinction between only imaginable and also realizable would be the extendability by using strong form of holography.

Although p-adic space-time sheets as such are not conscious, p-adic physics would provide a beautiful mathematical realization for the intuitions of Descartes. The formidable challenge is to develop experimental tests for p-adic physics. The basic problem is that we can perceive p-adic reality only as "thoughts" unlike the "real" reality, which represents itself to us as sensory experiences. Thus it would seem that we should be able generalize the physics of sensory experiences to physics of cognitive experiences.

Hierarchy of Planck constants and consciousness

The hierarchy of Planck constants is realized in terms of a generalization of the causal diamond $CD \times CP_2$, where CD is defined as an intersection of the future and past directed light-cones of 4-D Minkowski space M^4. $CD \times CP_2$ is generalized by gluing singular coverings and factor spaces of both CD and CP_2 together like pages of book along common back, which is 2-D sub-manifold which is M^2 for CD and homologically trivial geodesic sphere S^2 for CP_2 [K36]. The value of the Planck constant characterizes partially given page and arbitrary large values of $\hbar$ are predicted so that macroscopic quantum phases are possible since the fundamental quantum scales scale like $\hbar$. All particles in the vertices of Feynman diagrams have the same value of Planck constant so that particles at different pages cannot have local interactions. Thus one can speak about relative darkness in the sense that only the interactions mediated by the exchange of particles and by classical fields are possible between different pages. Dark matter in this sense can be observed, say through the classical gravitational and electromagnetic interactions. It is in principle possible to photograph dark matter by the exchange of photons which leak to another page of book, reflect, and leak back. This leakage corresponds to $\hbar$ changing phase transition occurring at quantum criticality and living matter is expected carry out these phase transitions routinely in bio-control. This picture leads to no obvious contradictions with what is really known about dark matter and to my opinion the basic difficulty in understanding of dark matter (and living matter) is the blind belief in standard quantum theory.

Dark matter hierarchy and p-adic length scale hierarchy would provide a quantitative formulation for the self hierarchy. To a given p-adic length scale one can assign a secondary p-adic time scale as the temporal distance between the tips of the causal diamond (pair of future and past directed light-cones in $H = M^4 \times CP_2$). For electron this time scale is .1 second, the fundamental biorhythm. For a given p-adic length scale dark matter hierarchy gives rise to additional time scales coming as h_{eff}/g multiples of this time scale. These two hierarchies could allow to get rid of the notion of self as a primary concept by reducing it to a quantum jump at higher level of hierarchy. Self would in general consists of quantum jumps inside quantum jumps inside... and thus experience the flow of time through sub-quantum jumps.

The hierarchy of Planck constants means the possibility of temporal zooms of the event sequences of the external world making possible "stories" as either zoomed up or zoomed down versions of the actual course of events. This makes possible simulation in the time natural time scales of neuronal activity and is expected to be a key element of conscious intelligence.

The realization that dark matter hierarchy corresponds to a hierarchy of quantum criticalities leads to an understanding of general characteristics of living systems. NMP demands increase of NE and spontaneous increase of h_{eff} can occur in the first state function reduction to the opposite boundary of CD. This however means death of self and self tries to survive as long as possible by gathering NE stored to mental images so that the NE associated with mental images increases. Metabolism makes this gathering of NE possible if metabolites carry NE. Even sensory qualia would involve in the capacitor model transfer negentropic carriers of quantum numbers having interpretation as generalized metabolites so that the primary qualia would characterize metabolites. Nutrients should carry or generate NE. An open question is in what scale NE is present or is generated. In [K73] it is proposed that NE is in scale of Earth.

10.1.3 The Meanings Of Sensory, Cognitive, Symbolic

With my physicist's background I have used the attributes sensory, cognitive and symbolic somewhat sloppily and the precise meanings of these become only gradually clear. The recent view is that p-adic space-time sheets correspond to cognition and imagination and that their intersections with real space-time sheets in the intersection of real and p-adic worlds define simultaneously both sensory and cognitive representations in algebraic extension of rationals.

These representations are defined in terms of data coming from the rational and algebraic points common to real and partonic 2-surfaces with the algebraic extension in question characterized by the mathematical representation of the partonic 2-surfaces and string world sheets making sense for both real and p-adic 2-surfaces simultaneously. Lowest level corresponds to discrete points of partonic 2-surfaces which string world sheets meet them and their boundaries carrying fermions being. For string world sheets and partonic 2-surfaces discretization is at the level of conformally invariant parameters. A number theoretic variant of quantum field theory is needed in order to have a first principle description of conscious intelligence and intentionality. Strong form of holography defines representations at space-time level.

The classical non-determinism of Kähler action quite generally implies that space-time surfaces define what might be called symbolic representations realizing quantum classical correspondence. This applies irrespective of the number field used and in p-adic context p-adic non-determinism is an additional ingredient. For instance, nerve pulse patterns define symbolic real physics representations of the sensory input but do not give rise to sensory qualia which reside at the level of the primary sensory organs (contrary to the expectations raised by various findings of neuro-science). Sensory experience is always a multiverse experience since sensory qualia have quantum jump increments as quantum correlates, and is thus not reducible to the level of space-time.

10.1.4 Topics Of The Chapter

The topics of the chapter is as follows.

1. Various candidates for measures for conscious information are discussed. The basic information measure being the reduction of entanglement entropy in state function process for given subsystem as it splits to two parts. NE is also possible and this kind of systems are stable against state function reduction to a pair of unentangled states. It is tempting to characterize self by this entanglement negentropy which is well-defined and positive in the intersection of real and p-adic worlds. Strong form of holography and the appearance of algebraic extensions of rationals whose basic parameters allow information theoretic interpretation allows to assign information measure also with space-time surface as parameters of extension assignable to the string world sheets and partonic 2-surfaces.

2. Frieden's proposal that action principles, including also Maxwell action, could have information theoretic interpretation is discussed in TGD framework in the hope that this would provide additional insights about quantum classical correspondence and living matter. Frieden's

prooposal fails in Minkowskian regions but works in Euclidian regions and allows to consider the possibility that entanglement negentropy assignable to Minkowskian regions and fermionic strings equals to the Kähler function apart from a constant factor.

3. The realization of quantum variant of Boolean logic in terms of zero energy fermion states is discussed.

4. The next sections are devoted to the relationship of TGD based visions about brain as computer, hologram, and association machine. Also the connection with the neuro science view about brain is discussed.

5. The notions of meme and morphic field are discussed in TGD framework.

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` [L17].

10.2 How To Define Measures For The Information Content Of Consciousness?

In this section my aim is to discuss different approaches to the problem how to define the information contents of conscious experience rather than advocating any final truth. Of course, just at this moment the information measures based on entanglement negentropy and associated with self seem to be the most realistic ones to me personally, but during these 37 years of TGD I have learned that it it is better to tolerate all views about the solution of the problem even when their mutual consistency is not obvious.

10.2.1 Information Measures For Conscious Experience

The concepts of information, information flow and information gain of conscious experience would seem to have a natural place in theories of consciousness. It seems intuitively obvious that WCW spinor fields must contain information. WCW spinor fields have indeed interpretation as both objective realities and Platonic Ideas, the latter interpretation being suggested strongly by the possibility to interpret fermionic Fock state basis as a Boolean algebra of statements about statements. The basic statements are most naturally statements about space-time geometry since fermionic oscillator operators are determined by the second quantized free quantum field theory for the induced spinors [K54].

The condition that em charge is well-defined for the spinor modes led to realization that spinor modes must be restricted to 2-D string world sheets intersecting partonic 2-surfaces at discrete points. The result is consistent with the strong form of holography following from the strong form of GCI and implies that both space-time surfaces and scattering amplitudes can be constructed from the data at these 2-surfaces. This in turn leads to an elegant realization of number theoretic universality. The 2-surface in question are characterized by parameters, which are in some algebraic extension of rationals - all extensions are allowed - and can be therefore continued to the field of real numbers and to the induced extensions of various p-adic numbers fields. The outcome is what one could call adelic physics. Adelic space-time surfaces has a book-like structure with pages labelled by various number fields and glued together along back defined by the 2-surfaces. Same applies at the level of embedding space and WCW.

Despite the fact that one cannot write formula for the contents of conscious experience, one can define information measures for conscious experience as differences of the information measures associated for the initial and final states of quantum jump identified as those for the state assignable to passive boundary of CD. Note that one can assigned average negentropy also to the the active boundary but it seems that this is potential information rather than actualized information.

The most plausible measure information measure is based on p-adic norm and defined by a generalization of Shannon formula for entropy by replacing 5h3 logarithm of probability with logarithm of p-adic norm of probability and finding the prime for which the resulting negative

entropy identifiable as negentropy is maximal. This defies a measure for negentropic entanglement (NE) as number theoretic entropy for the largest power of prime factor dividing the dimension of the final state space resulting in state function reduction. I have discussed this measure already in the introduction and also in [K56] and there is no point repeating the discussion.

State function reduction sequence at fixed boundary of CD defines self. Self dies, when the first reduction to the opposite boundary takes place and re-incarnates as self assignable to the opposite boundary. The first state function reduction to opposite boundary reduction decomposes to a cascade of state function reduction both in zero modes and in quantum fluctuating degrees of freedom ultimately leading to a completely unentangled state decomposing to a product of un-entangled states consisting of bound states and and states for which every decomposition to a pair of subsystems is negentropically entangled. At each step system decomposes to a unique pair of unentangled subsystems. The entanglement probabilities defined by the density matrix for either subsystem characterize the probabilities for the outcomes of the self measurement. Both unentangled subsystems resulting in the first step are again subject to self measurements and the process continues until an unentangled state results.

Consider now the information measures.

1. The reduction of entanglement entropy defines a natural measure for conscious information gain in single step of the state of state function reduction process decomposing subsystem to a pair of un-entangled sub-systems. If entanglement is negentropic the entanglement negentropy either increases or the system is stable against state function reduction.

2. It seems natural to assume that the information measures are associated with the entire cascade and that they are additive in the sense that information gain is sum over the information gains of the steps of the cascade and that a given step contributes by the sum of the information gains associated with unentangled subsystems which are subject to self measurement in a given step of the cascade.

3. One can also assign information measures to the resulting indecomposable systems. For subsystem which is bound state in the normal sense and thus has entropic entanglement, one can consider all possible decomposition of the system to a sub-system and its complement and define the entanglement negentropy as the negative for the minimum value of entropy obtained in this manner. If the system is negentropically entangled one can define entanglement negentropy as the maximum of entanglement negentropy gaine in this manner. This means that one can assign to the final state of state function reduction unique negentropy as the sum of the negative contributions associated with selves which are internally bound state entangled and positive contributions of negentropic selves.

4. The information content of the conscious experience associated with self is more interesting practically. If one assumes that self experiences sub-self as a statistical ensemble of sub-subselves, it is straightforward to define entropies associated with the increments of quantum numbers and zero modes defining non-geometric and geometric qualia. These entropies characterize the fuzziness of the quale and are "negative" information measures. One can also assign to non-decomposable sub-selves the information measures and they give either positive or negative contribution to the information content of self.

5. In principle this allows to define also the net information gain of state function reduction as the difference of the total negentropies of the final and initial states of state function reduction identified as those produced by the state function reduction process. Initial and final state negentropies would characterize spinor fields of WCW ("world of classical worlds"). One can also assign negentropy gain with the life-cycle of self as difference of negentropies of the time reversed self resulting in the first reduction to opposite boundary of CD and self. This negentropy gain can be said to be the saldo of the life of self.

I have considered several forms for NMP starting from a form producing standard quantum measurement theory assuming that density matrix of the subsystem is the universal observable. The allowance of NE possible for entanglement probabilities in an algebraic extension of rationals was the next step. It was however realized that the condition that the outcome of reduction is eigenstate of the density matrix allows only final states for which the density matrix is projector:

unitary 2-particle entanglement corresponds to this kind of situation. Eventually I realized that weak form of NMP is the most plausible option. For strong form of NMP the final state would be essentially unique if the initial state density matrix contains a higher-dimensional projector. Weak form of NMP allows however possible to choose also lower-dimensional subspace of the sub-space giving rise to maximal negentropy gain. This option allows to derive a generalization of p-adic length scale hypothesis. It allows also free will and provides physical correlates for ethics and moral: the basic principles is that the best self can achieve is to increase negentropic resources of the Universe.

Weak form of NMP favor large prime factors in the dimension of the sub-space resulting in state function reduction, which can be any integer $n - k \geq 1$, $k = 1, 2...$ This does not yet imply that the integer $n = h_{eff}/h$ characterizing the super-symplectic subalgebra acting as gauge symmetries contains a large prime as a factor. The condition that the effective string tension associated with elementary particle magnetic flux tube is small is however satisfied if this is the case. For electron this would mean that $p = M_{127} = 2^{127} - 1$ divides n: this suggests that the magnetic flux tube involved carries 126 bits of information. That the fundamental time scale of living matter is .1 seconds and corresponds to the secondary p-adic length scale of electron and size scale of Earth gives additional support for the speculation. This modifies completely the neuroscience based vision about intelligence as emergent phenomenon but is consistent with what is experimentally known: we are not yet able to detect dark matter and in the case of electron the dark contribution to electrons mass is of order $\Delta m/m \sim 10^{-19}$.

In TGD framework negentropy gradients correlate with emotions, which means a somewhat counter intuitive connection between emotions and information gain or loss (consistent however with the fact that peptides are both informational molecules and molecules of emotion [J43]). Note that the binding of information molecules to receptors means the formation larger bound states accompanied by the experience of oneness at molecular level (are analogs spiritual experiences present already at the molecular level?) and macro temporal quantum coherence so that quantum computer like operations might become possible.

10.2.2   Information Concept At Space-Time Level

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

Can one assign an information measure to a space-time sheet?: the recent view

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

Can one assign an information measure to a space-time sheet?: the older view

I have included also the older attempts to assign information measure to a space-time sheet. Whether they have any connection with the vision based on ramified primes of algebraic extension, remains an open question. It would however not be too surprising if the character of non-determinism of Kähler action would correlate with the properties of algebraic extension involved. Pseudo-constants belong to the algebraic extension and the dimension of the space associated with given pseudo-constant is the dimension n of extension. If one has m pseudo-constants, the dimension of corresponding space is n^m, and if p divides n, the dimension is proportional to p^m as p-adic considerations would suggest. The information measure would be naturally number theoretic entropy of system with p^m states with identical probabilities and given by $N = m log(p)$.

Consider now the earlier argument. In the presence of the classical non-determinism of Kähler action and p-adic non-determinism one can indeed define ensembles, and therefore also probability distributions and entropies. For a given space-time sheet the natural ensemble consists of the deterministic pieces of the space-time sheet regarded as different states of the same system. The probability for the appearance of a given value of observable is of the general form $p_i = m_i/N$, $m_i < N$, where N is the number of deterministic pieces and S_p is always negative, when p divides N.

Obviously the primes dividing N define natural candidates for the information measures but the problem is which criterion selects one of them. There are three options.

1. Require that the information measure corresponds to the prime p for which S_p is smallest. Obviously p must divide N.

2. Define the information as sum

$$I = -\sum_{p|N} S_p \ ,$$

   (here $p|N$ means that p divides N) so that all contributions are positive.

3. Include all primes dividing N or m_i in $p_i = m_i/N$:

$$I = -\sum_{p|N \ or \ p|m_i} S_p \ ,$$

   In this case also negative contributions are present. This defition is actually equivalent with a definition

$$I = -\sum_p S_p \ ,$$

   in which the summation appears over all primes. One could say that the information decomposes into different kinds of informations labelled by primes.

   What is interesting is that, the ordinary Shannon entropy S for rational probabilities can be expressed as a sum of all p-adic entropies using the adelic decomposition $|x| = \prod_p |x|_p^{-1}$:

$$S = -\sum_p S_p = I \ .$$

   The sum of real and p-adic entropies vanishes. Real dis-information and the p-adic information would compensate each other completely. Whether the adelic formula for information theory might have some deeper interpretation remains open.

Does classical space-time physics represent factorization of integers?

Space-time region represents factorization of integer and p-adic space-time region corresponding to ramified primes define a similar adelic factorization. The reason for the preferred character of the ramified primes is that for them n separate space-time surfaces obtained by the action of Galois group on the parameters of 2-surfaces co-incide at the boundaries of CD (criticality!) so that one obtains analog of bound state [K119]. The different branches correspond to n discrete of freedom, and one can assign to them many-fermion states: at most 1 fermion at single sheet of the covering.

The following represents the older argument for factorization. Quantum-classical correspondence suggests that quantum computation processes might have counterparts at the level of space-time. An especially interesting process of this kind is the factorization of integers to prime factors. The classical cryptography relies on the fact that the factorization of large integers to prime factors is a very slow process using classical computation: the time needed to factor 100 digit number using modern computer would take more than the recent age of the universe. For

quantum computers the factorization is achieved very rapidly using the famous Shor's algorithm. Does the factorization process indeed have a space-time counterpart?

Suppose that one can map the integer N to be factored to a real space-time sheet with N deterministic pieces. If one can measure the powers $p_i^{n_i}$ of primes p_i for which the fractality above the appropriate p-adic length scale looks smoothness in the p-adic topology, it is possible to deduce the factorization of N by direct physical measurements of the p-adic length scales characterizing the representative space-time sheet (say from the resonance frequencies of the radiation associated with the space-time sheet). If only the p-adic topology corresponding to the largest prime p_1 is realized in this manner, one can deduce first it, and repeat the process for N/p_1^n, and so on, until the full factorization is achieved. A possible test is to generate resonant radiation in a wave guide of having length which is an integer multiple of the fundamental p-adic length scale and to see whether frequencies which correspond to the factors of N appear spontaneously.

Seeing the prime factorization might be also possible via a direct sensory perception. Oliver Sacks tells in his book "The man who mistook his wife for a hat" [J117] about twins, John and Michael, who had a mysterious ability to "see" large numbers and their prime factorizations despite the fact that their intelligence quotient was about 60 and they did not have any idea about the notions of integer and prime. For instance, matchbox was dropped from the table and its contents were spread along the floor. Both twins shouted immediately "111!". Then John mumbled "37", Michael repeated it and John said "37" third time. Obviously this was their sensory representation for the decomposition $111 = 3 \times 37$ of number 111 to a product of primes! The explanation of these strange feats suggested in [K89] is a less general idea about physical representation of the factorization. The proposed mechanism could indeed explain prime factorization as a sensory perception involving no algorithmic cognition at all.

10.2.3   Information Theoretic Interpretation Of Kähler Function

An important stimulus in the development of ideas was the Jan 30, 1999 issue of New Scientist [B22] in which the work of Roy Frieden [B21] about information theoretical interpretation of the variational principles of physics was discussed at popular level. The work of Frieden relies on the concept of Fisher information. One can find a precise definition of the Fisher information in Mathematical Handbooks but this definition does not help too much without any further knowledge about Frieden's work.

Although the article in New Scientist [B22] does not give any mathematical details about Frieden's work, it becomes clear that Fisher's theory as such does not apply to TGD framework. Frieden's basic idea seems however attractive. Indeed, TGD inspired theory of consciousness inspires a hypothesis concerning the information theoretic interpretation of the Kähler function.

Frieden's hypothesis inspired the idea that Kähler function (Kähler action for a preferred extremal) has information theoretic interpretation. At that time I had not realized that Kähler function comes from Euclidian space-time regions whereas Minkowskian regions give an imaginary contribution due to the presence of the metric determinant and identifiable as the counterpart of quantum field theoretic action. This allows to solve the basic problem of the Frieden's approach due to the fact that in Minkowskian realm action is not positive definite. Therefore the information theoretic interpretation of Kähler function might work but Frieden's idea does not have a feasible realization in TGD framework.

Information theoretic interpretation of action in Frieden's theory

Frieden [B21, B22] introduces two kinds of information concepts. Fisher information, usually denoted by I, is defined as the information which can extracted from a physical phenomenon by measurements of a specific type. Information J is defined as the information contained by the phenomenon and in general $J - I \geq 0$ holds true.

The action defining the dynamical equations of a physical theory decomposes into a difference $I - J$, where J is the total information contained by the state and I is the available information. I and J depend on what is measured. Minimization of $I - J$ for position measurement leads to classical Newton's equations.

In classical mechanics J corresponds typically to the integral of potential energy V and I corresponds to the integral of kinetic energy I, in accordance with the decomposition

$$S = \int L dt, \quad L = T - V \ .$$

Maxwell action is obtained by considering position measurement in presence of charge. For Maxwell action

$$S = \int (B^2 - E^2) d^4 x \ ,$$

the entire integral of B^2 corresponds to I whereas total (or potential) information J is non-vanishing only provided there is coupling to external currents.

Information theoretic interpretation of Kähler function

The first thing to notice is that without further assumptions the Kähler function of the Universe should be infinite since otherwise the exponent of Kähler action becomes zero. ZEO provides the manner to escape this conclusion: each CD defines it sub-Universe and Kähler function is Kḧler action for the space-time surface inside CD.

Information theoretic interpretation of Kähler function - albeit not in the sense proposed by Frieden - might make sense in TGD framework. Quantum classical correspondence suggests that Kähler function could serve as a classical correlate for quantal information measure defined by negentropy.

It is however essential that one accepts the possibility of Euclidian space-time regions predicted by TGD to serve as space-time correlates for the lines of generalized Feynman diagram and thus representation of matter. One must accept also the number theoretic vision that conscious information is possible in the intersection of real and p-adic worlds.

1. When should one use entanglement negentropy and when entanglement entropy based on real numbers is appropriate? It seems that entanglement negentropy makes sense at the passive end of CD at which state does not change and reduction to an eigen-space of density matrix has occurred for given sub-system-complement pair.

   At the active boundary of CD situation is different since the entanglement does not reduce to this simple form and one could argue that the ordinary entanglement entropy is natural notion. After all, future is uncertain!

2. For the regions with Euclidian signature representing generalized Feynman graphs with lines represented as deformations of CP_2 type vacuum extremals one must be very careful with the sign factors. One cannot distinguish between electric and magnetic contributions and the sign of the Kähler function is positive. It would be attractive to assign entropy or negentropy with elementary particles and identify it as Kähler function apart from possible numerical factor. Whether one has entropy or negentropy seems to be a matter of convention. Strict adherence to thermodynamical analogy would suggest the interpretation as entropy.

3. Entanglement negentropy assignable to strings connecting partonic 2-surfaces in Minkowskian regions is the quantal information measure. Strings are assignable to magnetic flux tubes carrying possible monopole flux.

4. The generalization of AdS/CFT duality suggests that the descriptions provided by Kähler function in Euclidian regions and fermionic strings in Minkowskian regions are dual. Could these two negentropies be identical as also quantum classical correspondence suggests.

   An immediate objection is that entanglement negentropy for the outcomes of state function reduction is is a discrete number: logarithm of integer. Kähler function cannot have discrete spectrum. One can consider also the active boundary of CD for which state-complement pairs would be characterized by ordinary entanglement entropy giving a continuous measure of entropy. Kähler function could have an interpretation as entropy as standard thermodynamics suggests.

The above interpretation says nothing about the Kähler action in Minkowskian regions. Both magnetic flux tubes and electric flux quanta are of special interest in Minkowskian regions. Could Kähler action also now have an interpretation as information measure? NE can be assigned to strings accompanying magnetic flux tubes carrying monopole flux. Could the Kähler action for flux tubes be identified as entanglement negentropy at the passive boundary of CD? Again the discontinuous spectrum of entanglement negentropy is a problem unless the parameters of flux tubes are quantized, which is in principle possible by preferred extremal property. Quantization of action is indeed a basic aspects of quantum classical correspondence and Planck constant was introduced originally as quantum of action.

But what about regions carrying Kähler electric fields and Kähler action and information with opposite sign. Is there any reasonable interpretation or should one assume that it is only the total Kähler action that matters and that total Kähler action corresponds to positive negentropy?

10.3   Logic And Fermions

The state basis for the fermionic Fock space has a natural interpretation as a Boolean algebra (fermion number $=1/0\leftrightarrow$ yes/no). In this manner ordinary Boolean algebra is extended to vector space spanned by fermionic states. When cognitive fermion pairs are used instead of fermions, fermion number conservation does not pose any constraints and full linear superposition of the Boolean algebra elements is possible. An interesting question is whether one could consider ordinary Boolean logic as some kind of limit for the complex quantum logic.

The simplest TGD based model for thinking systems leads to the result that thoughts correspond to quantum states in discrete spaces. The reason is that slightly non-deterministic classical time evolution means a finite number of multi-furcations. These additional dynamical degrees of freedom correspond to N-element set labelling the different time evolutions associated with given initial values. This suggests that a suitably defined *binary* Hilbert space having Z_2 rather than complex numbers as a coefficient field could provide a simple quantum model for a thinking system. This raises the following question.

What would a quantum field theory in discrete space and with the field of complex numbers replaced with binary numbers Z_2 (0, 1/Yes, No) look like?

The answer is following.

1. The state basis of the quantum field theory defined in N-element set is nothing but a Boolean algebra consisting of 2^N elements: all possible statements about the N elements interpreted as propositions! Bosons and fermions are one and the same thing and behave like fermions since occupation number can have only the values 0 and 1.

2. The requirement that triangle equality for the inner product is satisfied, does not allow linear superposition and one must choose some orthogonal basis for the space. The absence of quantum superposition means that theory is completely classical. Thus it seems that Boolean QFT is completely classical and the transition from classical mechanics to quantum theory could be regarded as a transition from binary QFT to complex QFT or from a binary logic to complex logic.

3. Quantization means construction of statements about statements: the simplest model for an abstraction process one can imagine! One can of course continue this quantization: second, third, etc., quantization is possible and this corresponds to a construction of statements about statements about..... Hence a direct connection with the ideas about genetic code emerges.

4. Also the state basis in the Fock space of the ordinary fermions has interpretation as a Boolean algebra, all possible statements about some propositions (particle with a definite spin component is at point x).

10.3.1   The State Basis Of Fermionic Fock Space As Boolean Algebra

The state basis of a fermionic Fock space can be interpreted as a basis of a Boolean algebra. In quantum TGD all elementary particles are constructed using fermionic oscillators operators. This

suggests that entire quantum field theory is actually a representation of Boolean algebra and N-fermion states have interpretation as statements about basic propositions labelled by the indices labelling fermionic oscillator operators. In particular, WCW spinor structure is constructed in terms of the fermionic oscillator operators for the second quantized spinor fields on space-time and this suggests a deep connection between spinor geometry and logic. Perhaps one could say that quantum logic is C-valued in the sense that all complex superpositions of a statement and its negation are possible.

In Boolean algebra one can select the maximum number of 2^{N-1} statements consistent with given atomic statement (one bit fixed) statements as axioms. An interesting possibility is that only these statements consistent with given atomic statement (one bit fixed) are physically realized so that the number of states is reduced by a factor of one half. Amusingly, in the ordinary fermionic field theory the states created by a finite number of oscillator operators are the counterparts of these preferred statements, their negations would correspond to a vacuum state obtained as an infinite product of all creation operators annihilated by creation operators. The states created by annihilation operators from this states are not allowed in QFT since they would have infinite energy.

One can identify the complex valued linear space of fermions as a generalization of Boolean algebra to complex Hilbert space. Cognitive fermion pairs could provide realization for this space as pairs of fermion and anti-fermion belonging to different space-time sheets and representing logical statement and its negation: the automatic presence of negation is rather natural from the point of view of consciousness theory. The splitting of the wormhole contacts connecting the space-time sheets gives rise to annihilation process generating fermion and anti-fermion pair (fermionic quantum numbers reside on the boundary components of the split wormhole contact). In this manner one avoids problems related to fermion number conservation encountered otherwise in physical realization of the fermionic logic. Alternative possibility is to assume fixed number of fermions and associate truth values with the direction of spin.

10.3.2 Boolean Algebra As Boolean QFT

Boolean algebra $B(N)$ is generated by all possible yes/no statements about N propositions. It consists of sequences of N binary digits of form $(..., 1, 0, 0, .., 1)$ having value of 0 or 1. Addition is with respect to Z_2 so that $1 + 1 = 0$. Boolean algebra is Z_2 linear space and the elementwise multiplication of the binary digits in the string makes it algebra. $(0, 0, 0, ..)$ and $(1, 1, ...,)$ are zero and unit elements of the algebra.

Geometrically Boolean algebra $B(N)$ corresponds to all possible subsets of an N-element set. Sum corresponds to a symmetric difference (take the union of sets and throw away the common elements). Multiplication corresponds to the intersection of the sets. Entire set represents unit element and empty set zero. Empty set is not physically realizable, or equivalently, the zero element of the Boolean algebra does not correspond to a physical state in the Z_2 Hilbert space defined by the Boolean algebra.

Quantum field theory in N-element set formed by the basic propositions (analogous to 3-space in QFT) means associating to each element of the N-element set creation and annihilation operators and postulating standard commutation relations with them:

$$[a^\dagger(i), a(j)] = 1 \ .$$

One can also consider fermions that is anti-commutation relations but since -1=1 in Boolean algebra, they are equivalent with the bosonic commutation relations so that Boolean bosons and fermions are one and the same thing in the Boolean QFT.

The states of this QFT are constructed in the usual manner. The only difference is the occupation numbers are Z_2 valued and are either one or zero just as in the case of fermions. Thus Boolean particles are fermions always. Since N creation operators are involved one obtains a space generated by 2^N states. The proposition and its negation correspond to the states created by, say I oscillator operators and the dual of this state created by the remaining $N - I$ oscillators operators. Statement corresponds to I particles and its negation to I holes in the dual ground state containing all N oscillator operators.

Thus the state basis is nothing but the Boolean algebra associated with the N element set! Thus the state basis of Z_2 valued quantum field theory in the set of N propositions is nothing but

the formation of all possible statements about these statements: a model for abstraction process. One can apply this process to the $2^N - 1$ element set and by continuing this process get a sequence of second quantizations as a sequence of abstractions.

The assumption of unrestricted linear superposition in Z_2 Hilbert space leads to difficulties with Schwartz and triangle inequalities. The physical interpretation of the theory requires that inner product satisfies Schwartz inequality

$$|(x,y)| \leq |x||y| \; .$$

Linear superposition allows states, say y, with zero norm since any superposition of even number of orthonormal states has zero norm in Z_2. The norm of the inner product of one of the basis states appearing in zero norm state, call it x, with the zero norm state y equals to one and is not smaller than the product of the norm of the basis state and state with vanishing norm: one obtains $1 < 0$, which does not make sense if inner product is interpreted as real number (as a Z_2 valued number one could perhaps say $1 = -1 < 0$). One ends up to difficulties also with the triangle inequality: $|x + y| \leq |x| + |y|$ if x and y are zero norm states with single common element of orthonormal basis so that one has $|x + y| = 1$.

The only possible manner to save Schwartz and triangle inequalities is to assume that linear superposition is not allowed for Z_2 Hilbert space. This in turn means that situation is completely classical! If the set generating Boolean algebra consists of entire 3-space, this means that every state is gauge equivalent with an N-particle state of completely localized particles. This in turn implies that Boolean QFT should be more or less equivalent with classical mechanics and one could understand the transition from classical physics to quantum physics as the replacement of Z_2 with complex numbers C as the coefficient field of the state space.

One can change state basis by unitary transformations. Unitary matrices are obtained from orthogonal Z_2 valued unit vectors possessing entries equal to 1 or 0. Any unitary matrix corresponds to a matrix representing the permutation of 2^N elements of the basis of the Boolean algebra. Time development operator in this quantum field theory is always defined for a *finite* time interval only (the length of the "chronon" is fixed naturally in p-adic QFT) and represents a permutation of this basis. In particular, a nonlinear transformation of the oscillator operators in general occurs. All unitary transformations are permutations, which do *not* lead to state basis involving superpositions of the basic states. This is in accordance with the observation that Boolean QFT is completely classical.

10.3.3   Fermions, Zero Energy Ontology, And Boolean Cognition

Fermionic Fock state basis defines naturally a quantum version of Boolean algebra. In zero energy ontology predicting that physical states have vanishing net quantum numbers, positive and negative energy components of zero energy states with opposite fermion numbers define realizations of Boolean functions via time-like quantum entanglement. One can also consider an interpretation of zero energy states in terms of rules of form $A \to B$ with the instances of A and B represented as elements Fock state basis fixed by the diagonalization of the density matrix defined by $M-$matrix. Hence Boolean consciousness would be basic aspect of zero energy states. Physical states would be more like memes than matter. Note also that the fundamental super-symmetric duality between bosonic degrees of freedom (size and shape of the 3-surface) and fermionic degrees of freedom would correspond to the sensory-cognitive duality.

This would explain why Boolean and temporal causalities are so closely related. Note that zero energy ontology is certainly consistent with the usual positive energy ontology if unitary process U associated with the quantum jump is more or less trivial in the degrees of freedom usually assigned with the material world. There are arguments suggesting that U is tensor product of of factoring S-matrices associated with 2-D integrable QFT theories [K24]: these are indeed almost trivial in momentum degrees of freedom. This would also imply that our geometric past is rather stable so that quantum jump of geometric past does not suddenly change your profession from that of musician to that of physicist.

10.3.4 Negentropic Entanglement, Fuzzy Logic, Quantum Groups, And Jones Inclusions

Matrix logic [A9] emerges naturally when one calculates expectation values of logical functions defined by the zero energy states with positive energy fermionic Fock states interpreted as inputs and corresponding negative energy states interpreted as outputs. Also the non-commutative version of the quantum logic, with spinor components representing amplitudes for truth values replaced with non-commutative operators, emerges naturally. The finite resolution of quantum measurement generalizes to a finite resolution of Boolean cognition and allows description in terms of Jones inclusions $\mathcal{N} \subset \mathcal{M}$ of infinite-dimensional Clifford algebras of the world of classical worlds (WCW) identifiable in terms of fermionic oscillator algebras. $\mathcal{N}$ defines the resolution in the sense that quantum measurement and conscious experience does not distinguish between states differing from each other by the action of $\mathcal{N}$.

The finite-dimensional quantum Clifford algebra $\mathcal{M}/\mathcal{N}$ creates the physical states modulo the resolution. This algebra is non-commutative which means that corresponding quantum spinors have non-commutative components. The non-commutativity codes for the that the spinor components are correlated: the quantized fractal dimension for quantum counterparts of 2-spinors satisfying $d = 2cos(\pi/n) \leq 2$ expresses this correlation as a reduction of effective dimension.

The moduli of spinor components however commute and have interpretation as eigenvalues of truth and false operators or probabilities that the statement is true/false. They have quantized spectrum having also interpretation as probabilities for truth values and this spectrum differs from the spectrum $\{1, 0\}$ for the ordinary logic so that fuzzy logic results from the finite resolution of Boolean cognition [K120].

10.3.5 Cognitive Codes And Fermions

p-Adic length scale hypothesis leads to the idea that each $p \simeq 2^k$, k integer, defines a hierarchy of cognitive codes with code word having duration given by the n-ary p-adic time scale $T(n, k)$ and number of bits given by any factor of k. Especially interesting codes are those for which the number of bits is prime factor or power of prime factor of k. $n = 2$ seems to be in special position in zero energy ontology. This is a strong quantitative prediction since the duration of both the code word and bit correspond to definite frequencies serving as signatures for the occurrence of commutations utilizing these codes.

If k is prime, the amount of information carried by the codon is maximal but there is no obvious manner to detect errors. If k is not prime there are several codes with various numbers of bits: information content is not maximal but it is possible to detect errors. For instance, $k = 252$ gives rise to code words for which the number of bits is $k_1 = 252, 126, 63, 84, 42, 21_2, 9, 7, 6_2, 4, 3_2, 2$: the subscript $_2$ tells that there are two non-equivalent ways to get this number of bits. For instance, $126 = 42 \times 3$-bit codon can have 42 -bit parity codon: the bits of this codon would be products of three subsequent bits of 126-bit codon. This allows error detection by comparing the error codon for communicated codon and communicated error codon.

Mersenne primes are especially interesting as far as cognitive codes are considered the Mersenne prime M_{127} assignable to electron is of special interest since the corresponding time scale for CD is .1 seconds whereas the duration of bit corresponds to the time scale of 1 ms assignable to quark CDs.

Combinatorial Hierarchy as a hierarchy of "genetic codes"

The simplest model for abstraction process is based on the process in which one forms first all possible Boolean statements about N basic statements, 2^N altogether. If one drops one of the statements one has $M_N = 2^N - 1$ statements: M_N is Mersenne number. The motivation for the dropping of one statement might be that in set theoretical realization one of the statements corresponds to empty set and is not realizable. Alternatively, in the realization based on many-fermion states, vacuum state could correspond to this kind of state. One can form also statements about statements: the first level of abstraction. This leads to $M_{M_N} = 2^{M_N} - 1$ many-fermion states. Construction is especially intersting if the numbers $M(M_N)$ are primes, so called Mersenne primes.

Indeed, in some cases one obtains hierarchies of Mersenne primes by repeating the construction as long as it works.

The so called Combinatorial Hierarchy, shown already earlier to provide an explanation for the numbers of the Genetic Code, emerges as the most notable hierarchy. The Combinatorial Hierarchy [A25] consists of the Mersenne numbers $2, M(1) = 3, 7$, $127, 2^{127} - 1, ..$ constructed using the rule $M(n + 1) = M_{M(n)} = 2^{M(n)} - 1$. The explicitly listed ones are known to be primes. Combinatorial Hierarchy emerges from a model of abstraction process as subsequent transitions from level to metalevel by forming Boolean statements about Boolean statements of level n and dropping one statement away and starting from $n = 2$ basic statements. Combinatorial Hierarchy results also by constructing the sets of all subsets with empty set excluded starting from two element set.

The set of statements at level n can be given a structure of Finite Field $G(M(n), 1)$ if $M(n)$ is prime. The multiplicative groups $Z_{M(n)-1}$ form a nested hierarchy and the coset spaces $Z_{k_n} \equiv Z_{M(n+1)-1}/Z_{M(n)-1}$ are cyclic groups. Combinatorial Hierarchy based model of Genetic Code explains the number of DNA: s and amino-acids and the representation of words of the GC as triplets of 4 different codons. Amino-acids correspond to $k_{n=3} = 21$ axioms of a formal system defined by $n = 3$ level of Combinatorial Hierarchy having a unique embedding as the group $Z_{k_n} \subset Z_{M(n)-1} = Z_{126}$ and DNA: s correspond to the set $X_{N(DNA)} \subset Z_{M(n)-1}$ of $N(DNA) = (M(n) + 1)/2 = 64$ statements consistent with given atomic statement (one bit fixed) at level n regarded as special cases of general theorems. GC corresponds to the mapping $x \to x^{k_{n-1}} = x^6$ in $Z_{M(n)-1}$ mapping DNA type statements to amino-acid type statements. The numbers of DNA: s coding single amino-acid are reproduced in a symmetry breaking mechanism involving the finite groups $Z_{p_{n-1}}$ and Z_{k_n} and symmetry breaking is in a well defined sense minimal. The infinite hierarchy of possible genetic codes suggests the possibility of an infinite hierarchy of increasingly complicated lifeforms or forms of intelligence.

Boolean mind and memetic code

The original proposal for the realization of Boolean mind was in terms of sequences cognitive neutrino pairs. These can be interpreted as wormhole contacts carrying neutrino and antineutrino at the light-like wormhole throats and would thus represent boson like entities. In the framework of the standard model the proposal looks of course completely non-sensical. TGD however predicts the existence of long range classical electro-weak fields, and one might imagine that inside neutrino-whose Compton length corresponds to length scale of cell- intermediate gauge bosons behave like massless fields. Although neutrinos could be important, the time scale of corresponding CD - about 10^4 years - suggests that cognitive neutrinos might be important in much longer time scale than the.1 second time scale assignable to the memetic code.

The recent view about TGD allows a much more general view. Zero energy ontology allows to interpret the fermionic parts of zero energy states as quantum superpositions of Boolean statements of form $a \to b$ with a and b represented in terms of positive and negative energy parts of the zero energy state. If one has negentropic entanglement this kind of state has interpretation as an abstraction - a "law of physics" - representing as a quantum superposition various instances of a more general law.

The simplest situation corresponds to a CD having only single positive energy fermion and negative energy fermion at its light-like boundaries. The fermion number or spin or isospin of the fermion could represent qubit. The hypothesis that memetic code corresponds to the next level of Combinatorial Hierarchy, when combined with p-adic length scale hypothesis, led to a prediction of order .1 seconds for the duration of the "wake-up" period of sub-self corresponding to the codeword of the memetic code. Since the CD assignable to electron has time scale.1 seconds and the CD assignable to u and d quarks has time scale $1/1.28$ milliseconds there is a temptation to proposed that the quark-like sub-CDs of electronic CD give to a realization of memetic code word as a sequence of 126 quark like sub-CDs. u and d quarks would be assigned to the magnetic flux tubes connecting DNA and the lipids of the cell membrane in the model of DNA as topological quantum computer. Clearly, beautiful connection between new elementary particle physics, genetic code, nerve pulse activity, DNA as topological quantum computer, logical thought, and the basic time scales of speech are suggestive.

This codeword consists of 126 bits represented by quarks such that the two possible mag-

netization directions correspond to the two values of Boolean statement. This implies that the duration of single bit should 1/1260 seconds. The duration of the nerve pulse is slightly longer than this which might mean that the full memetic code is realized as membrane oscillations rather than nerve pulse patterns. Both hearing and vision have .1 second time scale as a fundamental time scale and sounds are indeed coded to membrane oscillations in ear.

One can consider also the realization of genetic code with six bits of the codon represented by various scaled up versions of quark CD coming as size powers of 2. In this case the ordering of the bits would come from the size of sub-CD whereas in previous example temporal ordering would define the ordering. It is not however clear whether the powers of two can be realized physically.

One can understand the number 126 as related to the total number of separately experienced frequencies in the interval $20 - 20.000$ Hz spanning 10 octaves. $10 \times 12 = 120$ is not far from 126: here 12 corresponds to 12 tones of basic music scale. Also speech has 10 Hz frequency as fundamental frequency. In visual primary cortex replicating triplets, 4-, 5- and 6-plets of spikes with highly regular intervals between spikes have been detected. The triplets are accompanied by ghost doublets. This would suggest a coding of some features of visual experience to reverberating mental images. The time scale for various patterns is.1 seconds. This could be seen as a support for the realization of some degenerate version of the memetic code as nerve pulse patterns.

The model for the memetic code encourages the following conclusions.

1. Membrane oscillation/nerve pulse patterns correspond to temporal sequences of magnetization directions for quarks representing yes/no Boolean statements.

2. The spin polarization of quarks is changed from the standard direction fixed by the spontaneous magnetization in the direction of axon by a ME moving parallel to axon, and inducing membrane oscillation or even a nerve pulse. Nerve pulses could correspond to a degenerate memetic code resulting by frequency coding for which the number of distinguishable code words is 64, and would thus naturally correspond to the reduction of the memetic code to the genetic code.

A very precise correspondence with the basic structures of the genetic code results. mRNA $\rightarrow$ protein translation corresponds to the translation of temporal sequences of magnetization directions to conscious cognitive experiences. Under very natural constraints the mapping to cognitive experiences is not one-to-one and the predicted degeneracy (2^{126} sequences correspond to $(2^{126} - 1)/63$ cognitive experiences) can be understood.

One might think that the full memetic code is an evolutionary newcomer and involved only with the logical thought: this would explain the completely exceptional characteristics of human brain. The full memetic code could be realized for certain regions of brain only. These regions certainly include auditory pathways responsible for the comprehension of speech [K41, K80, K81, K84].

How nerve pulse patterns and membrane oscillations could be coded to Boolean statements?

The original proposal for the realization of the memetic code was based on the notion of cognitive neutrino pair. Zero energy ontology however disfavors this identification since the time scale assignable to CD of neutrino is of order 10^4 years. Therefore neutrinos would most naturally correspond to a time scale of consciousness much longer than the time scale of.1 seconds predicted to be present. If the proposed view about cell membrane is correct, classical weak fields should be important within the Compton length of any particle and therefore the interactions of neutrinos with Z^0 fields should be important as also the large chiral asymmetry in living matter suggests.

The realization of memetic codewords in terms of sub-CDs assignable to u and d quarks look much more attractive option since they have time scale of 1/1.28 millisecond.

1. The bit would correspond to quark existing in this kind of sub-CD. Memetic codon would correspond to electron's sub-CD containing a row of 127 quark sub-CDs. Standard physics interpretation could be as quantum fluctuation generating virtual pair of quark and negative energy antiquark. For non-standard values of $\hbar$ the durations of codewords and bits would be scaled up.

2. The time-like row of quark sub-CDs resides in em (and possibly also Z^0) field associated with the cell membrane and having the direction of the axon. There is a time-like row of quark sub-CD at some points of axon with one sub-CD per millisecond time interval between sub-CDs. DNA as topological quantum computer hypothesis suggests that each lipid could correspond to quark sub-CD so that many-quark system would be in question. The minimization of the magnetic energy for a given sub-CD fixes the direction of spin and one has spontaneous magnetization in the case that the direction of magnetic field inside quark sub-CD does not change during the pulse.

3. The time that it takes for a nerve pulse to traverse the point is slightly longer than millisecond. If the time which magnetic field has reversed direction is of order millisecond then the magnetic field experienced by quark can preserve its direction during the time interval that quark exists from the point of view of outsider. This is achieved if the temporal center of mass positions of the quark sub-CDs are given by $t_n = nz_0/v$, where z_0 is the distance between lipids containing quark sub-CD and the position of nerve pulse is given by $z = vt$, where v is the conduction velocity of nerve pulse. Unless this condition is satisfied, the direction of magnetic field changes during the time interval associated with sub-CD. In this case a superposition of bits identifiable as a qubit results.

4. This means that nerve pulse sequence defines a (qu-)bit sequence with the direction of spin telling whether there was nerve pulse present in particular sub-CD. The presence/absence of nerve pulse corresponds to true/false statement in accordance with neuro science intuition.

If this view is correct, the values of the positional coordinates and the velocity of the object of the perceptive field should correlate with the CP_2 orientation of the active neuron and/or ME(s) associated with it. First of all, the level of hologrammic activity for ME measured by the strength of the light-like em current depends on its CP_2 orientation. Secondly, different CP_2 orientations correspond to slightly different values of the membrane potential and could be directly mapped to the degree of alertness of neuron. For instance, if a moving object of the perceptive field is in nearby space and moves towards the perceiver, the (P_i, Q_i) values could be such that the resting potential is lowered and nearer to the critical value for firing. Also the light-like em currents associated with MEs would be stronger in this kind of situation.

10.4 Quantum Computationalism

TGD Universe can be formally regarded as infinite quantum computer like structure in the sense that each quantum jump involves the unitary process U analogous to a Schrödinger evolution lasting infinite time and is followed by state function reduction and state preparation process. Therefore TGD suggests what might be called quantum computationalism. Universe would be performing huge quantum computation and the computation like processes performed by us or by our brains would be only a ridiculously small portion of this computation. Of course, this must be taken as a rough metaphor, the quintessence of the conscious quantum computation like processes could be quite different from the essence of the ordinary quantum computation.

The average increment of the psychological time in quantum jump is rather small: the simplest guess suggest that the average quantum of psychological time is or order "CP_2 time", about 10^4 Planck times. This means that the relation of the information processing performed by biosystems to quantum jump would be the same as the relationship of macroscopic physics to physics in CP_2 scale about 10^4 Planck length scales. This would however mean an extremely short de-coherence time in an obvious conflict with the experimental facts. Macrotemporal quantum coherence, which corresponds to the formation of bound states, however effectively fuses a sequence of quantum jumps to a single quantum jump so that the de-coherence occurring otherwise in CP_2 time scale can be circumvented.

The notion of self is absolutely crucial for TGD approach to consciousness and makes possible to understand consciousness in macroscopic time scales. A very natural notion is that of cascades of selves within selves generated spontaneously or by quantum jumps. This implies a connection with the basic conceptual structure of computationalism. The cascades have natural modular structure, which is quintessential for the understanding of the symbol processing performed by brain. A

very attractive hypothesis is that selves within selves are conscious counterparts of computational agents or more or less equivalently, of the subroutines of computer program. Selves can perform two kinds of quantum jumps and a natural identification of these modes is as computational and sensory (input) modes. Subjective memory takes automatically care of output in the sense that the subjective history of sub-self is experienced as an abstracted memory by self.

Communication between selves could occur as it does between human beings. Also "mass media" at neuronal level seem to be possible and would make possible the concept of global workspace. Quantum jumps can be regarded hopping in the space of zero modes identifiable as fundamental order parameters and Haken's theory of feature recognition generalizes. Quantum entanglement in turn provides elegant realization of association concept so that the basic ideas of connectionism emerge naturally from quantum computationalism. There are also drastic differences with between TGD and computationalism, basically implied by the different concept of psychological time which implies that cognition has holistic aspect also with respect to time. Thoughts are definitely not deterministic computations and living systems are definitely not robots.

10.4.1 Computationalism And Connectionism

Computational approach to cognition [J140] is the dominating approach in cognititive and neuro sciences and has had undeniable successes. Computationalism is often identified as traditional AI based on the concept of truth preserving manipulation of symbols according to some fixed rules of the formal system. This approach indeed explains nicely computational aspects of mind. Combinatorial explosion is the basic failure of the approach at practical level. Connectionism relies on the concept of association and associative neural net provides a quantitative model for how brain learns. Connectionism is often regarded as a variant of the computationalism and it is believed that neural nets provide models for unconscious parallel information processing whereas conscious information processing is best modelled by hierarchical program like structures. The general philosophical shortcomings of these approaches are obvious: they cannot provide any insights to the problem how meaning, understanding, emotions and volition, which are factors crucially important for the functioning of conscious brain, arise. This has even led some advocates of this approach [J140] to believe that human brain, being computer basically, is simply incapable of understanding the problem of consciousness! This would probably be the case if human beings were robots: fortunately we are not!

Traditional AI approach

In the traditional AI approach brain is modelled as a complicated computer. Computation is realized using rigid algorithms, which are hierarchical structures consisting of subprograms. Using more abstract terminology, the basic concepts are symbols and agents, "demons". Symbols are inputs for "demons", subroutines of program manipulating symbols and creating new outputs as symbols. One could however interpret also agents themselves as symbols. The concept of global work-space [J38] realizes the intuition that short-term memory is available to many users. Also the concepts of belief and desire can be formulated without referring to consciousness. Beliefs are inscriptions about the world and desires are identified as goals. For instance, problem solving means simply making trials with the aim of minimizing the difference between goal and result of trial. The concept of representation is central. It is known that brain realizes several types of representations [J140]. Visual mosaic like representations, phonological representations in short-term memory consisting of few phonemes (say remembering phone number for some time), grammatical language like representations with hierarchical structures and "mentalese", which is the most abstract representation type summarizing in very implicit manner the essentials of, say, mathematical model.

Computationalism explains nicely the general features of language by providing a representation for the hierarchical structure of language. One can also easily think brain as a population of (possibly) conscious demons. Some demons receive sensory input, some demons process it and the ouputs of some demons are realized as motor outputs. It seems that this approach models quite satisfactorily those aspects of cognition, which can be realized as purely mechanical truth preserving symbol manipulation modellable universally by Turing machine. The best proof for the claim that computers have caught something about the basic structure of cognition is that computers

are already now able to beat chess champions. The weak point of the computationalism is its extreme rigidity: minor input error or programming error and program fails to work. Combinatorial explosion is second shortcoming. For instance, all possible melodies formed from finite number of musical notes with finite number of durations for each and lasting the typical length of musical piece is immense. In computer chess combinatorial explosion makes the simple-minded trial and error approach completely unpractical and the only possible manner to proceed is to teach the computer by mechanizing the human intuitions about good chess.

Connectionism and neural nets

Connectionism provides a modern version of associationism proposed by British philosophers Locke, Hume, Hartley, Berkeley and Mills. Behaviorism was the first purely mechanistic version of this approach but was quite too simplistic to work. Associationism consists of two laws. The first law states that the ideas which are often experienced together get associated: when one is activated also the other one gets activated. Second law states that similar ideas activate each other. Connectionism tries to realize these two aspects of associationism mathematically and construct practical realizations for associative thinking. Typical application would be feature recognition and machines learing automatically from their inputs some predetermined tasks.

   Neural nets provide a mathematical model for the concept of association and associative learning. The simplest model for learning simply associates unique self-organized state of a dissipative neural net to the state of the external world represented as an external force driving the neural net. Dissipation realizes also the second law: if input is sufficiently similar to the standard input generating given standard output, the standard output is indeed generated. Also Haken's model for feature recognition realizes second law as a feature recognition based on non-equilibrium thermodynamics. Features correspond to equilibrium states of a nonlinear dissipative system (free energy minima for order parameters). If input creates initial output belonging to the attractor of the feature, dissipative dynamics takes care that the asymptotic output is feature.

   Associative net can be regarded as a many-layered structure, in which the states of some nodes correlate strongly with the states of some other nodes. The state of node is characterized by a component of vector, whose components give the values of the amplitude in the nodes. For a given input the net rapidly achieves equilibrium in which the associations created by the input are determined by those nodes in which the amplitude is large. The equilibrium states of neural nets with coupling to external are identified as representations for stable mental states representing some states of the external world.

   The flexibility of the neural nets is the strength of connectionism. Also combinatorial explosion can be avoided. Neural nets might indeed model lower level cognition which is mostly unconscious to us. The absence of the hierarchical structures means the loss of "expressive power" essential for higher cognition and leads to the problems described in [J140].

1. Connectionistic approach is not able to distinguish between individual and class: what is created from the inputs is some kind of average individual: neural network can learn to recognize human face but not a particular human face or to recognize particular human face but not to make abstraction about what human face looks like.

2. Second problem is so called compositionality: the ability of the representation to be build out of parts and represent the meaning of the whole deriving from the meanings of parts. A related problem are the difficulties in the identification of the meaning of linguistic expressions. For instance, the meanings of the expressions consisting of words "the child", "ate" and "the slug" depend on the order in which the words are represented and connectionism is not able to distinguish between "the child ate the slug" and "the slug ate the child". The natural ordering of symbols provided by hierarchical tree solves this problem in AI approach. Simple neural network learns easily to recognize picture containing horse but if the picture contains two horses, network fails completely!

3. The third problem is a combination of these two. An example from [J140] illustrates this. Network can learn to sum 1 and 3 to 4. When it learns to sum 2 and 2 to 4 it can lose the already learned ability. Second example: consider the expression "Every forty five seconds some-one in the United States sustains a head injury". Human brain can easily realize the

meaning of this sentence which suggests that quantification occurs in brain and human brain transforms the sentence either to expression "Every forty-five seconds {there exists an X[who gets injured]} " instead of "There exists an X{who every forty-five seconds[gets injured]} "

4. What multiplies human thoughts is recursion. We can take proposition and give it a role in another proposition and so on. In this manner a combinatorial explosion of propositions is generated. To get propositions-inside-propositions network, one could add a new layer of connections but this solution is clumsy and non-economical. The addition of a new level of abstraction would mean a new network containing additional level. In computationalism the solution of the problem is much more elegant. Each proposition is represented in long term memory once. One can of course combine computationalism and connectivism and use simple neural networks as basic modules of computer program like modular structure.

5. Neural net models, which realize connectionistic philosophy in practice, have serious problems in modelling long term memory. If its is assumed that long term memories are coded into the matrices defining output of the node in terms of its inputs, which are modified during learning process, the unavoidable conclusion is that new memories destroy the old ones. Childhood memories seem however to be the most stable ones.

10.4.2 How Connectionism Emerges From TGD Framework?

Brain as an associative net in TGD

TGD leads to a variant of connectionism which differs from the standard version in some crucial respects. Brain as a quantum self-organizing system moving in spin glass energy landscape generalizes the neural net realization of connectionism. The plasticity of the neural substrate corresponds directly to the spin glass property and the notion of frustration fundamental for spin glass type systems is guaranteed by the inhibitory/excitatory nature of nerve pulses. Neural net becomes dynamical rather than being a fixed structure. One can view brain as system moving in the space of neural nets and perceiving and affecting its own position in this abstract space.

Brain can be regarded as a conscious associative net developing by quantum self-organization to asymptotic self-organization patterns which correspond to recognized features, learned habits, skills $\cdots$: dissipation can be said to serve as fundamental Darwinian selector in this process. By music metaphor each neuron, when it fires, generates a characteristic neuronal experience possibly contributing to our conscious experience: only the intensity of this experience depends on the nerve pulse pattern. The firing of a neuron gives rise to a conscious neuronal association $A \to B$.

This would suggest that brain is like a conscious music instrument, or rather, entire orchestra, played by the nerve pulse patterns and our experiences corresponds to the sound patterns created by this orchestra. It has turned out that this view is probably quite not correct. Brain and body are much more. The music is at the level of sensory organs as sensory qualia, and neural activity cognizes, that is analyses the sensory music to notes and represents the notes. This view, which is certainly not possible in the standard neuroscience framework and surprisingly close to what a layman knowing nothing about neuroscience would think spontaneously, makes sense in TGD framework if one assumes that entanglement between brain and sensory organs binds sensory qualia with the cognitive associations generated by the sensory input. This view also allows to understand elegantly the differences between sensory experience, dreaming, hallucinations, and imagination. An essential element is the feedback from brain to sensory organs enabling "qualification" during dreaming and hallucinations. This feedback is also active during the ordinary wake-up consciousness.

Spin glass energy landscape is four-dimensional in a well defined sense and the identification of the long term memories as geometric memories solves the basic paradox of the neural net models of memory. One can also understand how brain knows that the mental image represents memory and why repetition and reverberation of nerve pulse patterns in neural circuits leads to learning and why emotional experiences are easily remembered.

Feature recognition

The first law of associationism states that similar ideas tend to induce each other. For instance, a part of familiar face in the visual field induces a memory about the entire face. In computa-

tional approach feature recognition is believed to involve unconscious low level parallel processing. [B16] [B16] has proposed an elegant model of feature recognition based on non-equilibrium thermodynamics. The features to be recognized represent the minima of the potential depending on order parameters and the presence of dissipative terms implies that system ends up to potential minimum representing feature.

Haken's theory generalizes to TGD context almost as such. Dissipative time evolution is replaced with quantum self-organization by quantum jumps and in each step entire macroscopic space-time surface is replace by a new one. The zero mode degrees of freedom of the configuration space are identifiable as fundamental order parameters and each quantum jump involves complete localization in continuous zero modes. The localization in discrete zero modes characterizing cognitively degenerate space-time surfaces need not be complete: what is needed is localization to a subset of space-time sheets for which the eigenvalues of the p-adic density matrix are degenerate. This means that the time evolution by quantum jumps corresponds to hopping in the space of zero modes, which leads to that part of zero mode sector, where WCW spinor field has largest value. The maxima of Kähler function are excellent candidates for the attractors of the quantum self-organization process.

A more concrete brain level model of feature detection based on the realization of the self-hierarchy as a hierarchy of Josephson currents frequency-modulating each other perhaps helps to clarify the abstract general ideas about conscious feature detection.

1. The feature to be detected is represented as a reference supra current flowing in a neural circuit and weakly coupled to a parallel neural circuit representing the input. When the supra currents are identical, constructive interference of the Josephson currents flowing between the two circuits occurs and induces large modulation of the rest potentials of neurons of the circuit and leads to a synchronous generation of nerve pulses. Synchronous neural firing can start under rather wide limits depending on the alertness of the neural circuit (how near to the threshold value resting potential is) controlled by the modulating Josephson currents also.

2. Synchronous neural firing wakes-up sub-self which starts to self-organize and develops into an asymptotic pattern representing a mental image about the detected feature. The final state depends only weakly on the initial state of the neural circuit representing self so that genuine feature detection is in question. For instance, some minimal number of neurons firing in the neural circuit leads to given final state pattern so that the constructive interference of the Josephson currents need not be maximal.

3. The self-organization patterns in neural circuits define a population of sub-selves defining cognitive mental images, features. These sub-selves wake-up and fall asleep (even periodically during their lifetime (after images)). Falling asleep occurs, when the sub-system generates a bound state entanglement with some other sub-system, and wake-up by a reduction of the bound state entanglement.

4. Self-organizing neural circuit starts to approach the maximum of "subsystem" Kähler function (recall that approximate representability of Kähler function as a sum of subsystem Kähler functions is probably possible) is accompanied by the wake-up of sub-self. This corresponds to the motion of neural circuit in its spin glass energy landscape induced by various neural transmitters inducing short term or long term changes in the synaptic contacts. Thus self-organization induces also a generalized motor action shifting the position of the neural circuit in the spin glass energy landscape.

5. Feature detection involves kind of *Eureka!* experience. Perhaps the sub-self representing the mental image about recognized object remains for some time irreducible and hence does not possess any sub-selves (and is in "enlightened" state). This could be the situation for some time until sub-selves are generated during self-organization and lead to the analysis of of the recognized feature.

One can ask whether it makes sense to speak about entanglement between different number fields. The original idea was that this might make sense. In the recent vision however fermions responsible for Boolean cognition reside in the intersection of reality and various p-adicities formed by an extension of rationals at the level of parameters characterized string world sheets and partonic

2-surfaces. Hence fermions and string world sheets are number theoretically universal rather than assignable to some particular number field. Hence for fermions the entanglement is also number theoretical universal and expressible in terms of numbers in the extension of rationals.

The emergence of a positive entanglement negentropy is a physical correlate for the experience of love, understanding, Eureka experience and various other experience with positive emotional coloring. Generation of negentropic entanglement can can give rise to experiences like seeing beauty, feeling truth, and feeling love. Both p-adic and real physics, cognitive and symbolic representations are involved automatically in the adelic view about physics in which all structures are Cartesian products of they real and p-adic variants.

Learning of associations

The second law of associationism states that ideas experienced simultaneously tend to form associations. TGD suggests two mechanisms for realizing associative learning.

1. The purely quantal mechanism realizes associations in terms of quantum entanglement. This mechanism would be extremely elegant because super position principle allows huge capacity of forming associations. Quantum entanglement however seems to associate parts to form wholes with the ensuing loss of conscious information about parts rather than giving rise to conscious associations $A \to B$. One could say that the association in question is spatial rather than temporal. Note also that quantum entanglement lacks the directional character of association. It seems that this mechanism is essential for associating various cognitive features at the level of brain with sensory qualia at the level of sensory organs.

2. In second mechanism the classical neural net type realization is replaced by a process in which sub-self wakes up another sub-self. A process in which presynaptic neuron wakes up postsynaptic neuron and the mental images of these neurons form the association, could indeed serve as building blocks of our associations.

It has turned out that these mechanisms are actually not mutually exclusive, and that both are involved with the association mechanism. The TGD based notion of sub-system, relying on the topological non-triviality of the many-sheeted space-time, makes possible for separate selves (unentangled systems) to share mental images via the entanglement of their sub-selves. Topologically this corresponds to the following situation. Two selves (say sensory mental image and cognitive mental image) are realized as disjoint space-time sheets S_i, $i = 1, 2$ and their sub-selves as smaller space-time sheets S_{ij} glued by wormhole contacts to the space-time sheets S_i. When sub-self space-time sheets S_{1j} and S_{2k} are connected by join along boundaries bonds, the fusion and sharing of these mental images occurs.

The neural network model for the formation of associations relies on the idea that some states of the neural net are in a correspondence with the states of the external world. Also the states of different layers of neural net have natural mutual correspondence. Association basically creates one-one map. In neural net models the interaction with external world occurs via driving force and dissipation leads to asymptotic states, which can be interpreted as association of net-states with the states of the external world. The problem of the neural network models is how the learning process could be realized in living brain. In particular, how two simultaneous ideas represented by the substates of neural net get associated with each other. This seems to require that the presence of two active nodes present in the net tends to strengthen their mutual coupling. There is a lot of empirical supports for this and neural transmitter action is an essential element of this process. In TGD framework this process corresponds to the gradual movement of neurons and brain in their spin glass energy landscape induced by neural transmitter action.

In TGD framework the formation of association $A \to B$ would mean that the stimulus A alone can generate B. This means that the sub-self representing mental image A tends to wake up the sub-self representing mental image B. At the neuronal level this simply means that the firing presynaptic neuron excites postsynaptic neuron so that it also fires: the long term changes of the synaptic connection promotes this ability. At the level of our mental images the waking up process must involve nerve pulse transmission from neural circuit representing sub-self A to the neural circuit representing sub-self B. Josephson current model suggests that during learning period, when A and B are experienced simultaneously, they are mapped to reference currents in

feature recognition network $A + B$. Later when only A serves as input, part A of the circuit $A + B$ begins to fire when it receives A as input. If the synaptic connections between circuits A and B have been strengthened during learning period, the firing spreads out to B and also B wakes up. This in turn leads to the self-organization process generating experience $A + B$.

Many associations are bi-directional: for instance, symbols for real world objects are bi-directional associations. In TGD framework one can model the generation of the bi-directional associations in classical sense along following lines. Denote by A and B the symbols to be associated: A and B correspond to sub-selves of say self X. Neural net philosophy suggests that A and B should co-operate to keep each other in wake-up state (alive!): self-organization by quantum jumps could lead to this kind of co-operation. This is achieved if sensory experiences stimulate automatically co-operative self-populations, whose members tend to keep each other awake. This model is consistent with the fact that associations do not involve conscious thought. For instance, A could generate nerve pulse patterns waking up B and vice versa. Note that at the next level of the self hierarchy this could be regarded as a formation of self-association $X \to X$ possibly giving rise to a stable short term memory and also as survival of self X guaranteed by co-operation of sub-selves.

10.4.3   Computationalism And TGD

Computationalism in strong sense (brains as deterministic machines) does not emerge from TGD. The basic reason is that the time concept is totally different from that of computationalism. One can say that quantum jumps select between different time evolutions and the overall-important modular structures result from self cascades.

How computationalism and TGD approach differ?

A good example is provided by vision discussed in [J140] . Vision builds representation or description of the world from sensory data. Since inverse optics is not possible, implicit assumptions about the structure of the external world are necessary. Typically illusions rely on the breaking of these implicit assumptions. Illusions are not always undesirable. Two-dimensional pictures are an example of an illusion making possible visual communication! Auto-stereograms [J140] consisting of diffuse soup of points are a particularly striking example of illusion: looking the picture for a sufficient time, one can experience a dramatic re-shapening of the experience: beautiful 3-dimensional picture emerges from the chaos. Auto-stereograms support the hypothesis that vision involves computational activities or quantum counterparts of them. This process can be seen as a school example about how brain adds to a pure sensory input symbolic and cognitive representations.

In TGD universe brain does not probably deduce the representation of the world from picture by a straightforward computation. Certainly the data and implicit or learned assumptions about the world appear as an input in some sense. Some kind of iterated guessing based on implicit assumptions seems to involved: guess is made and compared with the actual picture. Quantum self-organization indeed makes possible the iteration, being in itself an iterative process. Guesses are very probably based on the existing abstract data about possible configurations of the world. The paradigm of 4-dimensional brain allowing to realized long term memories as geometric memories could be crucial in this respect. One can wonder whether the implicit assumptions might also develop from temporal entanglements with larger selves (during sleep) giving rise to information about world in longer length and time scales.

Control of motion is second good example of what might happen. There is no deterministic program proceeding with respect to geometric time and selecting what happens next and creating the quantum history step by step. Rather, the entire pattern of motion is selected by the creation of the main program self by quantum jump. The subsequent quantum jumps occur in the cascade proceeding in top-to-bottom type manner to shorter spatial and temporal scales. Thus the main program corresponds to, say the pattern of large scale motion, and sub-programs correspond to the details of the motion. What is new as compared to computationalism is that the program is created while it runs.

At the level of CNS anatomy sensory perceptions and motor actions loook mirror images of each other. TGD suggests that they could be mirror images at much deeper level. Motor actions would be time reversal of sensory perception in appropriate time scales for MEs (topological

light rays, "massless extremals") and routinely involve breaking of the second law in this p-adic time scales. This assumption implies that motor action results like a painting starting from a rough sketch. Dissipation and its time reversal automatically perform Darwinian selection leading quantum jump by quantum jump to the final motor action. No detailed planning is needed. Motor imagination is motor action starting from some level above the muscles and motor skills can be learned by imagining them.

Real selves as symbols

The ability to think in terms of symbols is certainly one of the key features of intelligence. The hierarchical structure of selves within selves and the possibility of cascades creating selves within selves allows to interpret sub-selves of self as conscious representations for symbols, at least under certain additional conditions. The condition seems to be that symbol sub-self and the primary sub-self representing the real object must be able to wake-up each other bi-directionally. Symbol self and "real self" could also belong to different levels of the hierarchy. For instance, single neuron could serve as a representative of neuron group in the sense that neuron and neuron group can wake-up each other. Perhaps Grandma neuron serves as a symbol for a complicated experience of entire neuron group. Linguistic associations would certainly be sub-selves representing this kind of representative function very effectively. This kind of symbol neurons would correspond to leaders at the level of human society. Indeed, words can generate actions and word selves are excellent candidates for the leaders of the neuronal society!

Selves allow also other interpretations. In very general sense they can be identified as agents or "demons" in the sense of computationalism. Agents can be also regarded as counterparts of submodules of main program. The call of subroutine from main program could be regarded as a wake-up of subprogram self. The main program forms automatically abstraction of the entire subjective history of subprogram self. The input data of submodules realized as sub-selves is most naturally realized as sensory input. For instance, neurons are expected to have chemical senses making communication between neuronal selves possible [K39]. Nerve pulses provide obvious candidate for a communication mode.

The concept of global workspace [J38] is one of the basic concepts used in the modelling of cognition and short term memory. The model visualizes short term memory as a global workspace, kind of common blackboard seen by various agents. The agents in turn can add write data to the global work space. Communication via global workspace is clearly analogous to mass media. Communication via global work space could be realized as chemical communication. Hormonal system could be an example of mass media operating at the level of our conscious experience. A surprisingly large volume of brain is free of neurons and glial cells and there is experimental evidence for chemical communication occurring via this free volume [I20]. In TGD framework global work space could be also realized in terms of coherent photons if selves act as quantum antennas able to receive and send messages: this would be very much like mass media in neuronal and sub-neuronal length scales.

Wholes and parts, classes and individuals

Wholes contra parts and classes contra individuals are basic concepts of computationalism and should allow representation as quantum level concepts. Also in TGD framework these concepts emerge naturally. The sub-selves X_i of self X are individuals and a natural hypothesis is that X experiences X_i as separate sub-selves. The self Y at the next level of hierarchy containing X in turn experiences the set $\{X_i\}$ of sub-selves of X as an average $\langle X_i \rangle$, typical representative of class X. For instance, if sub-selves of X represent different faces, then Y forms abstraction about the concept of face.

"Whole" is a concept different from class. A good example of "whole" is letter F formed from smaller F: s. Whole is something more than a sum of individuals and the problem is to understand how this whole is represented at quantum level. A very natural hypothesis is that the whole formed by sub-selves is formed by quantum entanglement between sub-selves leading to the disappearance of the individual sub-selves. When entanglement is destroyed, sub-selves or some of them are experienced as separate: this mechanism could also be regarded as a quantum mechanism for the formation of associations. Sensory experiences would wake up sensory selves

involving sensory organ and parts of brain giving rise to different representations of sensory data and the analysis of sensory experience would involve the decomposition of these selves to sub-selves.

Our body consciousness provides testing ground these ideas. Contrary to the basic dogma of neuroscience, in TGD framework the fundamental representation of the body is formed by the body itself as is clear also on basis of the concept of self. Of course, representations at the level of brain are also involved and make possible the analysis of the body experience. We do not however experience our bodies as a huge number of separate cells. The explanation is that our sub-selves correspond to structures that are much larger than cell. Various parts of our body could obviously correspond to the sub-selves of our self. The fact that we recognize all parts of our body as such suggests that our self is at least as large as our body or perhaps even larger. Interestingly, in some brain disorders patient does not admit that some part of body, say left side of the body, belongs to them. This would suggest that the self of these persons is reduced to the self of the other side of the body rather than that of entire body.

Predictions and memories

The paradigm of 4-dimensional brain (and of 4-dimensional body and even of 4-dimensional Universe!) differentiates between TGD based computationalism and classical computationalism. One of the most important predictions is the possibility of two kinds of memories: geometric "memory" generating simulations of past and future and subjective memory making it possible to have genuine memories about previous moments of consciousness. The comparison of the predictions with what actually happened seems to be basic activity of conscious mind. The fundamental realizations of both subjective and geometric memory elegantly circumvent the memory storage problems encountered in the computationalistic approach and multiplied by the combinatorial explosion.

These basic memory types allow several realizations. The identification of immediate short term memories as subjective memories is very natural. Geometric memories seem to be the only reasonable candidate for long term memories. Procedural memories relying on association of say nerve pulse patterns with experiences are possible.

Self at a given level of hierarchy forms automatically abstractions about the wake-up periods of the lower level selves. This makes possible to form abstractions about the time development of sub-selves and to gain wisdom given by experience. Long term memories involve both the formation of abstractions as some kind of time averages and detailed information. This is difficult to realize in the neural network approach.

Boolean logic and logical deductions

One can easily invent models of logical reasoning but probably the most realistic model is based on representing the premises of the logical deduction using Boolean statements realized in terms of fermions. These cognitive representations defined in the intersection of realities and p-adicities symbolic representations, and generate a neural activity representing the logical deduction, which is basically realized using learned associations. This model involves minimum amount of p-adic physics, is essentially isomorphic with the model of imagination, and is consistent with neuroscience facts.

An interesting possibility is that many particle states of cognitive neutrino pairs providing representation of logical thoughts could replicate. This might be possible. If the macroscopic phase determined by cognitive neutrino pairs is completely fixed by the structure of mind-like space-time sheets then the replication of the material space-time sheet and mind-like space-time sheet would lead to the replication of thought. DNA replication seems to occur in too short length length scale to be associated with this process. Cell replication could however quite well involve replication of thoughts. Cell replication does not seem to occur at the level of brain. Presumably nerve pulses generating standardized patterns of cognitive neutrino pairs have replaced direct decay of cell as a more effective manner to replicate thoughts and eventually even communicate them.

Beliefs and desires

Computational approach does not have much to say about emotions. Beliefs and desires are however concepts allowing symbolic (one might say computational) representation: this of course does not explain what gives for belief or desire its emotional content.

Beliefs could be very generally regarded as basic axioms of formal system from which various deductions by truth preserving symbol manipulations are obtained. The mathematical model behind numerical calculation is a nontrivial example of this kind of belief system. Desires can be realized in computational science in terms of goals assigned with the initial state. For instance, the desire of the problem solver is to solve the problem that is get from initial state to the desired final state by applying fixed rules. Initial state could correspond to the assumptions of a theorem and final state to the theorem itself. If it is possible to solve the problem at the level of symbolic representation, the solution of problem can be mapped to the real world. Beliefs and desires could easily be represented symbolically in terms of neural activity using associations. A Boolean representation of beliefs could be in terms of logical statements using cognitive neutrinos or real neutrinos.

It is not so easy to understand what gives rise to the conscious experience of belief or desire. The geometric time development can be regarded as a prediction of future (and past) whereas "reality" corresponds to the subjective time development. The belief about what happens in the future is a special belief and could be seen as "memories" with respect to the geometric time: seeing to the future. Intention would be the p-adic counterpart of this kind of belief, seeing to the p-adic future. A wide class of emotions could result from the comparison of the predicted and real. That predicted and real coincide, could correspond to nearly identical sub-selves able to form a bound state accompanied by a a period of macrotemporal quantum coherence and a positive emotion like understanding.

The fundamental desire of the sub-self is to stay conscious, to survive. Cognitive, symbolic, and Boolean representations would give for the desire of the mental images of the conscious world model to survive an interpretation as a higher level desire. Also beliefs might be determined to a large extend by the desire of the sub-selves to survive: giving up a belief means death of the corresponding mental images and unpleasant mental images are a threat for mental images defining the self model. We tend to have beliefs which do not threat our ego.

Simple model for problem solving

Problem solving is certainly quite high level cognitive skill. A good test for the proposed scenario is how simple conscious problem solving could proceed. The basic desire of problem solver is to achieve the goal given the initial state. Problem solver makes trials and when goal and achieved state are sufficiently near to each other problem can be said to be solved. The model for this activity could be roughly like follows:

1. Goal is represented as a physical state of some subsystem and the basic problem is how problem solver can compare the result of trial with the goal. It seems that all conscious comparisons must reduce at fundamental level to the comparisons of geometric and subjective time developments of some sub-self. Thus it seems that problem solver self must directly experiences whether the goal was achieved by experiencing how much the hoped for geometric time development and subjective time development generated by the trial resembled each other.

2. This approach as such is not practical. Standard computationalism would the comparison of the result of a trial to the goal necessitates circuit which carries out comparisons. This kind of circuit is easy to realize. For instance, Josephson junctions could physically realize the difference between the result of trial and goal as the phase difference between weakly coupled superconductors. To know whether the trial was successful, problem solver must compare the desire represented by a binary digit one in geometric memory with the result of comparison represented by a binary digit having one one or zero in subjective memory. For instance, limbic brain could be the seat of these binary digits and comparison could occur there.

3. Problem-solver sub-self generates solution trials. Most naturally this involves quantum jump leading to decomposition of problem solver self to two subsystems. This decomposition represents the trial. Good problem solver must be able to generate very many different trials: this means that entanglement entropy is almost constant function of sub-self generated in quantum jump.

4. Problem solver self performs the comparison. When output is "No" problem-solver self generates a new trial. System must have a *Eeureka!* experience, when the problem is solved. This is achieved if "problem solver" self is "enlightened" when it receives output "yes" from the comparison circuit. This means that problem-solver selves begins to make quantum jumps reducing matter-mind entanglement and does not generate trials anymore.

5. The trials could be representable as p-adic space-time sheets defining the initial states of the symbolic representation defining the world model and realized as patterns of neural activity based on association mechanism. Their transformation to real ones would initiate the simulation. Also this process is very similar to that behing logical reasoning and imagination.

There is no need to add that in reality problem solving is much more complicated procedure! The above model could however provide insight about the conscious experiences related to the problem solving.

Quantum computationalism in TGD Universe

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

1. Spin glass degeneracy provides the needed huge number of degrees of freedom making quantum computations very effective. These degrees of freedom are associated with the join along boundaries bonds/flux tubes and are essentially gravitational so that a connection with Penrose-Hameroff hypothesis emerges.

2. Bio-systems would be especially attractive candidates for performers of both non-cognitive and cognitive quantum computation like processes. The binding of molecules by lock and key mechanism is a basic process in living matter and the binding of information molecules to receptors is a special case of this process. All these processes would involve new physics not taken into account in the standard physics based biochemistry.

3. The possibility of cognitive quantum computation like information processing forces generalize the standard quantum computer paradigm also because ordinary quantum computers represent only the lowest, 2-adic level of the p-adic intelligence. Qubits must be replaced by qupits since for algebraic $R - R_p$ entanglement two-state systems are naturally replaced with p-state systems and for $R_{p_1} - R_{p_2}$ entanglement with $p_1 \times p_2$ state systems. For primes of order say $p \simeq 2^{167}$ (the size of small bacterium) this means about 167 bits, which means gigantic quantum computational resources. The secondary p-adic time scale $T_2(127) \simeq .1$ seconds basic bit-like unit corresponds to $M_{127} = 2^{127} - 1$ M_{127}-qupits making about 254 bits. The idea about neuron as a classical bit might be a little bit wrong!

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

The progress taken place in quantum TGD during the period 2005-2010 allows to add to this picture several new elements.

1. The hierarchy of Planck constants and identification of ordinary particles at magnetic flux tubes with arbitrarily large value of Planck constant as dark matter leads to the vision about DNA and nuclear and cell membrane acting as topological quantum computer with the

braiding of flux tubes defining the space-time correlate for the quantum computation [K2]. The intronic portions of genome are natural candidates for the parts of genome specialized to quantum computation like activities and for these purposes the exact nucleotide content of the DNA sequence is not crucial so that DNA looking like "junk" is not junk from the point of view of quantum computation.

2. Zero energy ontology brings in naturally the 4-D ensemble of quantum computations assignable to sub-CDs of given CD. The classical correlates for quantum computations are 4-D classical field patterns assignable to space-time surfaces inside CDs. Causal diamonds bring in the time scales of 1 ms and.1 s associated with quarks and leptons, which are also the time scales of nerve pulse activity and of memetic code. This supports the view that dark quarks at the ends of magnetic flux tubes connecting DNA nucleotides and the lipids of the cell membrane are indeed the key element of computation.

3. In the intersection of real and p-adic worlds negentropic entanglement is possible. This stabilizes qubits but makes them fuzzy. This requires reformulation of topological quantum computation in terms of the U-matrix characterizing U-process for zero energy states and restricted to the states with negentropic entanglement (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book).

10.4.4   How Brain Builds The Model Of The External World?

What we experience is not completely determined by the sensory data: a lot of computation like processes at the level of cortex is involved. In TGD generation of symbolic representations would perhaps be more appropriate term. The phenomenon of illusions, most importantly, our ability to see planar pictures as 3-dimensional, shows that this computation involves a model of external world based on definite assumptions [J140]. Stereo vision [J140] is a good example of a sensory experience involving a lot of cognitive processing at the level of cortex. Depth cannot be experienced directly and the deduction of the actual positions for the points of the visual field must involve large amount of cognitive processing carried out in cortex. At the level of conscious experience the fusion of right and left visual fields to single visual field seems to be responsible for the emergence of the 3-D visual experience.

That complicated information processing is involved is demonstrated by autostereograms, in which a chaotic set of points experienced as a planar picture organizes to a beautiful 3-dimensional picture after intensive concentration (all subject persons are not able to see the 3-dimensional picture). It is known that stereo vision develops in age of few months at the same time when some cortical neurons specialize to receive input from only single eye instead of superposing the inputs from both eyes. Brain is also able to estimate the state of motion of objects of visual field from sensory data and this must involve a lot of computation. The fact that some people cannot experience motion in the visual field provides a support for the claim that this experience is a result of a complicated neuronal processing. At first, the computational aspects of the conscious experience would seem to be in conflict with the idea that sensory organs are the primary sensory experiencers. The situation is however not so simple as the closer examination of the computational aspects of the visual experience demonstrates. The basic point is that brain quantum entangles to the sensory representation various symbolic and cognitive representations giving meaning to what is sensed.

TGD based view about construction of sensory representations

The motion of eye or head does not induce the sensation that the world is moving although the sensory image moves around the cortex. Rather, brain acts like a (possibly moving) canvas at which the sensory input is projected and monitored by an external observer. This very simple observation is a strong objection against the idea that the ultimate sensory and cognitive representations reside inside brain, and leads to the view that the magnetic flux tube structures associated with the primary and secondary sensory organs define a hierarchy of sensory and symbolic representations outside brain. Magnetic flux tube structures would serve as the sensory canvas to which sensory images are projected from brain and possibly from sensory organs and even neurons. MEs serve as projectors and place coding by magnetic transition frequency associated with ME wakes-up sensory

sub-selves at various positions of magnetic flux tubes having varying thickness and associate thus various sensory qualia and even more complex attributes to the objects of the perceptive field. Thus the experiencer would the complex containing so called material body and hierarchy of field bodies.

EEG MEs correspond to our level in this hierarchy of projections. The simplest possibility is that the sizes of these sensory selves are of the order of EEG ME sizes ($L(EEG) = c/f(EEG)$) and thus can be of the order of Earth size! Thus the ultimate sensory representations are magnetic gigants in TGD and diametrical opposites of the neurophysiological dwarfs of standard neuroscience populating also TGD brain.

The known strange effects of large scale perturbations of Earth's magnetic field on consciousness (say, statistics about the effects of magnetic storms in mental state and tectonic activity inducing UFO experiences) provide a rich palette of anomalies supporting this view. The conservation of magnetic flux makes the magnetic flux tube structures of Earth size very stable: thus physical death presumably means only that our magnetic body redirects its attention to something more interesting. Near death experiences discussed in more detail in [K19] indeed support this view. Of course, this view about human consciousness is not new, it is shared by all spiritual practices. What is new is the concrete physical model realizing this view physically.

It would seem that the generation of the visual experience involves some kind of iterative computational process laeding to an optimal conscious sensory representation of the external world. This process must involve a model of the external world, which is improved iteratively. Each computational step must provide an estimate for the various positional coordinates of the object and features associated with it and a subsequent comparison of the real sensory data with the virtual sensory data yielded by the model world. The virtual world sensory input yielded by this model is compared with the real world sensory input in comparison circuit and when virtual and real inputs are sufficiently near each other synchronous neural firing leading to a wake-up of sensory sub-self and conscious recognition of the object of the perceptive field occurs. This could also involve intermediate cognitive, symbolic, and sensory representations not conscious to us who see only the final product of this process. In case of vision the model suggests that both eyes yield actually stereovision separately in ordinary circumstances. This might be the case: one must hold second eye closed for sufficiently long time before the picture gradually flattens.

This quasi-computational process is cognitive process involving imagined sensory, motor and Boolean representations ("this is true" experiences) realized. If the primary qualia are at the level of sensory organs it is easy to understand why imagination lacks the sensory qualia. Only during dreams and hallucinations would the back-projection to the sensory organs occur and "qualiafy" the symbolic representations generated by imagination.

The original proposal was that imagination is a purely p-adic process involving transformation of p-adic space-time sheets to real ones. In the adelic vision this does not make sense. Both real and p-adic (cognitive) aspects are always present. If motor action is a geometric time reversal of sensory perception in relevant p-adic time scales, it is initiated at some level above muscles and proceed to higher levels so that there is no danger that real motor actions are generated. Dissipation and its time reversal implying a Darwinian selection of mental images are probably the basic tools of imagination and problem solving: second law becomes an ally rather than an enemy. Problem solving and motor actions quite generally start from a rough sketch and there is no need for rigid and bureucratic program structures as in case of AI. Program develops as it runs.

There are several information sources at use when cortex deduces the positional coordinates for the objects of the perceptive field. In case of vision the decomposition of the right and left visual fields to objects is an essential element of the approach. For instance, simple estimate for the distance of object results from the comparison of the positions of the images of object in the retina. If illumination is constant, the comparison of the intensities of the reflected light coming from various planar pieces of the surface representing object gives estimate for the normal direction of the planar piece. Also the fact, that some points of the object are not seen simultaneously by right and left eye can be used as a constraint. In case of autostereograms there is no decomposition into objects and the problem is to identify, which points of the right eye and left eye correspond to same point of the external world: the color of the points is obvious clue. Also long term memories about objects seen earlier are obviously involved.

In the simple situation that the visual world consists of simple objects, no comparison of the model world with the real world is needed provided that cortex is able to perform some simple

arithmetics (which is not at all obvious!). In the general situation experience is yielded by the iterative computation like process (actually a rather long sequence of quantum computations if single quantum computation lasts about 10^4 Planck times).

A possible model for the computational aspects of sensory experience

The mind-like space-time sheets in the regions of cortex and various brain nuclei could see each other in the illumination provided by the Bose-Einstein condensed photons propagating along axonal (possibly also microtubular) wave guides. This would make possible comparison circuits in which inputs from two different areas of brain to area of brain are compared. The comparison circuit based on Josephson currents is ideal for this purpose. In case that inputs are identical, synchronous neural activity results. The comparison of the images could be crucial in realizing the iterative evaluation of the computational aspects of sensory experience. This iterative comparison process need not be conscious to us.

From our point of view brain seems to generate only symbolic representations. Cortex might however also generate virtual world sensory experiences at lower levels of the self hierarchy and not conscious to us. These could be compared with the genuine sensory input in (say) thalamus and convergent iteration would lead to a resonant firing and conscious experience of recognition. This would explain the observed adaptive resonance phenomenon in which thalamo-cortical feedback loop directs conscious attention to those aspects of sensory percept which agree with the expectation. Direction of attention would mean generation of a sensory sub-self representing the recognized part of perceptive field. Novelty detection could occur at higher information processing level and could be based on inhibitory projections from feature detectors to the novelty detecting neural circuit.

Just to concretize the idea, one could imagine the following rough scenario for how the comparison involving neuronal sensory qualia (not ours) could proceed.

1. Neurons in some parts of brain, most naturally in the thalamus, have neural window to the primary sensory organ radiating coherent light propagating along microtubular waveguides to thalamus. Besides vision and perhaps even hearing, neurons would also have chemical senses and receptor-transmitter complexes would define different qualia. Different sensory modalities feed different regions of thalamus with difference wavelengths characterizing the sensory modality so that the neuronal window based on coherent light might be used by all sensory modalities to achieve this comparison. This is consistent with the fact that microtubuli are present in all axons. There is an intensive feedback from cortex to thalamus and this feedback could quite generally be related to the cognitive representations generated in cortex and communicated to thalamus for comparison. The results of the comparison are sent back to the cortex coded in nerve pulse patterns and change the properties of the model world to give a better fit.

2. The imagery model world consisting of neuronal mind-like space-time sheets in cortex represents the results of a cortical computation. Mind-like space-time sheets radiate coherent light with the intensity determined by the model of the external world specifying the intensity of the reflected light from a particular object. The simplest possibility is that the representation consists of mind-like space-time sheets whose size and shape are deduced from the size and shape of the objects and from the estimated values of the height function. Only the active cortical neurons send coherent light along microtubules to thalamus. The result of the comparison is coded to nerve pulse pattern and sent back to cortex to make possible next trial.

Connection with the observations of Barbara Shipman

There is also an interesting connection with the model the model of Barbra Shipman for the dance of honeybee [A12, A13, A14].

The model relies on the puzzling observation that the manifold $F_3 = SU(3)/U(1) \times U(1)$ parametrizing different choices of color quantum numbers seems to be involved with the dance [K39]. In TGD framework color rotations do not leave classical Z^0 and em fields invariant although induced Kähler field is color invariant. For instance, in a color rotation a pure Z^0 ME is in general

transformed to a ME carrying a light-like vacuum em current generating a hologram possibly acting as a biological control command. This suggests an explanation for the observations of Shipman and also that the canonical coordinates (P_i, Q_i) for the 6-dimensional symplectic space F_3 play crucial role in the construction of sensory representation. In fact, in Shipman's model the Hamiltonians associated with color isospin and hypercharge take the role of planar coordinates for the dance floor at which the dance of honeybee takes place. More generally, it might be possible to represent the position of the object of a perceptive field using some coordinates of F_3. The optimal situation would be that both the velocity and position would be coded to a point of F_3 so that CP_2 orientation of space-time sheet would represent position for an object of a perceptive field.

10.5 Number Theoretical Feats and TGD Inspired Theory of Consciousness

Number theoretical feats of some mathematicians like Ramanujan remain a mystery for those believing that brain is a classical computer. Also the ability of idiot savants - lacking even the idea about what prime is - to factorize integers to primes challenges the idea that an algorithm is involved. In this article I discuss ideas about how various arithmetical feats such as partitioning integer to a sum of integers and to a product of prime factors might take place. The ideas are inspired by the number theoretic vision about TGD suggesting that basic arithmetics might be realized as naturally occurring processes at quantum level and the outcomes might be "sensorily perceived". One can also ask whether zero energy ontology (ZEO) could allow to perform quantum computations in polynomial instead of exponential time.

The indian mathematician Srinivasa Ramanujan is perhaps the most well-known example about a mathematician with miraculous gifts. He told immediately answers to difficult mathematical questions - ordinary mortals had to hard computational work to check that the answer was right. Many of the extremely intricate mathematical formulas of Ramanujan have been proved much later by using advanced number theory. Ramanujan told that he got the answers from his personal Goddess. A possible TGD based explanation of this feat relies on the idea that in zero energy ontology (ZEO) quantum computation like activity could consist of steps consisting quantum computation and its time reversal with long-lasting part of each step performed in reverse time direction at opposite boundary of causal diamond so that the net time used would be short at second boundary.

The adelic picture about state function reduction in ZEO suggests that it might be possible to have direct sensory experience about prime factorization of integers [L30]. What about partitions of integers to sums of primes? For years ago I proposed that symplectic QFT is an essential part of TGD. The basic observation was that one can assign to polygons of partonic 2-surface - say geodesic triangles - Kähler magnetic fluxes defining symplectic invariance identifiable as zero modes. This assignment makes sense also for string world sheets and gives rise to what is usually called Abelian Wilson line. I could not specify at that time how to select these polygons. A very natural manner to fix the vertices of polygon (or polygons) is to assume that they correspond ends of fermion lines which appear as boundaries of string world sheets. The polygons would be fixed rather uniquely by requiring that fermions reside at their vertices.

The number 1 is the only prime for addition so that the analog of prime factorization for sum is not of much use. Polygons with $n = 3, 4, 5$ vertices are special in that one cannot decompose them to non-degenerate polygons. Non-degenerate polygons also represent integers $n > 2$. This inspires the idea about numbers $\{3, 4, 5\}$ as "additive primes" for integers $n > 2$ representable as non-degenerate polygons. These polygons could be associated many-fermion states with negentropic entanglement (NE) - this notion relate to cognition and conscious information and is something totally new from standard physics point of view. This inspires also a conjecture about a deep connection with arithmetic consciousness: polygons would define conscious representations for integers $n > 2$. The splicings of polygons to smaller ones could be dynamical quantum processes behind arithmetic conscious processes involving addition.

10.5.1   How Ramanujan did it?

Lubos Motl wrote recently a blog posting (`http://tinyurl.com/zduu72p`) about $P \neq NP$ computer in the theory of computation based on Turing's work. This unproven conjecture relies on a classical model of computation developed by formulating mathematically what the women doing the hard computational work in offices at the time of Turing did. Turing's model is extremely beautiful mathematical abstraction of something very every-daily but does not involve fundamental physics in any manner so that it must be taken with caution. The basic notions include those of algorithm and recursive function, and the mathematics used in the model is mathematics of integers. Nothing is assumed about what conscious computation is and it is somewhat ironic that this model has been taken by strong AI people as a model of consciousness!

1. A canonical model for classical computation is in terms of Turing machine, which has bit sequence as inputs and transforms them to outputs and each step changes its internal state. A more concrete model is in terms of a network of gates representing basic operations for the incoming bits: from this basic functions one constructs all recursive functions. The computer and program actualize the algorithm represented as a computer program and eventually halts - at least one can hope that it does so. Assuming that the elementary operations require some minimum time, one can estimate the number of steps required and get an estimate for the dependence of the computation time as function of the size of computation.

2. If the time required by a computation, whose size is characterized by the number N of relevant bits, can be carried in time proportional to some power of N and is thus polynomial, one says that computation is in class P. Non-polynomial computation in class NP would correspond to a computation time increasing with N faster than any power of N, say exponentially. Donald Knuth, whose name is familiar for everyone using Latex to produce mathematical text, believes on $P = NP$ in the framework of classical computation. Lubos in turn thinks that the Turing model is probably too primitive and that quantum physics based model is needed and this might allow $P = NP$.

What about quantum computation as we understand it in the recent quantum physics: can it achieve $P = NP$?

1. Quantum computation is often compared to a superposition of classical computations and this might encourage to think that this could make it much more effective but this does not seem to be the case. Note however that the amount of information represents by N qubits is however exponentially larger than that represented by N classical bits since entanglement is possible. The prevailing wisdom seems to be that in some situations quantum computation can be faster than the classical one but that if $P = NP$ holds true for classical computation, it holds true also for quantum computations. Presumably because the model of quantum computation begins from the classical model and only (quantum computer scientists must experience this statement as an insult - apologies!) replaces bits with qubits.

2. In quantum computer one replaces bits with entangled qubits and gates with quantum gates and computation corresponds to a unitary time evolution with respect to a discretized time parameter constructed in terms of fundamental simple building bricks. So called tensor networks realize the idea of local unitary in a nice manner and has been proposed to defined error correcting quantum codes. State function reduction halts the computation. The outcome is non-deterministic but one can perform large number of computations and deduce from the distribution of outcomes the results of computation.

What about conscious computations? Or more generally, conscious information processing. Could it proceed faster than computation in these sense of Turing? To answer this question one must first try to understand what conscious information processing might be. TGD inspired theory of consciousnesss provides one a possible answer to the question involving not only quantum physics but also new quantum physics.

1. In TGD framework Zero energy ontology (ZEO) replaces ordinary positive energy ontology and forces to generalize the theory of quantum measurement. This brings in several new

elements. In particular, state function reductions can occur at both boundaries of causal diamond (CD), which is intersection of future and past direct light-cones and defines a geometric correlate for self. Selves for a fractal hierarchy - CDs within CDs and maybe also overlapping. Negentropy Maximization Principle (NMP) is the basic variational principle of consciousness and tells that the state function reductions generate maximum amount of conscious information. The notion of negentropic entanglement (NE) involving p-adic physics as physics of cognition and hierarchy of Planck constants assigned with dark matter are also central elements.

2. NMP allows a sequence of state function reductions to occur at given boundary of diamond-like CD - call it passive boundary. The state function reduction sequence leaving everything unchanged at the passive boundary of CD defines self as a generalized Zeno effect. Each step shifts the opposite - active - boundary of CD "upwards" and increases its distance from the passive boundary. Also the states at it change and one has the counterpart of unitary time evolution. The shifting of the active boundary gives rise to the experienced time flow and sensory input generating cognitive mental images - the "Maya" aspect of conscious experienced. Passive boundary corresponds to permanent unchanging "Self".

3. Eventually NMP forces the first reduction to the opposite boundary to occur. Self dies and reincarnates as a time reversed self. The opposite boundary of CD would be now shifting "downwards" and increasing CD size further. At the next reduction to opposite boundary re-incarnation of self in the geometric future of the original self would occur. This would be re-incarnation in the sense of Eastern philosophies. It would make sense to wonder whose incarnation in geometric past I might represent!

Could this allow to perform fast quantal computations by decomposing the computation to a sequence in which one proceeds in both directions of time? Could the incredible feats of some "human computers" rely on this quantum mechanism (see `http://tinyurl.com/hk5baty`). The indian mathematician Srinivasa Ramanujan (see `http://tinyurl.com/l42q7a2`) is the most well-known example of a mathematician with miraculous gifts. He told immediately answers to difficult mathematical questions - ordinary mortals had to hard computational work to check that the answer was right. Many of the extremely intricate mathematical formulas of Ramanujan have been proved much later by using advanced number theory. Ramanujan told that he got the answers from his personal Goddess.

Might it be possible in ZEO to perform quantally computations requiring classically non-polynomial time much faster - even in polynomial time? If this were the case, one might at least try to understand how Ramanujan did it although higher levels selves might be involved also (did his Goddess do the job?).

1. Quantal computation would correspond to a state function reduction sequence at fixed boundary of CD defining a mathematical mental image as sub-self. In the first reduction to the opposite boundary of CD sub-self representing mathematical mental image would die and quantum computation would halt. A new computation at opposite boundary proceeding to opposite direction of geometric time would begin and define a time-reversed mathematical mental image. This sequence of reincarnations of sub-self as its time reversal could give rise to a sequence of quantum computation like processes taking less time than usually since one half of computations would take place at the opposite boundary to opposite time direction (the size of CD increases as the boundary shifts).

2. If the average computation time is same at both boundaries, the computation time would be only halved. Not very impressive. However, if the mental images at second boundary - call it A - are short-lived and the selves at opposite boundary B are very long-lived and represent very long computations, the process could be very fast from the point of view of A! Could one overcome the $P \neq NP$ constraint by performing computations during time-reversed re-incarnations?! Short living mental images at this boundary and very long-lived mental images at the opposite boundary - could this be the secret of Ramanujan?

3. Was the Goddess of Ramanujan - self at higher level of self-hierarchy - nothing but a time reversal for some mathematical mental image of Ramanujan (Brahman=Atman!), representing

very long quantal computations! We have night-day cycle of personal consciousness and it could correspond to a sequence of re-incarnations at some level of our personal self-hierarchy. Ramanujan tells that he met his Goddess in dreams. Was his Goddess the time reversal of that part of Ramanujan, which was unconscious when Ramanujan slept? Intriguingly, Ramanujan was rather short-lived himself - he died at the age of 32! In fact, many geniuses have been rather short-lived.

4. Why the alter ego of Ramanujan was Goddess? Jung intuited that our psyche has two aspects: anima and animus. Do they quite universally correspond to self and its time reversal? Do our mental images have gender?! Could our self-hierarchy be a hierarchical collection of anima and animi so that gender would be something much deeper than biological sex! And what about Yin-Yang duality of Chinese philosophy and the ka as the shadow of persona in the mythology of ancient Egypt?

10.5.2 Symplectic QFT, $\{3, 4, 5\}$ as Additive Primes, and Arithmetic Consciousness

For years ago I proposed that symplectic QFT is an essential part of TGD [K20, K104]. The basic observation was that one can assign to polygons of partonic 2-surface - say geodesic triangles - Kähler magnetic fluxes defining symplectic invariance identifiable as zero modes. This assignment makes sense also for string world sheets and gives rise to what is usually called Abelian Wilson line. I could not specify at that time how to select these polygons in the case of partonic 2-surfaces.

The recent proposal of Maldacena and Arkani-Hamed [B20] (see `http://tinyurl.com/ych26gcm`) that CMB might contain signature of inflationary cosmology as triangles and polygons for which the magnitude of n-point correlation function is enhanced led to a progress in this respect. In the proposal of Maldacena and Arkani-Hamed the polygons are defined by momentum conservation. Now the polygons would be fixed rather uniquely by requiring that fermions reside at their vertices and momentum conservation is not involved.

This inspires the idea about numbers $\{3, 4, 5\}$ as "additive primes" for integers $n > 2$ representable as non-degenerate polygons. Geometrically one could speak of prime polygons not decomposable to lower non-degenerate polygons. These polygons are different from those of Maldacena and Arkani-Hamed and would be associated many-fermion states with negentropic entanglement (NE) - this notion relates to cognition and conscious information and is something totally new from standard physics point of view. This inspires also a conjecture about a deep connection with arithmetic consciousness: polygons would define representations for integers $n > 2$. The splicings of polygons to smaller ones could be dynamical quantum processes behind arithmetic conscious processes involving addition. I have already earlier considered a possible counterpart for conscious prime factorization in the adelic framework [L30].

Basic ideas of TGD inspired theory of conscious very briefly

Negentropy Maximization Principle (NMP) is the variational principle of consciousness in TGD framework. It says that negentropy gain in state function reduction (quantum jump re-creating Universe) is maximal. State function reduction is basically quantum measurement in standard QM and sensory qualia (for instance) could be perhaps understood as quantum numbers of state resulting in state function reduction. NMP poses conditions on whether this reduction can occur. In standard ontology it would occur always when the state is entangled: reduction would destroy the entanglement and minimize entanglement entropy. When cognition is brought in, the situation changes.

The first challenge is to define what negentropic entanglement (NE) and negentropy could mean.

1. In real physics without cognition one does not have any definition of negentropy: on must define negentropy as reduction of entropy resulting as conscious entity gains information. This kind of definition is circular in consciousness theory.

2. In p-adic physics one can define number theoretic entanglement entropy with same basic properties as ordinary Shannon entropy. For some p-adic number fields this entropy can be

negative and this motivates an interpretation as conscious information related to entanglement - rather to the ignorance of external observer about entangled state. The prerequisite is that the entanglement probabilities belong to an an extension of rationals inducing a finite-dimensional extension of rationals. Algebraic extensions are such extensions as also those generate by a root of e (e^p is p-adic number in Q_p).

A crucial step is to fuse together sensory and cognitive worlds as different aspects of existence.

1. One must replace real universe with adelic one so that one has real space-time surfaces and their p-adic variants for various primes p satisfying identical field equations. These are related by strong form of holography (SH) in which 2-D surfaces (string world sheets and partonic 2-surfaces) serve as "space-time genes" and obey equations which make sense both p-adically in real sense so that one can identify them as points of "world of classical worlds" (WCW).

2. One can say that these 2-surfaces belong to intersection of realities and p-adicities - intersection of sensory and cognitive. This demands that the parameters appearing in the equations for 2-surface belong algebraic extension of rational numbers: the interpretation is that this hierarchy of extensions corresponds to evolutionary hierarchy. This also explains imagination in terms of the p-adic space-time surfaces which are not so unique as the real one because of inherent non-determinism of p-adic differential equations. What can be imagined cannot be necessarily realized. You can continued p-adic 2-surface to 4-D surface but not to real one.

There is also second key assumption involved.

1. Hilbert space of quantum states is *same* for real and p-adic sectors of adelic world: for instance, tensor product would lead to total nonsense since there would be both real and p-adic fermions. This means same quantum state and same entanglement but seen from sensory and various cognitive perspectives. This is the basic idea of adelicity: the p-adic norms of rational number characterize the norm of rational number. Now various p-adic conscious experiences characterize the quantum state.

2. Real perspective sees entanglement always as entropic. For some finite number number of primes p p-adic entanglement is however negentropic. For instance, for entanglement probabilities $p_i = 1/N$, the primes appearing as factors of N are such information carrying primes. The presence of these primes can make the entanglement stable. The total entropy equal to the sum of negative real negentropy + various p-adic negentropies can be positive and cannot be reduced in the reduction so that reduction does not occur at all! Entanglement is stabilized by cognition and the randomness of state function reduction tamed: matter has power over matter!

3. There is analogy with the reductionism-holism dichotomy. Real number based view is reductionistic: information is obtained when the entangled state is split into un-entangled part. p-Adic number based view is holistic: information is inthe negentropic entanglement and can be seen as abstraction or rule. The superposition of state pairs represents a rule with state pairs (a_i, b_i) representing the instance of the rule A↔B. Maximal entanglement defined by entanglement probabilities $p_i = 1/N$ makes clear the profound distinction between these views. In real sector the negentropy is negative and smallest possible. In p-adic sector the negentropy is maximum for p-adic primes appearing as factors of N and total negentropy as their sum is large. NE allows to select unique state basis if the probabilities p_i are different.

For $p_i = 1/N$ one can choose any unitary related state basis since unit matrix is invariant under unitary transformations. From the real point of view the ignorance is maximal and entanglement entropy is indeed maximal. For instance, in case of Schrödinger cat one could choose the cat's state basis to be any superposition of dead and alive cat and a state orthogonal to it. From p-adic view information is maximal. The reports of meditators, in particular Zen buddhists, support this interpretation. In "enlightened state" all discriminations disappear: it does not make sense to speak about dead or alive cat or anything between these two options. The state contains information about entire state - not about its parts. It is not information expressible using language relying on making of distinctions but silent wisdom.

How do polygons emerge in TGD framework?

The duality defined by strong form of holography (SH) has 2 sides. Space-time side (bulk) and boundary side (string world sheets and partonic 2-surfaces). 2-D half of SH would suggest a description based on string world sheets and partonic 2-surfaces. This description should be especially simple for the quantum states realized as spinor fields in WCW ("world of classical worlds"). The spinors (as opposed to spinor fields) are now fermionic Fock states assignable to space-time surface defining a point of WCW. TGD extends ordinary 2-D conformal invariance to super-symplectic symmetry applying at the boundary of light-cone: note that given boundary of causal diamond (CD) is contained by light-cone boundary.

1. The correlation functions at embedding space level for fundamental objects, which are fermions at partonic 2-surfaces could be calculated by applying super-symplectic invariance having conformal structure. I have made rather concrete proposals in this respect. For instance, I have suggested that the conformal weights for the generators of supersymplectic algebra are given by poles of fermionic zeta $\zeta_F(s) = \zeta(s)/\zeta(2s)$ and thus include zeros of zeta scaled down by factor $1/2$ [K35]. A related proposal is conformal confinement guaranteeing the reality of net conformal weights.

2. The conformally invariant correlation functions are those of super-symplectic CFT at light-cone boundary or its extension to CD. There would be the analog of conformal invariance associated with the light-like radial coordinate r_M and symplectic invariance associated with CP_2 and sphere S^2 localized with respect to r_M analogous to the complex coordinate in ordinary conformal invariance and naturally continued to hypercomplex coordinate at string world sheets carrying the fermionic modes and together with partonic 2-surfaces defining the boundary part of SH.

Symplectic invariants emerge in the following manner. Positive and negative energy parts of zero energy states would also depend on zero modes defined by super-symplectic invariants and this brings in polygons. Polygons emerge also from four-momentum conservation. These of course are also now present and involve the product of Lorentz group and color group assignable to CD near its either boundary. It seems that the extension of Poincare translations to Kac-Moody type symmetry allows to have full Poincare invariance (in its interior CD looks locally like $M^4 \times CP_2$).

1. One can define the symplectic invariants as magnetic fluxes associated with S^2 and CP_2 Kähler forms. For string world sheets one would obtain non-integrable phase factors. The vertices of polygons defined by string world sheets would correspond to the intersections of the string world sheets with partonic 2-surfaces at the boundaries of CD and at partonic 2-surfaces defining generalized vertices at which 3 light-like 3-surfaces meet along their ends.

2. Any polygon at partonic 2-surface would also allow to define such invariants. A physically natural assumption is that the vertices of these polygons are realized physically by adding fermions or antifermions at them. Kähler fluxes can be expressed in terms of non-integrable phase factors associated with the edges. This assumption would give the desired connection with quantum physics and fix highly uniquely but not completely the invariants appearing in physical states.

The correlated polygons would be thus naturally associated with fundamental fermions and a better analogy would be negentropically entangled n-fermion state rather than corresponding to maximum of the modulus of n-point correlation function. Hierarchy of Planck constants makes these states possible even in cosmological scales. The point would be that negentropic entanglement assignable to the p-adic sectors of WCW would be in key role.

Symplectic invariants and Abelian non-integrable phase factors

Consider now the polygons assignable to many-fermion states at partonic 2-surfaces.

1. The polygon associated with a given set of vertices defined by the position of fermions is far from unique and different polygons correspond to different physical situations. Certainly one must require that the geodesic polygon is not self-intersecting and defines a polygon or set of polygons.

2. Geometrically the polygon is not unique unless it is convex. For instance, one can take regular n-gon and add one vertex to its interior. The polygon can be also constructed in several ways. From this one obtains a non-convex $n + 1$-gon in $n + 1$ ways.

3. Given polygon is analogous with Hamiltonian cycle connecting all points of given graph. Now one does not have graph structure with edges and vertices unless one defines it by nearest neighbor property. Platonic solids provide an example of this kind of situation. Hamiltonian cycles [A3, A6] are key element in the TGD inspired model for music harmony leading also to a model of genetic code [K80] [L18].

4. One should somehow fix the edges of the polygon. For string world sheets the edges would be boundaries of string world sheet. For partonic 2-surfaces the simplest option is that the edges are geodesic lines and thus have shortest possible length. This would bring in metric so that the idea about TGD as almost topological QFT would be realized.

One can distinguish between two cases: single polygon or several polygons.

1. One has maximal entanglement between fundamental fermions, when the vertices define single polygon. One can however have several polygons for a given set of vertices and in this case the coherence is reduced. Minimal correlations correspond to maximal number of 3-gons and minimal number of 4-gons and 5-gons.

2. For large $h_{eff} = n \times h$ the partonic 2-surfaces can have macroscopic and even astrophysical size and one can consider assigning many-fermion states with them. For instance, anyonic states could be interpreted in this manner. In this case it would be natural to consider various decompositions of the state to polygons representing entangled fermions.

The definition of symplectic invariant depends on whether one has single polygon or several polygons.

1. In the case that there are several polygons not containing polygons inside them (if this the case, then the complement of polygon must satisfy the condition) one can uniquely identify the interior of each polygon and assign a flux with it. Non-integrable phase factor is well-defined now. If there is only single polygon then also the complement of polygon could define the flux. Polygon and its complement define fluxes Φ and $\Phi_{tot} - \Phi$.

2. If partonic 2-surface carries monopole Kähler charge Φ_{tot} is essentially $n\pi$, where n is magnetic monopole flux through the partonic 2-surface. This is half integer - not integer: this is key feature of TGD and forces the coupling of Kähler gauge potential to the spinors leading to the quantum number spectrum of standard model. The exponent can be equal to -1 for half-odd integer.

   This problem disappears if both throats of the wormhole contact connecting the space-time sheets with Minkowski signature give their contribution so that two minus-signs give one plus sign. Elementary particles necessarily consist of wormhole contacts through which monopole flux flows and runs along second space-time sheet to another contact and returns along second space-time sheet so that closed monopole flux tube is obtained. The function of the flux must be single valued. This demands that it must reduce to the cosine of the integer multiple of the flux and identifiable as as the real part of the integer power of magnetic flux through the polygon.

The number theoretically deepest point is geometrically completely trivial.

1. Only $n > 2$-gons are non-degenerate and 3-, 4- and 5-gons are prime polygons in the sense that they cannot be sliced to lower polygons. Already 6-gon decomposes to 2 triangles.

2. One can wonder whether the appearance of 3 prime polygons might relate to family replication phenomenon for which TGD suggests an explanation in terms of genus of the partonic 2-surface [K23]. This does not seem to be the case. There is however other three special integers: namely 0,1, and 2.

The connection with family replication phenomenon could be following. When the number of handles at the parton surface exceeds 2, the system forms entangled/bound states describable in terms of polygons with handles at vertices. This would be kind of phase transition. Fundamental fermion families with handle number 0,1,2 would be analogous to integers 0,1,2 and the anyonic many-handle states with NE would be analogous to partitions of integers $n > 2$ represented by the prime polygons. They would correspond to the emergence of p-adic cognition. One could not assign NE and cognition with elementary particles but only to more complex objects such as anyonic states associated with large partonic 2-surfaces (perhaps large because they have large Planck constant $h_{eff} = n \times h$) [K74].

Integers $(3, 4, 5)$ as "additive primes" for integers $n \geq 3$: a connection with arithmetic consciousness

The above observations encourage a more detailed study of the decomposition of polygons to smaller polygons as a geometric representation for the partition of integers to a sum of smaller integers. The idea about integers $(3, 4, 5)$ as "additive primes" represented by prime polygons is especially attractive. This leads to a conjecture about NE associated with polygons as quantum correlates of arithmetic consciousness.

1. Motivations

The key idea is to look whether the notion of divisibility and primeness could have practical value in additive arithmetics. 1 is the only prime for addition in general case. $n = 1 + 1 + ...$ is analogous to p^n and all integers are "additive powers" of 1.

What happens if one considers integers $n \geq 3$? The basic motivation is that $n \geq 3$ is represented as a non-degenerate n-gon for $n \geq 3$. Therefore geometric representation of these primes is used in the following. One cannot split triangles from 4-gon and 5-gon. But already for 6-gon one can and obtains 2 triangles. Thus $\{3, 4, 5\}$ would be the additive primes for $n \geq 3$ represented as prime polygons.

The n-gons with $n \in \{3, 4, 5\}$ appear as faces of the Platonic solids! The inclusions of von Neumann algebras known as hyperfinite factors of type II_1 central in TGDs correspond to quantum phases $exp(\pi/n)$ $n = 3, 4, 5....$ Platonic solids correspond to particular finite subgroups of 3-D rotation group, which are in one-one correspondence with simply laced Lie-groups (ADE). There is also a direct connection with the classification of $\mathcal{N} = 2$ super-conformal theories, which seem to be relevant for TGD.

I cannot resist the temptation to mention also a personal reminiscence about a long lasting altered state of consciousness about 3 decades ago. I called it Great Experience and it boosted among other things serious work in order to understand consciousness in terms of quantum physics. One of the mathematical visions was that number 3 is in some sense fundamental for physics and mathematics. I also precognized infinite primes and much later indeed discovered them. I have repeatedly returned to the precognition about number 3 but found no really convincing reason for its unique role although it pops up again and again in physics and mathematics: 3 particle families, 3 colors for quarks, 3 spatial dimensions, 3 quaternionic imaginaryunits, triality for octonions, to say nothing about the role of trinity in mystics and religions. The following provides the first argument for the special role of number 3 that I can take seriously.

2. Partition of integer to additive primes

The problem is to find a partition of an integer to additive primes $3, 4, 5$. The problem can be solved using a representation in terms of $n > 2$-gons as a geometrical visualization. Some general aspects of the representation.

1. The detailed shape of n-gons in the geometric representation of partitions does not matter: they just represent geometrically a partition of integer to a sum. The partition can be regarded as a dynamical process. n-gons splits to smaller n-gons producing a representation for a partition $n = \sum_i n_i$. What this means is easiest to grasp by imagining how polygon can be decomposed to smaller ones. Interestingly, the decompositions of polytopes to smaller ones - triangulations - appear also in Grassmannian twistor approach to $\mathcal{N} = 4$ super Yang Mills theory.

2. For a given partition the decomposition to n-gons is not unique. For instance, integer 12 can be represented by 3 4-gons or 4 3-gons. Integers $n \in \{3, 4, 5\}$ are special and partitions to these n-gons are in some sense maximal leading to a maximal decoherence as quantum physicist might say.

   The partitions are not unique and there is large number of partitions involving 3-gons,4-gons, 5-gons. The reason is that one can split from n-gons any n_1-gon with $n_1 < n$ except for $n = 3, 4, 5$.

3. The daydream of non-mathematician not knowing that everything has been very probably done for aeons ago is that one could chose n_1 to be indivisible by 4 and 5, n_2 indivisible by 3 and 5 and n_3 indivisible by 3 and 4 so that one might even hope for having a unique partition. For instance, double modding by 4 and 5 would reduce to double modding of $n_1 \times 3$ giving a non-vanishing result, and one might hope that n_1, n_2 and n_3 could be determined from the double modded values of n_i uniquely. Note that for $n_i \in \{1, 2\}$ the number $n = 24 = 2 \times 3 + 2 \times 4 + 2 \times 5$ playing key role in string model related mathematics is the largest integer having this kind of representation. One should numerically check whether any general orbit characterized by the above formulas contains a point satisfying the additional number theoretic conditions.

   Therefore the task is to find partitions satisfying these indivisibility conditions. It is however reasonable to consider first general partitions.

4. By linearity the task of finding general partitions (forgetting divisibility conditions) is analogous to that of finding of solutions of non-homogenous linear equations. Suppose that one has found a partition

$$n = n_1 \times 3 + n_2 \times 4 + n_3 \times 5 \leftrightarrow (n_1, n_2, n_3) \ . \tag{10.5.1}$$

   This serves as the analog for the special solution of non-homogenous equation. One obtains a general solutions of equation as the sum $(n_1 + k_1, n_2 + k_1, n_3 + k_3)$ of the special solution and general solution of homogenous equation

$$k_1 \times 3 + k_2 \times 4 + k_3 \times 5 = 0 \ . \tag{10.5.2}$$

   This is equation of plane in N^3 - 3-D integer lattice.

   Using $4 = 3 + 1$ and $5 = 3 + 2$ this gives equations

$$k_2 + 2 \times k_3 = 3 \times m \ , \quad k_1 - k_3 + 4 \times m = 0 \ , \quad m = 0, 1, 2, ... \tag{10.5.3}$$

5. There is periodicity of $3 \times 4 \times 5 = 60$. If (k_1, k_2, k_3, m) is allowed deformation, one obtains a new one with same divisibility properties as the original one as $(k_1 + 60, k_2 - 120, k_3 + 60, m)$. If one does not require divisibility properties for all solutions, one obtains much larger set of solutions. For instance $(k_1, k_2, k_3) = m \times (1, -2, 1)$ defines a line in the plane containing the solutions. Also other elementary moves than (1,-2,1) are possible.

   One can identify very simple partitions deserving to be called standard partitions and involve mostly triangles and minimal number of 4- and 5-gons. The physical interpretation is that the coherence is minimal for them since mostly the quantum coherent negentropically entangled units are minimal triangles.

1. One starts from n vertices and constructs n-gon. For number theoretic purposes the shape does not matter and the polygon can be chosen to be convex. One slices from it 3-gons one by one so that eventually one is left with $k \equiv n \mod 3 == 0, 1$ or 2 vertices. For $k = 0$ no further operations are needed. For $k = 1$ *resp.* $k = 2$ one combines one of the triangles and edge associated with 1 *resp.* 2 vertices to 4-gon *resp.* 5-gon and is done. The outcome is one of the partitions

$$n = n_1 \times 3 \ , \quad n = n_1 \times 3 + 4, n = n_1 \times 3 + 5 \tag{10.5.4}$$

These partitions are very simple, and one can easily calculate similar partitions for products and powers. It is easy to write a computer program for the products and powers of integers in terms of these partitions.

2. There is however a uniqueness problem. If n_1 is divisible by 4 or 5 - $n_1 = 4 \times m_1$ or $n_1 = 5 \times m_1$ - one can interpret $n_1 \times 3$ as a collection of m_1 4-gons or 5-gons. Thus the geometric representation of the partition is not unique. Similar uniqueness condition must apply to n_2 and n_3 and is trivially true in above partitions.

   To overcome this problem one can pose a further requirement. If one wants n_1 to be indivisible by 4 and 5 one can transform 2 or or 4 triangles and existing 4-gon or 5-gon or 3 or 6 triangles to 4-gons and 5-gons.

   (a) Suppose $n = n_1 \times 3 + 4$. If n_1 divisible by 4 *resp.* 5 or both, $n_1 - 2$ is not and 4-gon and 2 3-gons can be transformed to 2 5-gons: $(n_1, 1, 0) \to (n_1 - 2, 0, 2)$. If $n_1 - 2$ is divisible by 5, $n_1 - 3$ is not divisible by either 4 or 5 and 3 triangles can be transformed to 4-gon and 5-gon: $(n_1, 1, 0) \to (n_1 - 3, 2, 1)$.

   (b) Suppose $n = n_1 \times 3 + 5$. If n_1 divisible by 4 *resp.* 5 or both, $n_1 - 1$ is not and triangle and 5-gon can be transformed to 2 4-gons: $(n_1, 0, 1) \to (n_1 - 1, 2, 0)$. If $n_1 - 1$ is divisible by 4 or 5, $n_1 - 3$ is not and 3 triangles and 5-gon can be transformed to 2 5-gons and 4-gon: $(n_1, 0, 1) \to (n_1 - 3, 1, 2)$.

   (c) For $n = n_1 \times 3$ divisible by 4 or 5 or both one can remove only $m \times 3$ triangles, $m \in \{1, 2\}$ since only in these case the resulting $m \times 3$ (9 or 18) vertices can partitioned to a union of 4-gon and 5-gon or of 2 4-gons and 2 5-gons: $(n_1, 0, 0) \to (n_1 - 3, 1, 1)$ or $(n_1, 0, 0) \to (n_1 - 6, 2, 2)$.

   These transformations seem to be the minimal transformations allowing to achieve indivisibility by starting from the partition with maximum number of triangles and minimal coherence.

   Some further remarks about the partitions satisfying the divisibility conditions are in order.

1. The multiplication of n with partition (n_1, n_2, n_3) satisfying indivisibility conditions by an integer m not divisible by $k \in \{3, 4, 5\}$ gives integer with partition $m \times (n_1, n_2, n_3)$. Note also that if n is not divisible by $k \in \{3, 4, 5\}$ the powers of n, n^k has partition $n^{k-1} \times (n_1, n_2, n_3)$ and this could help to solve Diophantine equations.

2. Concerning the uniqueness of the partition satisfying the indivisibility conditions, the answer is negative. $8 = 3 + 5 = 4 + 4$ is the simplest counter example. Also the m-multiples of 8 such that m is indivisible by 2,3,4,5 serve as counter examples. 60-periodicity implies that for sufficiently large values of n the indivisibility conditions do not fix the partition uniquely. (n_1, n_2, n_3) can be replaced with $(n_1 + 60 + n_2 - 120, n_3 + 60)$ without affecting divisibility properties.

3. Intriguing observations related to 60-periodicity

60-periodicity seems to have deep connections with both music consciousness and genetic code if the TGD inspired model of genetic code is taken seriously code [K80] [L18].

1. The TGD inspired model for musical harmony and genetic involves icosahedron with 20 triangular faces and tetrahedron with 4 triangular faces. The 12 vertices of icosahedron correspond to the 12 notes. The model leads to the number 60. One can say that there are 60 +4 DNA codons and each 20 codon group is 60=20+20+20 corresponds to a subset of aminoacids and 20 DNAs assignable to the triangles of icosahedron and representing also 3-chords of the associated harmony. The remaining 4 DNAs are associated with tetrahedron.

   Geometrically the identification of harmonies is reduced to the construction of Hamiltonian cycles - closed isometrically non-equivalent non-self-intersecting paths at icosahedron going through all 12 vertices. The symmetries of the Hamiltonian cycles defined by subgroups of the icosahedral isometry group provide a classification of harmonies and suggest that also genetic code carries additional information assignable to what I call bio-harmony perhaps related to the expression of emotions - even at the level of biomolecules - in terms of "music" defined as sequences 3-chords realized in terms of triplets of dark photons (or notes) in 1-1 correspondence with DNA codons in given harmony.

2. Also the structure of time units and angle units involves number 60. Hour consists of 60 minutes, which consists of 60 seconds. Could this accident somehow reflect fundamental aspects of cognition? Could we be performing sub-conscious additive arithmetics using partitions of n-gons? Could it be possible to "see" the partitions if they correspond to NE?

4. Could additive primes be useful in Diophantine mathematics?

The natural question is whether it could be number theoretically practical to use "additive primes" $\{3, 4, 5\}$ in the construction of natural numbers $n \geq 3$ rather than number 1 and successor axiom. This might even provide a practical tool for solving Diophantine equations (it might well be that mathematicians have long ago discovered the additive primes).

The most famous Diophantine equation is $x^n + y^n = z^n$ and Fermat's theorem - proved by Wiles - states that for $n > 2$ it has no solutions. Non-mathematician can naïvely ask whether the proposed partition to additive primes could provide an elementary proof for Fermat's theorem and continue to test the patience of a real mathematician by wondering whether the parition for a sum of powers $n > 2$ could be always different from that for single power $n > 2$ perhaps because of some other constraints on the integers involved?

5. Could one identify quantum physical correlates for arithmetic consciousness?

Even animals and idiot savants can do arithmetics. How this is possible? Could one imagine physical correlates for arithmetic consciousness for which product and addition are the fundamental aspects? Is elementary arithmetic cognition universal and analogous to direct sensory experience. Could it reduce at quantum level to a kind of quantum measurement process quite generally giving rise to mental images as outcomes of quantum measurement by repeated state function reduction lasting as long as the corresponding sub-self (mental image) lives?

Consider a partition of integer to a product of primes first. I have proposed a general model for how partition of integer to primes could be experienced directly [L30]. For negentropically entangled state with maximal possible negentropy having entanglement probabilities $p_i = 1/N$, the negentropic primes are factors of N and they could be directly "seen" as negentropic p-adic factors in the adelic decomposition (reals and extensions of various p-adic number fields defined by extension of rationals defined the factors of adele and space-time surfaces as preferred extremals of Kähler action decompose to real and p-adic sectors).

What about additive arithmetics?

1. The physical motivation for n-gons is provided symplectic QFT [K20, K104], which is one aspect of TGD forced by super symplectic conformal invariance having structure of conformal symmetry. Symplectic QFT would be analogous to conformal QFT. The key challenge is to identify symplectic invariants on which the positive and negative energy parts of zero energy states can depend. The magnetic flux through a given area of 2-surface is key invariant of this kind. String world sheet and partonic 2-surfaces are possible identifications for the surface containing the polygon.

Both the Kähler form associated with the light-cone boundary, which is metrically sphere with constant radius r_M (defining light-like radial coordinate) and the induced Kähler form of CP_2 define these kind of fluxes.

2. One can assign fluxes with string world sheets. In this case one has analog of magnetic flux but over a surface with metric signature (1,-1). Fluxes can be also assigned as magnetic fluxes with partonic 2-surfaces at which fundamental fermions can be said to reside. n fermions defining the vertices at partonic 2-surface define naturally an n-gon or several of them. The interpretation would be as Abelian Wilson loop or equvalently non-integrable phase factor.

3. The polygons are not completely unique but this reflect the possibility of several physical states. n-gon could correspond to NE. The imaginary exponent of Kähler magnetic flux Φ through n-gon is symplectic invariant defining a non-integrable phase factor and defines a multiplicative factor of wave function. When the state decomposes to several polygons, one can uniquely identify the interior of the polygon and thus also the non-integrable phase factor.

   There is however non-uniqueness, when one has only single n-gon since also the complement of n-gon at partonic 2-surface containing now now polygons defines n-gon and the corresponding flux is $\Phi_{tot} - \Phi$. The flux Φ_{tot} is quantized and equal to the integer valued magnetic charge times 2π. The total flux disappears in the imaginary exponent and the non-integrable phase factor for the complementary polygon reduces to complex conjugate of that for polygon. Uniqueness allows only the cosine for an integer multiple of the flux.

   The non-integrable phase factor assignable to fermionic polygon would give rise to a correlation between fermions in zero modes invariant under symplectic group. The correlations defined by the n-gons at partonic 2-surfaces would be analogous to that in momentum space implied by the momentum conservation forcing the momenta to form a closed polygon but having totally different origin.

Could it be that the wave functions representing collections of n-gons representing partition of integer to a sum could be experienced directly by people capable of perplexing mathematical feats. The partition to a sum would correspond to a geometric partition of polygon representing partition of positive integer $n \geq 3$ to a sum of integers. Quantum physically it would correspond to NE as a representation of integer.

This might explain number theoretic miracles related to addition of integers in terms of direct "seeing". The arithmetic feats could be dynamical quantum processes in which polygons would decompose to smaller polygons, which would be directly "seen". This would require at least two representations: the original polygon and the decomposed polygon resulting in the state function reduction to the opposite boundary of CD. An ensemble of arithmetic sub-selves would seem to be needed. NMP does not seem to favour this kind of partition since negentropy is reduced but if its time reversal occurs in geometric time direction opposite to that of self it might look like partition for the self having sub-self as mental image.

10.6 Holographic Brain And Quantum TGD

Brain as a hologram paradigm states that one cannot locate the information in brain in any specific region. There is indeed considerable empirical support for this hypothesis [J119, J96, J95].

10.6.1 Evidence For Holographic Brain

The first empirical motivations for holographic brain came from the experiments of Lashley [J96] with rats. Psychologist Karl Lashley started 1920 lifelong study of the effect of brain vaults in memory. Lashley studied the behaviour of rats in mazes and found that the reduction of the brain tissue did not destroy the visual memory of rats totally, only the intensity of the memory was weakened. This led to the introduction of the terms mass action and equi-potentiality. Mass action says that the intensity of the memory depends on the amount of the brain tissue present and equi-potentiality says that each neuron carries the memory traces. The experiments of Lashley lead to the idea that the memory storage mechanism in brain is non-local and hologram like.

In 1948 physicists Dennis Gabor discovered the idea of optical hologram and within twenty years the same principles had been applied to brain. What hologram stores is the information about both amplitude and phase of incoming light wave, quantum mechanically identifiable as the order parameter characterizing coherent light. What makes holographic information storage so attractive is its extreme robustness and flexibility: a small piece of hologram carries same information as entire hologram, albeit in blurred form. Philip Westlake [J124] was one of the first mathematicians to argue that hologram priciple matches with what brain does with the information. Karl Pribram [J95] and colleagues have done a lot of experimental work with monkeys using the holographic theory to see in detail how the theory makes it possible for brains to remember. The book "Shuffle brain" [J119] popularizes in an enjoyable manner the idea of holographic brain and the work Pietch with salamanders. The experimental work of Pietch provides rather convincing experimental support for the idea of holographic data storage [J119] . The experiments of Pietch with salamanders involved the cutting the brain of the salamander to pieces, shuffling the pieces randomly and putting them back together: no detectable changes in the behaviour of salamander occurred as a result of this operation! It is hard to imagine a computer which would function after this kind of treatment.

Holographic data storage is extremely flexible and stable. Since brains have developed in jungle rather than in safe computer laboratory, these properties make the idea of holographic brain much more attractive than the paradigm of computer brain. Also transformations between sensory modalities are easily realized. For instance, acoustic holograms can be transformed to optic holograms. One can however also invent objections against holographic data and memory storage.

1. The creation of hologram is based on the interference of a reference beam of light with the beam of light reflected from the object. The reading of the hologram is done by using reference beam to regenerate the original picture. It is however not clear whether this kind of mechanism is possible to realize at the level of brain. Furthermore, in reality it is the real beam which stimulates memory recall rather than the hypothetical reference beam! It seems that comparison of reference pattern representing the expected experience with input is what happens in brain rather than illumination of holograms.

2. In order to have holographic memory, it should be possible to code very many holograms simultaneously to single hologram. Multiple holograms are indeed possible [J119]. One must however admit that the idea about storing large number of temporal events to same multiple hologram does not look very attractive. The identification of the long term memory as geometric memory solves these problems in TGD framework so that hologram idea could survive as a a restricted principle determining how the experience is generated.

3. The structure of the human brain suggests that data representation is not completely hologram like. For instance, the various phonemes are recognized by well defined regions located in linguistic areas of the brain like potatoes in the field. The differences between right and left brain are a challenge for the hologram idea in its simplest form. One must however notice that it is brain functions that are localized whereas data storage could quite well be hologram like. Of course, it could quite well be that brain decomposes into regions in which data represented as a hologram is different: for instance, different sensory modalities seem to use different regions of brain. In particular, the existence of various sensory homunculi in brain is consistent with the holographic data representation.

10.6.2   Three Explanations For The Hologram Like Properties Of Brain

The fact is that brain seems to be extremely flexible and this does not fit nicely with the idea that brain is some kind of extremely complicated electronic circuit. Hologram like data storage in which each neuron is like a part of hologram provides only one explanation for the empirical data. The common feature of TGD based explanations is that conscious experience is not so strongly dependent on the neurophysiogical state of the neural substrate as the vision about brain as a computer would suggest.

1. Quantum self-organization implies that systems self-organize to dynamical patterns which do not depend very much on the initial state. For sufficiently simple brains, whose presence

is not absolutely crucial for the "household" activities of the organism, this could be all that is needed. For instance, the ability of a lizard to generate a new head supports this view. Salamanders are simple creatures and the mere quantum self-organization without recourse to hologram memory could explain the results of the experiments of Pietch.

2. TGD based model of conscious brain relies on self hierarchy realized in terms of various Josephson currents forming a master-slave hierarchy. Josephson currents do not depend very strongly on the material substrate of brain. Josephson currents and associated supra currents allow also basic wave like phenomena like interference crucial for hologram model. Comparison circuits formed by weakly coupled super conductors and constructive interference of Josephson currents provide a quantum model of brain which resembles hologram model but also differs from it in certain crucial aspects. In particular, reference ray is replaced by reference current representing expected experience. Also comparison circuits in which parallel supra currents of same intensity flow in coupled superconductors, are possible. In this case large Josephson net current is generated by constructive interference of Josephson currents when the phases of supra currents differ by a constant phase.

3. It might be that brain is indeed hologram like in some sense although reference rays are probably not involved. In TGD framework it seems to be possible to abstract from the hologram idea its essentials, namely the fact that a piece of hologram is like a small window. This makes it possible to circumvent the most obvious objections against the idea.

   i) The essential feature of the hologram is that a small piece of a hologram acts like a window. The visual experience is not changed much even when one perceives through a small window. Hence one could give up the assumption that brain prepares holograms. Rather, one could consider the possibility that neurons see part of the same sensory scene through neuronal windows. Seing would be made possible by some field like quantity whose values would be determined by its sources in the same non-local manner as electromagnetic field is determined by its sources. Sources could be either objects of the external world or of model world generated by sensory experience, consisting perhaps of mind-like space-time sheets. Massless fields are especially attractive alternative since the form of the wave is preserved during propagation. Hence coherent photons generated by so called massless extremals [K68] assumed to be associated with the linear structures like microtubules contained inside every axon, are especially promising as a tool of neuronal vision.

   ii) TGD framework provides extremely general mechanisms of subjective and geometric memory corresponding to actual memories and expectations for what will happen and possibly happened. In principle it is possible to avoid memory storage completely. The experiments of Lashley could be understood by assuming only that the sensory data are experienced through neuronal windows. Thus there is no need to store memories in multiple holograms and even holograms are un-necessary. All boils down to the idea of neural window and TGD based quantum model of memory.

   iii) The existence of sensory homunculi is not in conflict with the holographic data representation. What happens is that single neuron sees part of the perceptive landscape through a window. Each neuron could be specialized to particular task, such as recognizing whether particular feature is present in the sensory landscape. This would involve simple comparison circuit making possible feature recognition perhaps involving neuronal wake-up. Feature recognition could rely basically on the generalization of Haken's theory [K87].

10.6.3   From Holographic Brain To Neuronal Window?

The notion of neural window

All sensory experiences should reduce to representations generated by zero modes, in particular zero modes characterizing classical Kähler field, which can reduce to pure electromagnetic (vision?) or Z^0 field (auditory experience?). If the primary or secondary stimuli generate Kähler electric fields proportional to the gradient of the intensity one can understand the generation of the objects of the perceptive field. If the gradient is strong, as it is on the boundary of the image of the object, the conservation of the Kähler electric flux forces the generation of mind-like space-time sheet at which

part of the flux goes. Thus secondary sensory organ would automatically create representation for the objects of the perceptive field as mind-like space-time sheets, which in turn could give rise to selves representing objects of the perceptive field as mental images.

The idea that parts of brain automatically form a model for the objects of the external world as mind-like space-time sheets suggests an interesting connection with the holographic model of brain [J119] and with micro-tubules as quantum antenna hypothesis [K68].

1. If mind-like space-time sheets are massless extremals, they act as quantum antennae and generate coherent photons. Axons contain microtubules and this leads to ask whether these axons could serve as wave guides for the coherent light generated by the mind-like space-time sheets representing the objects of the external world. Also the vacuum currents associated with these microtubular massless extremals could code the intensity of the coherent light emitted by the mind-like space-time sheets. If either of these guesses is correct, axons provide neurons with a direct sensory window to the representation of the external world formed by the mind-like space-time sheets residing at sensory organs. Coherent photons would also give rise to neuronal lingua franca realized as a direct neuronal/microtubular vision.

2. Sensory window would be in question in a rather literal sense. The fact that a piece of hologram provides the representation given by the entire hologram, albeit in a somewhat blurred form, is essentially equivalent with the possibility to see through a small window. Therefore the idea about neuronal window is in accord with the holographic model of brain [J119, J95], which is based on the idea that all neurons receive more or less the same sensory input, analogous to the visual experience generated by a piece of hologram. Clearly, coherent photons would serve as kind of mass media at the level of brain.

3. What is interesting is that the decomposition of the neuronal vision to a large number of different views represented by small groups of light sensitive neurons could even help to build monocular stereoscopic vision since much more information would be used about the visual field.

4. Music metaphor provides a considerable restriction to the neuronal window idea. The Bose-Einstein condensed photons should correspond to single frequency equal to some cyclotron frequency. Thus it would seem that the sensory input of single neutron is yes/no type. The neuronal window however makes however still sense for neuronal groups: in this case the input would be determined by light and dark pixels. Various nuclei or brain could thus have neuronal windows to cortex and other nuclei of brain.

Neural window and imagery

Mental imagery is something which is difficult to understand in the framework of the standard neuro science. There are empirical results suggesting that mental images correspond to patterns of activity inside cortex, which are three-dimensional and continuous so that neural activation provides a concrete recognizable image about object [J140]. Rather remarkably, also imaginative thought resembles very much visual imagery as is clear from the fact that language is full of visual metaphors [J140]. It is also known that imagery uses same regions of cortex as real sensory experience and the problem is to understand why there is genuine sensory experience involved with imagery.

In the framework of the standard neuroscience the obvious question is why the pattern of the imagery activity is not accompanied by a direct sensory experience. Also the boundary between direct sensory experience and imagination is sometimes problematic: for instance, in the state between sleep and awake, sensory images often enter into mind. During dreams one can have sensory images and eidetic memory is essentially sensory memory. I have a personal experience about extended state of consciousness, or rather whole-body consciousness (this experience actually made me consciousness theoretician!). During this state I could see my thoughts as vivid visual images and had also peculiar odour and taste experiences also reported to occur during mystic experiences. Could the correct interpretation be that thalamus, cortex and sensory organs temporarily formed a larger self during this experience?

If one accepts that sensory qualia are at the level of sensory organs and neural activity only builds symbolic and cognitive representations, it is easy to understand the difference between

imagination and sensory perception. Sensory imagination is sensory perception without sensory qualia. Quantum entanglement between sensory organs and cortex and TGD based view about long term memory resolves the obvious objections against this view.

This does not exlude the possibility that neurons have chemical senses and even see and hear. Neurons would not only contribute to our experience. Neurons able to perceive sensorily would be probably much more effective information processors than neurons which are blind and deaf. Therefore the notion of neuronal window could be useful metaphor in the modelling the neuronal basis of the mental imagery. For instance, the understanding of processes like rotation of an imagined object of visual field provides an exciting challenge. The rotation of mind-like space-time sheet should induce the rotation of the region containing nerve pulse activity. Neuronal window idea suggest that the imagined rotation of the object involves virtual sensory experience generated in the somatosensory- auditory-visual association region of the neocortex (note that only humans have these association regions). This region would be able to form representations of the basic objects of the perceptive field and manipulate them. The imagined rotation of the object could occur here and would be observed by the primary sensory regions.

Sensory perceptions involve a lot of computation like processing at the level of cortex (consider stereo vision as an example), which can be naturally identified as imagination yielding successive models for the external world as consisting of familiar objects. Both the imagined world represented by the mind-like space-time sheets inside cortex and the mind-like space-time sheets in the sensory organ could be seen by the secondary sensory organs in thalamus and compared to see whether the imagined world yields the same sensory input as the real world. The result of the comparison would be fed back to cortex as a nerve pulse pattern serving as a feedback modifying the model.

Neuronal window and blind sight

The phenomenon of blind sight [J141] suggests that there is kind of a Zombi within us [J26], which can see but that this vision does not give rise to a conscious vision. Typically persons who have blind sight can grasp the object of the visual field once they have been told that it contains the object. The Zombi within us seems to be much more rapid and reliable than the conscious "I" in its responses but it seems to be much less flexible. It also seems that Zombi within us cannot be cheated by illusions unlike conscious "I", which suggests that much less theorizing and pattern recognition is involved. Rapid responses of Zombies within us are certainly consistent with the fact that cortical processing is not involved. Non-flexibility would be the price paid for the reliability and absence of higher level cognitive processing.

One can imagine many models for Zombi within us and probably there are many of them (and they are actually not Zombies at all!).

1. Thalamus projects sensory data to amygdala which is often called brain inside brain, or emotional brain. Amygdala would thus have neuronal window to thalamus and could give rise to unconscious-to-us mental activity responsible also for the blind sight. Also the sensory perception at the level of retinae might be enough if one assumes that primary sensory qualia are at the level of sensory organs.

2. Formation of the symbolic representations for the objects of the perceptive field could occur also in the thalamic nuclei.

3. The decomposition of the perceptive field to objects could occur for the first time already at the level of retina and the coherent light from the mind-like space-time sheets provides a representation of the visual field seen by neurons of thalamus, whose regions serve as secondary secondary organs identifiable Zombies within us (Zombies only from our view point!).

10.6.4 Possible Evidence For The Neuronal Window Idea

To find whether the neuronal window based on coherent light hypothesis could make sense, it would be important to eliminate the effects of the higher level information processing. This requires the study of simple organisms having primitive sense of vision. There is indeed experimental support

for identifying the coherent states of photons as associated with vision. It is known that some mono-cellulars possess elementary vision based on the microtubules [I39]. The emergence of the multi-cellulars during the Cambrian explosion was preceded by the appearance of the microtubules. If the emergence of the microtubules meant the emergence of the visual consciousness in the length scale of the cell, then the formation of the multi-cellulars as cell societies can be understood as a natural consequence.

The length distribution of the microtubules in the rods and cones of the eye is concentrated in the region of the visible wavelengths. The coherent light in question could be identifiable as bio-photons of Popp [I59]. The architecture of retina is "wrong" from the engineering point of view. The ganglial axons feeding sensory input to brain are in front of the retina. This is in accordance with the TGD based model of vision in which the photons of incoming light Bose-Einstein condense on the ganglial axons and amplify the signal to the thalamus.

A further piece of evidence comes from the work of Callahan about the sense of smell of insects [I62]. Many insects, such as moths and ants, are known to be attracted by light, say candles and electric lamps and Callahan took as his challenge to understand what is involved. Callahan discovered that insect's olfaction is not based on chemistry (alone) but to a maser like emission of infrared light generated by various molecules such as pheromones, scent molecules and many other biomolecules. Insects see rather than smell the sources of the infrared light. The sensillae of the insects serve as receiving antennas and amplify the incoming infrared radiation. Callahan also observed that the oscillation of insect antennae induce maser like emission from scent/etc. molecules by creating an oscillating emf. Thus sensory experiencing seems to involve active participation from the part of insect. In any case, the results of Callahan suggest that coherent light could be important also in our neuronal sensory experiencing.

The infrared light emissions from pheromones mediate sexual messages in case of insects. Quite remarkably, pheromones are known to mediate sexual and social signals also in case of many mammals. For instance, certain chemical messages from a female mouse can make male mouse to mate immediately while certain chemical messages from other males make him agressive. Many mammals, for instance rodents, are known to possess vomeronasal organs, small cigar like sacks containing neurons and having length of order few millimeters [J3], giving rise to an accessory olfactory system, which is known to have much more primitive structure and to work in different way than the ordinary olfactory system. It is also known that this systems bypasses cerebral cortex in rodents. There is evidence that even humans have the ability to sniff certain chemicals mediating social and sexual signals without being aware of it and there is already now an entire perfume industry based on this evidence. The chemicals giving rise to sexual attraction are probably pheromones. The fact that pheromones mediate sexual signals in case of both insects and mammals, is hardly an accident and suggests that the sensory mechanism must be the same and be based on the infrared emissions by pheromones. If the response is at neuronal level and if the cortex is not involved, one could understand why these messages are not experienced consciously. One could test this hypothesis by finding whether coherent infrared radiation at frequencies emitted by pheromones can affect the behaviour of higher mammals including humans.

There is a further peculiar co-incidence: the cascade of transduction events occurring in the absorption of photon in retina is repeated in a remarkably similar way in olfactory receptor cells, which respond to odours whereas the receptor cells that respond to sound use a very different system [J3]. Could this mean that also the experience of odour primarily involves the detection of (also) infrared light so that humans would not basically differ from insects or that olfactory system has evolved from the receptor neurons originally sensing infrared light? This would conform with the idea that the Kähler field generated in ear corresponds to classical Z^0 field, which does not generate coherent photons but couples with neutrinos. One must however notice that the resemblances between visual and linguistic imagery suggest that some part of ear generates cognitive representation based on coherent light and experienced by the secondary sensory organs in the thalamus.

10.6.5 Massless Extremals As Quantum Holograms

It took long time to really understand what MEs really and along with this understanding came the vision about precisely how MEs could act as holograms and what biological functions these holograms could correspond to. It indeed seems that massless extremals (MEs) are perhaps the

most fundamental solutions of the field equations as far as TGD inspired theory of consciousness is considered. What is important is that MEs play both the roles of quantum gravitational holograms [B8] and dynamical holograms [B13].

The hologram principle of quantum gravitational theories roughly states that the quantum theory in space-time with boundary reduces to a conformal quantum field theory at the boundary. If Kähler action were deterministic, precisely this would happen. The construction of the WCW geometry relies crucially on the assumption that the complications due to the non-determinism of Kähler action do not radically modify the picture resulting assuming complete determinism.

It has indeed turned out that the basic construction in which everything to the light-like boundary of M^4_+ (moment of big bang) acting as a hologram in quantum gravitational sense and defining conformal quantum theory, generalizes. The basic construction survives as a template of a more general construction in which also the light-like boundaries of MEs having always light-like M^4_+ projection are taken into account besides δM^4_+ as surfaces at which initial values can be prescribed arbitrarily. This brings in also time effectively absent in a strictly deterministic theory. The quantum gravitational hologram defined by δM^4_+ is replaced by a fractal structure formed by δM^4_+ and Russian doll hierarchy of the light-like boundaries of MEs inside MEs. The super-symplectic and superconformal invariances of the light-like boundaries generalize in an elegant manner on basis of the basic properties of MEs.

There are good reasons to expect that the light-like selves defined by the boundaries of MEs are fundamental in TGD inspired theory of consciousness. The super-symplectic quantum states associated with the light-like boundaries are genuine quantum gravitational states defined by WCW spinor fields, whose dependence on configuration space fiber degrees of freedom does not reduce to mere vacuum functional, and therefore do not possess any quantum field theoretic counterparts. They are state functionals in the world of worlds, so to say, and therefore should represent highest level in the hierarchy of quantum control in living systems.

MEs carry light-like vacuum currents. In passive state these currents are Z^0 currents whereas in active state, obtained by a color $SU(3)$ rotation, the current is electromagnetic and generates coherent state of photons. One can say that the light-like current provides a dynamical variant of the diffraction grating defined by the ordinary static hologram. This leads to a model of living matter in which the coherent states of ordinary photons and colored WCW photons act as control commands. Their phase conjugates (time reversals) in turn correspond to the time reversed commands. What is especially beautiful is that simple reference wave can activate arbitrarily complex hologram acting as a control command. This provides new visions about healing by time reversed reference waves forcing the biological program responsible for an illness like cancer to run backwards in time. One can also construct a general theory of sensory representations based on MEs [K83]. To sum up, it seems that the hologram principle is they key element of brain and biological functioning but in a sense somewhat different from what it was believed to be by the pioneers.

10.6.6 The Notion Of Conscious Hologram

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

The notion of conscious hologram combines the saint and sinner aspects of consciousness to single concept: macrotemporal quantum coherence due to the generation of bound state entanglement and giving rise to co-operation on one hand, and the dissipative self-organization giving rise to Darwinian selection and competition on the other hand.

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

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

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

The 3-D vision associated with ordinary holograms generalizes to stereo consciousness resulting in the fusion of mental images associated with the points of conscious hologram [K15].

10.7 Four-Dimensional Fractal Brain As An Associative Net

The identification of brain as 4-dimensional fractal associative net seems to provide a promising paradigm for the understanding of brain functioning. The associative net structure and mere real physics considerations are certainly not all that is needed. p-Adic physics as physics of cognition means that fundamental cognitive representations correspond to p-adic space-time regions, and, needless to say, in this respect huge amount of work remains to be done in order to build connections between theory and observations. In the following only the real physics aspects of brain as an associative net are considered.

10.7.1 Brain As An Associative Net

The notion of associative net suggests a general paradigm making it possible to understand brain functioning. The subjective time development of an associative net consists of experiences representing associations $A \rightarrow B$. In case of brain associative net is a network of neurons. "A$\rightarrow$ B" association is made possible because the emission of synaptic vesicles implies that postsynaptic and presynaptic neuronal space-time sheets form a connected space-time sheet. A is represented by the various presynaptic inputs and B corresponds to the output of the postsynaptic neuron. A and B can correspond to various sensory qualia or Boolean statements represented in terms of memes which in turn decompose into sequences of codons consisting of 126 binary digits and represented in terms of cognitive neutrino-antineutrino sequences. Memetic codons could also have interpretation as binary representations of integers providing quantitative measures for qualities. In Boolean case associations are experienced as logical implications "If A then B" is true. A and B can represented arbitrarily complicated statements composed of elementary statements. Neuron receives the conclusions of postsynaptic neuron as premises and feeds its own conclusion as premises to its own postsynaptic neuron.

Self-organization by quantum jumps selects gradually the allowed "$A \rightarrow B$" correspondences as asymptotic self- organization patterns. Quantum self-organization and quantum statistical determinism suggest a natural Darwinian selection of the memes caused by the dissipation inside self and completely analogous to protein folding. The correspondences $A \rightarrow B$ would be determined by chemical macro variables characterizing the state of the neuron and chemical transmitters would play a crucial part in the learning of the responses. Synchronization is necessary for the function of the network. Emotional control can modify the associations "A$\rightarrow$ B" in long time

scale (conditioning and de-sensitization): for instance, some conditions belonging to premises A of Boolean association drop away or B can change.

10.7.2   4-Dimensional Fractal Brain

One needs two additional principles in order to have vision about brain a la TGD.

1. Brain is 4-dimensional in well-defined and very restricted sense. This follows from the classical non-determinism of Kähler action. Self-organization by quantum jumps replaces the classical space-time surface repeatedly with a new one and the final result represents classically the activity as it would be detected by a completely mechanical instrument. One can say that the classical time development describing say sensory experience, long term memory, motor activity or logical thought is gradually refined by starting from a rough sketch and making successively finer corrections iteratively. The process is like making a painting stating from a rough sketch. The four-dimensionality of the brain and difference between subjective and geometric time is absolutely essential element.

2. Fractality is second element. The successive refinement process proceeds from long to short time and spatial length scales. Thus large and slow neural circuits correspond to rough sketches and small and rapid circuits to small details. Small circuits are simultaneously active (in sense of subjective time) in the entire space-time region defining the duration of the activity. Thus again the 4-dimensionality of brain is crucial.

The notion of associative net suggests a very general view about how brain functions and gives rise to conscious experiences. Brain itself is a huge associative circuit but decomposes into more or less autonomous subcircuits.

10.7.3   Sensory Experiences, Logical Thinking, Associations And Simulations

The notion of associative net allows readily to understand what happens in sensory experiencing, logical thinking, formation of associations and imagination

1. Sensory representations are formed by an iterative process involving comparison which takes also care about the computation of unknown data such as distances of the objects of the perceptive field. For instance, various cortico-thalamic loops could be related this process. The updating of the zero modes of the sensory inputs from sensory organs is performed in the thalamic neurons receiving real sensory input from the sensory organ and expected sensory input from cortex. An automatic comparison process possibly realized at quantum level in terms of two weakly coupled super conductors is in question [K72, K71]. This process involves also the concentration of attention to specific features of the sensory experience.

2. Neuronal input represents in general case several sensory modalities and conscious output single sensory modality or "Boolean quale" represented by memetic codon. Thus associative circuits can represent the formation of associations in associative regions of brain. Note however that pre- and postsynaptic neurons in principle represent always an association at the neural level and neuronal associations are basic building blocks of "our" associations involving entire groups of neurons and entire neural circuits. Also the formation of associations is very probably an iterative process.

3. The circuits of the associative net provide an ideal realization for predictive simulations of type $A \to B \to ....$ in terms of various kinds of sensory qualia. This makes possible imagination. The difference with respect to the standard neural net is that conscious neuron represents some sensory modality or Boolean modality: this makes the simulation "real" and assigns meaning to nerve pulse patterns: note that the generation of meaning is basic problem of the neural net models of consciousness. This kind of simulation circuits are expected to be related with frontal lobes and to be crucial for the planning of the future activities. Motor circuit involving basal ganglia, thalamus and prefrontal cortex is also a possible example of this kind of circuit. Again iteration bringing in more and more details to the motor plan is involved.

4. Logical deductions do not differ from simulation in an essential manner: the only difference is the replacement of the temporal causation by logical causations. In case of logical deductions premises and conclusions are coded to memetic codons represented by cognitive neutrino pairs. Much of our logical thinking might be actually habitual and almost deterministic deduction sequences associated with circular loops and unconscious to us. Logical consistency is thus not guaranteed and, unless the brain of a ideal mathematician is not in question, and results only from the logical consistency of the external world.

10.7.4 Formation Of Long Term Memories

Associative circuit give rise to learning of long term memories. Short term memories correspond to reverberating nerve pulse patterns in closed circuits giving rise to a repetition of the same component of experience again and again. In Boolean case periodic association sequences represented by closed loops $A \rightarrow B \rightarrow ...A$ correspond to tautologies. Reverberating memories are remembered with high probability if long term memories are realized as geometric memories. The reason is that there is high probability for a randomly generated cognitive space-time sheet in geometric past to reside on the region occupied by a reverberating loop. Repetition is the manner to learn. It is rather plausible that Nature has discovered effective learning in this manner and there are indeed circuits associated with long term learning.

   A quite recent finding in neuroscience is that during the learning of spatial tasks hippocampus and some other parts of brain generate long spike sequences. Typical interval between spikes varies between 1-2 milliseconds. This would mean that a sequence of 126 spikes would correspond to.1-.25 seconds which is of the same order of magnitude as the duration of our self identified as the duration of immediate sensory memory. Also long term memories are constructed as kind of artworks or charicatures.

10.7.5 Planning And Realization Of Motor Programs

Associative circuits are associated with planning and realization of the motor programs.

1. Motor activity is the reverse of sensory experiencing in a well-defined sense. The imagined motion of the object in the working memory representing perceptive field is transformed to the motion of the real world counterpart of the object so that motor organs are like puppets bound to axonal strings and moved by the little man in the brain. The perceptive field, where imagined motion occurs is located in the frontal cortex with primary motor cortex excluded. Several copies of the perceptive field providing different representation of the perceptive field are probably involved as "working memories". These working memories are formed by topographical maps between different parts of brain.

2. Planning of the motor action is almost motor action: the only difference is that the last stage when nerve pulse patterns characterizing the motion are fed to motor organs is not performed. Plan is essentially four-dimensional pattern of nerve pulse activity.

3. The ability to realize plan seems to require that it is memorized: this would require that the performance of the motor activity is repeatedly imagined and finally allowed to occur. Thus the nerve pulse activity representing plan becomes a periodical nerve pulse pattern and the actual motion starts when the coupling to primary organs is turned on. As a matter fact, 4-dimensional brain allows to give up the assumption about reverberation. Also the activation of a motor plan in the geometric past could be possible! This would be consistent with the results of the experiments of Libet about active aspects of consciousness: what was observed that neural activity started before the conscious decision to raise index finger. The relevant time scale would be of the order of second. Of course, an interesting question is whether adult person could initiate in the geometric childhood a motor action affecting dramatically the geometric present, say leading to traffic accident! This possibility would seem to lead to paradoxal looking consequences.

4. Learning of a motor skill presumably means that motor plans very rapidly self-organize to their final shapes. Learned skills correspond to motor plans which are winners in the Darwinian selection associated with self-organization.

5. The realization of the motor plan requires initial value sensitivity and muscles indeed provide an excellent example of an initial value sensitive system in which single nerve pulse generates macroscopic motion.

Motor action is planned and performed as a four-dimensional pattern. Construction of the motor plan means that *four-dimensional* virtual perceptive landscape is gradually deformed into the desired shape. Motor activity can be seen as a fractal top-down process analogous to the construction of a space-time fractal: fractal classical determinism of Kähler action is absolutely crucial for this and $1/f$ noise [K71] is one of the consequences of the fractality. The non-determinism of the p-adic differential equations is very probably a direct correlate of the classical non-determinism of the Kähler action.

Macroscopic motor activity starts from a rough 4-dimensional sketch of motion which is gradually refined to the final artwork and possibly memorized to represent a reverberating structure. The sketch and its various refinements are represented at the virtual perceptive landscape of the premotor cortex. More concretely:

1. First a large quantum jump realizing in rough sense the motor action occurs (for instance, hand grasps the object): this corresponds to certain classical time development starting in geometric past on new space-time surface. This stage corresponds to the activation of slow and large neural circuits with time scale characterizing the entire motion. This is like construction of the first sketch of a 4-dimensional fractal representing motor plan.

2. After this a cascade of smaller scale quantum jumps adding details to the motor plan occur: this is like adding further details to a four-dimensional fractal. The neural circuits involved are smaller and faster. Addition of details takes places in the entire time interval T of the geometric time associated with the full motion. This involves multitime moments of consciousness so that also neural circuits are active in the geometric interval defined by T.

10.7.6 Language

Memetic codons represented as temporal sequences of 126 binary digits should be the basic building blocks of the linguistic consciousness. The value of single binary digit is represented at the neural level by the presence/absence of nerve pulse and at the level of cognitive consciousness by the direction of the spin of the cognitive antineutrino. Boolean interpretation is not necessary: the interpretation of the sequences of 126 bit as integers providing quantitative measures for, say the intensities of the sensory experiences, is also possible. The proposed quantum models for the quantum correlate of hearing and for Boolean mind [K64, K39, K41] suggest that sound frequencies are mapped to Z^0 magnetic cyclotron frequencies of ions whereas thinking corresponds to Z^0 magnetic cyclotron frequency which is above the range of the audible sound frequencies. This supports the idea that memetic codons are as such experienced as some kind of internal speech and also that only certain brain regions allow Boolean mind: the generation of cognitive neutrino pairs indeed requires strong axonal Z^0 magnetic fields which could be present only in the postsynaptic axons of the associative regions of cortex.

The differences between right and left brain suggest that the output axons in the associative regions of left brain represent information using cognitive neutrino pairs whereas the corresponding axons in the right brain hemisphere could represent information in terms of Z^0 cyclotron frequency varying above the audible frequency range (left brain talks and right brain sings!). If audible frequencies are involved, Josephson frequencies must be sufficiently far from cyclotron frequencies so that right brain imagines of hearing the thoughts rather than actually hears them. Unless higher harmonics of the cyclotron frequency are used (which is quite possible!), this requires parallel mode of representation since music metaphor suggests that the Z^0 cyclotron frequency of the axon is not variable.

Language circuits would be involved with the translation of the Boolean statements to linguistic expressions coded eventually to motor activities yielding speech. This process is only special case of a motor activity and thought as an internal speech is like a motor plan. Language represents one possible realization of the memetic code analogous to the translation of DNA sequences to proteins. It is instructive to look what contraints the memetic code poses on the general structure of language. The first empirical fact is that the meaning of the linguistic experience is insensitive

to the local variations in the speed of speech. In particular, the repetition of a phoneme is usually interpreted as providing no additional purely linguistic information. On the other hand, the linguistic meaning of speech is determined by its purely local structure.

These facts are consistent with the hypothesis that phonemes are the basic codons of speech having fixed duration and that a repeated phoneme has the same linguistic meaning as single phoneme. This supports the identification of the phonemes as representations of the memetic codons: phoneme would thus represent single linguistic sub-self. By the previous estimate the duration of the memetic codon should have duration in the range $.1 - .25$ seconds. A more precise estimate comes from the detailed model for the physical realization of the memetic code and from the model of nerve pulse [K41, K81]: the resulting estimate for the duration of the memetic codon is about $.14$ seconds. The facts that a frequency $f \sim 10$ Hz represents the fundamental frequency associated with speech organs and that 20 Hz frequency represents the lower limit for the audible frequencies are consistent with the identification of the phonemes as linguistic images of the memetic codons.

Note that cognitive neutrino pairs of duration of order one millisecond are not experienced as separate components of conscious experience if time averaging is involved with temporal binding. This is consistent with the fact that language does not contain any smaller consciously experienced constituents than phonemes. Not that speech represents (very-!) many-to one expression of the memetic code (faithful coding would require language with 2^{126} different phonemes: this gives good idea about the present evolutional level of human culture!). Genetic code is not unique and some cell organelles, such as mitochondria, possess their own genetic code. Various languages could correspond to different translations of the memetic code to nerve pulse patterns in turn coded to motor activities representing expressions of language. The Mersenne prime $2^{127} - 1$ could be clearly re-christened to be the number of Babel!

10.8   Connection With The Neuroscience View About Brain

In the following an attempt to formulate a connection with the brain as it is seen in neuroscience is made. Learning is basic aspect of intelligence and the discussion concentrates on this aspect of intelligence.

10.8.1   A Simple Model For Cognition

Self hierarchy and summation hypothesis allows to construct a very general model for cognitive processes including as a special case thinking, analysis of visual experience, and language. In nutshell: cognitive process could be regarded as cascade like process leading to a generation of selves followed by generation of sub-selves for these leading to.... Quantum jump becomes the building block of cognition and thought but is not sufficient alone. p-Adic space-time sheets as correlates of cognition provide geometric correlates for thoughts, intentions, plans, etc.. are a fundamental element of cognition. The intersection of real and p-adic worlds understood as partonic 2-surfaces allowing an interpretation in both real and p-adic sense and the intersections of real and p-adic partonic 2-surfaces consisting of rational and common algebraic points define cognitive representations. Negentropic entanglement is possible only in the intersection in accordance with with the vision that cognitive representations carry the information.

Quantum criticality of TGD and existence of selves

The model of cognition provides a new view to the role of quantum criticality of TGD. One consequence of the quantum criticality could be the existence of a lot of sub-systems which are near the critical line at which phase transition changing the local topology (real or p-adic) occurs. TGD universe would be in a state of maximal alertness ready to generate cascades of selves representing cognitive acts. Our cognitive acts would be only part of the cognitive acts of the entire Universe proceeding from top to bottom as infinite trees with branches representing new selves and nodes representing moments of wake-ups for the selves. Or expressing it in the terminology of AI: we would be like subprograms of infinite program represented by entire universe. The presence of higher level selves means that cognitive acts can proceed from the level of even entire biosystem to

the level of DNA. This encourages to interesting speculations: for instance, the ideas of Sheldrake about learning at the level of species and even biosphere might find justification [K87].

Number theoretical criticality is an important aspect of quantum criticality and is taken to mean that life and conscious intelligence reside in the intersection of real and p-adic worlds, where discrete cognitive representations are possible.

Quantum jump as cognitive process

U process followed by a cascade of state function reductions will be identified as the basic cognitive act.

1. State function reduction can be characterized as a binary tree. At each step of the state function reduction cascade some sub-selves manage to remain unentangled, some sub-selves lose their consciousness by developing entropic bound state entanglement, or experience expansion of consciousness by entangling negentropically. A particular branch of the process stops if sub-self allows no decomposition to entropically entangled but otherwise free pieces. What is new is that the entanglement is also time-like and time-like entanglement turns out to be central for understanding of what happens in learning.

2. The binary tree of state function reduction has a natural ordering. This ordering need not have any correlate at the level of geometric time. At the level of subjective time and conscious experience the correlate for ordering could exist but if self experiences its sub-selves as averages of sub-sub-selves this cascade is experienced only partially by given sub-self. One can of course argue that self wakes up in each quantum jump separately and quantum jump sequence should be seen as a sequence of "awakenings" (I used this term earlier): this awakening is however something different from the emergence of mental image. Maybe time-like negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) is which binds this sequence of "awakenings" to a continuous stream of consciousness that we experience.

3. The outcome of the state function reduction is random when it leads to un-entangled sub-self but statistical determinism implies reliability at the level of ensemble. For negentropic entanglement state function reduction is nearly deterministic process and in this case one can speak in reasonable approximation about an iteration of a unitary processes defined by the powers of U. This iterative process defines a self-organization process expected to be also behind learning.

4. One possible interpretation of the self cascade is as a representation for an abstraction process representing thoughts about thoughts about... Our poor ability to form statements about statements about... would correspond to the fact that self experiences only its sub-selves directly. Another interpretation is as analysis, in which initial experience gradually sharpens and gets more and more structured during the decomposition into sub-selves. Sub-selves could be thought as symbols of language or as logical statements or objects in picture: interpretation depends on what kind of cognitive process is in question. This process occurs in several time scales- even in the time scale defined by human life cycle. The modular structure of cognitive acts is also analogous to the modular structure of a computer program: starting of subprogram means the reduction of entanglement for the corresponding subsystem.

   One can see this process also at the level of embedding space correlates.

1. Selves wake up and begin to perform quantum jumps. The embedding space counterpart for self is CD (causal diamond) characterized by time scale coming as powers of two and is scaling like the value of Planck constant. Subselves correspond to sub-CDs. Wake-up requires a feed of metabolic energy to destroy the bound state entanglement. Self could be also created from vacuum or disappear to it in a quantum jump generating a completely new CD or annihilating it.

2. Cognitive process proceeds in a cascade like manner starting from the root of tree formed by CDs and going downwards along the tree choosing at each node some branches. For instance,

understanding of a sentence would correspond to waking up of large self A representing sentence in its entirety, words its sub-selves B_i, phonemes to sub-selves C_{ij} of B_i, etc... waking-up in this order. Similarly, the act of decomposing the figure to objects and of objects to sub-objects would correspond to a temporal sequence generating selves within selves. Negentropic entanglement would be crucial for experiencing both the whole and the parts simultaneously. Background would be the largest conscious self and objects would correspond to a sequence of selves. Selves C_{ij} and further sub-selves can be generated before generation of next C_{i+1}: this should occur in case linguistic mental image: generation of word self would be followed by the generation of syllables and phonemes and only after this would next word be generated. Time non-locality of self experience with respect to geometric and subjective time would be essential.

10.8.2 Cognition, Learning, And Negentropic Entanglement At The Level Of Brain

Negentropic entanglement is information carrier and learning is gaining information. Does this mean that learning takes place automatically in the intersection of real and p-adic worlds? Unitary U-matrix between zero energy states characterizes single step of quantum jump sequences and for negentropic states the state function reduction is not random process and in the first approximation U^N characterizes the outcome of N subsequent quantum jump so that learning process should be characterized by the iteration defined by the powers of U.

In neuroscience synaptic contacts are believed to be crucial for cognition, learning, and memory and it is interesting to try to relate this picture to the TGD based vision about conscious information and learning. How negentropic entanglement could be realized at the level of brain? Is it time-like, space-like, or both? Can one assign the generation of negentropic entanglement between neurons to the attachement of neurotransmitter to receptor? Can one relate the general quantum model of learning to the neuroscience based model of learning relying on the growth of brain cells, synaptic contacts, and synaptic plasticity?

The picture of the standard neuroscience about learning

It is good to summarize first the vision of standard neuroscience about the neural correlates of learning.

1. Basic notions

Synaptic transmission [J9, J22] is believed to be a key element of brain consciousness. Synaptic transmission takes place as synaptic vesicles carrying neural transmitter. Given neuron can release several transmitters. The transmitter molecules bind to the receptors at the postsynaptic cell membrane. Depending on whether this process leads to a de-polarization or hyper-polarization one speaks of excitatory or inhibitory receptors (activation potentials). Since most transmitters attach mostly to either kind of receptor, one speaks about excitatory and inhibitory transmitters although this terminology is misleading. Receptors can be classified to relatively simple ion channel receptors and more complex receptors involving second messenger proteins.

The belief is that the primary process does not involve communications with genome but if one accepts the DNA as topological quantum computer picture-in particular, on the existence of magnetic flux tubes connecting cell membrane and DNA nucleotides- the possibility that these communications are an essential element of process and that a new kind of gene expression at cell membrane level is involved. The communication to the DNA could take with light velocity if massless extremals are involved.

The synaptic strength characterizes the sensitivity of the postsynaptic neuron to the firing of the presynaptic neuron. It depends on the density of receptors and their activity as well as the total amount of neural transmitter transferred between neurons determined by the number of synaptic vesicles transmitted. This in turn depends on the size of the synaptic button. All these parameters are affected in learning understood as a change of synaptic strengths. It must be emphasized that learning in this sense should be seen as a neural correlate for conscious (or unconscious-to-us) learning and possibly of memory. What is essential that the respose of the postsynaptic neuron changes. This picture relies on the technical assumption that learning reduces to the changes

of synaptic strengths. This assumption is probably an over-idealization: much more probably happens.

2. Learning at brain level

Learning in the sense as it is defined above can take place at the level of both anatomy and physiology. Learning at the level of anatomy can mean growth of new synaptic connections and of even new neurons. For instance, the growth of new neurons in hippocampus is now understood to be essential prerequisite for learning. It is believed that the information from the connections of old neurons is transferred to those of cortical neurons. This can of course happen but in TGD framework this is not necessary since the new view about time allows to interpret memory as communications with the brain of the geometric past.

Learning at the level of physiology is known as synaptic plasticity [J20] and involves several mechanisms. Synaptic plasticity means that the sensitivity of the postsynaptic neuron to the signals from presynaptic neuron can change.

1. Sensivity means essentially the probability for the firing as a response to the firing of presy-naptic neuron and this is controlled by the sign and magnitude of the activation potential and the increase of the sensitivity means a generation of stronger de-polarization or weaker hyper-polarization. Postsynaptic neuron can become more or less sensitive to the presynap-tic neuron whereas presynaptic neuron can send stronger signal by increasing the number of synaptic vesicles.

2. The change of the sensitivity of the postsynaptic neuron can take place several mechanisms [J20].

   (a) The first mechanism involves the modification of protein kinases whose function is to phosphorylate the receptor which means essentially providing it with metabolic energy. The effectiveness of the protein kinases is regulated. Second mechanism depends on second messenger neurotransmitters regulating gene transcription and regulates the levels of key proteins at synapses. Gene expression is affected in this mechanism and the effect is long-lasting.

   (b) Third mechanism affects the number of ion channels (ion transfer between cell interior and exterior is basically responsible for the activation potential) and is involved with long term potentiation (LTP [J13]) and - depression (LTD [J12]) believed to be central mechanisms of learning memory. LTP is believed to be of central importance in hippocampus. The change of the density of receptors is one manner to achieve LPT or LTD. For so so called AMPA receptors [J4] to which glutamate binds this mechanism is well-established. Also phosphorylation and dephosphorylation of AMPA receptors and change in the probability of glutamate release is a decisive factor.

3. The notion of Hebbian learning [J10] applies to LTP. Hebbian rules summarizes the above picture as simple mathematical rules allowing computer modelling. When pre-synaptic and postsynaptic neurons fire simultaneously, synaptic connections are affected. Weak stimula-tions of several pathways add up. Also temporal summation takes place if the frequency of firing is high enough. Strong stimulation of one pathway affects also other pathways. More general formulation of the rules does not require the firing of the postsynaptic neuron. For anti-Hebbian learning de-sensitization takes place. Also non-Hebbian learning is believed to take place.

4. The change of the postsynaptic action potential need not be the only outcome of learning. If this were the case, the huge number of neural transmitters and receptors inducing different responses would not be needed. The change of the sensitivity is only one aspect of learning and as its relationship to conscious learning is unclear.

TGD based vision about cognition and learning

In the following a brief summary about TGD inspired view concerning cognition and learning in general and at brain level is given.

1. Basic ideas

The general ideas about cognition have been also discussed but is useful to summarize them again.

1. Sub-self interpreted as a mental image is key notion. Subselves wake-up, fall asleep, and fuse together losing consciousness or experiencing expansion of consciousness.

2. The cascade of state function reductions can be regarded as an analysis leading to a final state in which sub-selves are either entropically or negentropically entangled systems. The latter systems can be seen as negentropic mental images resulting as sub-selves fuse together. In the case that two sub-selves are involved, the resulting mental image can be regarded as an abstraction or rule such that the state pairs appearing in the superposition correspond to the instances of the rule. If one state pair dominates then association in classical sense is in question in good approximation.

3. Negentropic entanglement can take place between systems which belong to same or different number fields and gives rise to various kinds of conscious experiences. At least in the case that the other system is p-adic, negentropic entanglement should be a correlate for the conscious experience of understanding.

4. Zero energy states for brain represent rules as pairs of positive energy (initial) and negative energy (final) states. M-matrix characterizes zero energy state and defines a rule representing "laws of physics" at the level of conscious experience. Different M-matrices are orthonormal with respect to each other and in ensemble all of them appear and each of them can be also regarded as representing one particular instance of a rule.

A new element is that unitary time evolution characterized by U-matrix forces the learning to occur in the sector of state space containing zero energy states for which positive and negative energy parts of the states are negentropically entangled. U-matrix and its powers characterize the learning process. When the states are negentropically entangled, state function reduction for M-matrix is not a random process but leads to a unique state maximing negentropy and in a good approximation the restriction of U matrix to these states codes for the evolution of M-matrix. U^N restricted in this manner characterizes the M-matrix after N quantum jumps. Therefore learning is unvoidable in the case of negentropic states and U^N at the limit of large number of quantum jumps characterizes the learning. The value of N is of course limited by the size of CD assigned to the learning system. One can of course wonder whether the unitary period is following by a return to unentagled state via the liberation of metabolic energy associated with the negentropic entanglement.

The powers of U define an iterative map and iterative maps are the key element of self organization and also one of the main tools of generating fractals [K87]. Quantum classical correspondence therefore suggests that 4-D fractal self-organization patterns define the space-time correlates for learning.

2. General view about learning at the level of brain

M-matrix for brain codes its view about laws of physics. In diagonal form represents pairing of initial and final states as rules $A \rightarrow B$. For instance, in fermionic degrees of freedom these rules can be interpreted as Boolean rules. More generally, the interaction as quantum associations containing superposition of instances of the associations are in question. Huge quantum superposition of rules is possible since the number of neurons large and the information storage capacity of entanglement increases exponentially with the number of neurons.

U-matrix approximated as a matrix restricted to represent unitary evolution of negentropic zero energy states assignable to brain provides the first principle description for learning as the sequence of powers U^N. In the models of associative learning learning is reduced to a local process expressible in terms of changes of the synaptic contacts. This suggests that the basic building block of U matrix is synaptic transmission. This means an analogy with the basic braiding operation of the neighboring strands represented as R-matrix defining the unitry matrix for topological quantum computation [K2]. There is also an analogy with generalized Feynman diagrams. The incoming particles would be neurons. Synaptic transmission analogous to particle exchange between

two neurons. U matrix can be regarded as a quantum superposition over all possible diagrams containing arbitrary number of synaptic transfers. Multiverse picture at neural level thus results as one might expect since macrotemporal and macroscopic quantum coherence is involved. If the situation reduces in a reasonable approximation to a description in terms of synaptic transfers one can in principle describe synaptic plasticity, LTP, and LTD and other mechanisms to in terms of the basic building block of U associated with the synaptic transmission and mathematically analogous to Feynman propagator. The binding to the receptor could induce communications with genome and also the U-matrix assignable to topological quantum computations at the DNA level might be involved.

As such this picture provides only a first principle formulation for what conscious learning is and it requires a work to deduce predictions testing this vision or at least to gain understanding using this vision. A key aspect of negentropic entanglement is that it carries metabolic energy. This has been already proposed to provide a first principle explanation for the notion of the high energy phosphate bond crucial for the understanding of $ATP \rightarrow ADP + P_i$ process defining the key stop of metabolism [**?**].

Also space-like negentropic entanglement is possible for positive (negative) energy parts of the states. In particular, negentropic entanglement between presynaptic neuron and postsynaptic genome generated by the attachment of the transmitter to the receptor might make sense. There is temptation to assign to this connection a magnetic flux tube identified as a carrier of metabolic energy released in the process and inducing ionic currents leading to the processes affecting the synaptic strength as well as the states of neurons involved. The larger the metabolic energy release is, the more intense are the ionic currents involved and the stronger the modification is. This would provide a first principle explanation for why more effective phosphorylazation of the receptor as a correlate for learning. Of course, the explanation works even without the heavy conceptual machinery if one is ready to accept the somewhat nebulous notion of high energy phosphate bond.

10.8.3 Negentropic Entanglement And The Role Of Neurotransmitters

Soon after starting to develop TGD inspired theory of consciousness, I somehow ended up to an email correspondence with Gene Johnson who insistently emailed me links to abstracts about neuroscience. I read the classic Bible about brain by Kandel *et al* [J94] and tried to make sense of it in my own conceptual framework. This was of course hopeless task since I had only the notions of quantum jump and self. The feeling that something very simple -about which I do not and perhaps cannot ever have a slightest clue- must be behind this incredible complexity made the situation really frustrating. The deeper meaning of EEG, nerve pulse neurotransmitters, hormones- actually of entire brain chemistry and also biochemistry- remained a total mystery.

Development of ideas

After the required number of years however some concrete ideas began to emerge.

1. The notion of magnetic body with fractal onion-like structure meant a decisive step of progress. Also the hierarchy of Planck constants and dark matter as controller of visible matter in living systems emerged. The function of EEG as communication and control tool of magnetic body using biological body as a motor instrument and sensory receptor looked very natural. This led also to a proposal that there is an entire hierarchy of EEGs and their variants. After several trials a vision about nerve pulses as concomitants of quantum level communications emerged as also a vision about DNA as topological quantum computer based on the flux tubes connecting DNA nucleotides with the lipid layers of cell membrane emerged and providing a function for the intronic portions of genome as carriers of quantum computer programs [K2].

2. Also a vision about the biochemical role of dark matter evolved. In particular, phase transitions reducing Planck constant for a magnetic flux tube would induce its contraction and force biomolecules near to each other. This would explain the miracles of DNA replication, translation, and transcription and quite generally the processes known as aggregation of proteins. The reconnection of magnetic flux tubes changing the topology of the biological Indra's net would be also a central mechanism.

3. The model of nerve pulse and the vision about living matter as a kind of dynamical Indra's net led to a first clear idea about the role of neural transmitters. Transmitters are classified to inhibitory or excitatory depending on whether they increase or reduce the magnitude of the membrane potential. This property is however a property of the receptor rather than that of the transmitter. The same transmitter can have both excitatory and inhibitory receptors although often either receptor type dominates. The proposal was that neural transmitters are associated with the ends of the links of the 4-dimensional web connecting neurons to each other. Neurotransmitter attaches to the plug defined by the receptor connecting the communication wire from presynaptic neuron to the flux tube leading to the passive portion of postsynpatic DNA strand acting as sensory receptor. This would make possible rapid communications to DNA. The corresponding active portion of DNA strand could then respond by generating an activity at the level of cell membrane. This conforms with the general idea that proteins represent only one particular outcome of the gene expression. This left open the question whether the excitatory-inhibitory dichotomy could have some deeper meaning.

4. Also it became clear the emotions and information are closely related and that peptides acting both as neurotransmitters and hormones are crucial for emotions [J43]. I proposed that emotions are "entropic" qualia. Although I realized the importance of negentropic entanglement I did not have time or I was not able to realize how far reaching this notion actually is.

Is genome a fractal counterpart of brain?

Fractality replaces standard reductionism in TGD Universe. An old idea inspired by p-adic length scale hypothesis is that the binary structures associated with p-adic scales $L(k) \propto 2^{k/2}$ and $L(k+2)$ define a fractal hierarchy. Brain hemispheres would represent one example of this kind of pair, lipid layers ofe cell mebrane second one, and DNA double strand third one. Just for fun one could assume that the structure and functions of brain hemispheres have fractal analogs at the level of DNA double strand and vice versa and look what kind of questions this inspires.

1. Could the identical structures of DNA strands correspond to the anatomical similarity of right and left brain and could the functional asymmetry of the strands correspond to the laterizalization of brain function? Could the genome act as the brain of cell? Could various brain areas have counterparts at the level of DNA? Could the hydrogen bonds between nucleotides serve as the counterpart of corpus callosum? Could the splitting of these bonds during transcription and replication correspond to what happens to a split brain patient?

2. Before continuing it must be made clear that the global identification of right-left dichotomy with holistic-reductionistic dichotomy is wrong. One can however consider its local variant with holism and reductionism assigned do the pairs of right and left brain areas. For instance, in contrast to the naïve rule the emotional right (left) brain (amygdala) would be reductionistic (holistic, negentropic) whereas the intellectual right (left) would be holistic (reductionistic, entropic). The practical reason to the division to the entropic and negentropic pieces could relate to the metabolism. The entropic regions could provide the binding energy as a usable energy to the positive energy negentropic entanglement. Good is not possible without Evil! There are no winners without loosers!

   Right brain is specialized in spatial thinking and left brain to verbal thinking and arithmetics: the geometry-algebra division of mathematics! Right brain is not so good in motor actions as left brain as any right-handed person knows. Right brain is however better in tactile sensing: right handed persons tend to use left hand for touching objects to get an idea about their shape. Also this can be understood in holistic-reductionistic picture.

3. Apart from reflex actions almost all activities of the body seem to be controlled to a high degree by brain. Could also the activitites of cell be regarded as motor actions of the genome acting as the brain of cell receiving sensory imput from the cell membrane? Could one identify the analogs of sensory areas receiving information from cell membrane, processing, and sending it to the association areas? Could the analogs associative areas be identified as intronic portions of DNA performing topological quantum computations and communicating

the outcome to the higher motor areas at the intronic portions of the of the complementary strand, wherefrom they would be communicated to the primary motor areas identifiable as the regions of DNA expressing themselves either chemically (RNA and proteins), as activitites generated directly at the level of cell membrane, or electromagnetically? For instance, could neurotransmitter in the receptor generate the feed of sensory input to the genome inducing the change of the membrane potential as the counterpart of motor action. Could prokaryotes without introns be analogous to brain with only primary sensory and motor areas or to mere ladder-like nervous system?

One could argue that the analogy between DNA are brain fails because second DNA strand is completely passive whereas both brain hemispheres express themselves via motor actions. This is not the case! Both DNA strand has regions expressing themselves but the transcription takes place in opposite directions. Hence DNA strands have motor and sensory areas as also brain does, and the natural guess is that primary motor areas correspond to the areas expressing themselves in terms of RNA, proteins, and possibly also as actions at the level of cell membrane. Primary sensory areas would correspond to to regions complementary to the primary motor regions.

4. What right brain sings-left brain talks metaphor could mean in this picture? Pitch-rhythm dichotomy is more technical expression for this dichotomy. Function providing local data and its Fourier transform providing global data is more abstract representation for this dichotomy and Uncertainty Principle for momentum and position relates closely to these two representations of information. This dichotomy could reflect the presence of two different natural time scales and millisecond time scale for nerve pulses and .1 second time scale for moments of sensory experience are the natural candidates.

   If so, this dichotomy could directly reflect the different time scales assignable to u and d type quarks (1 millisecond) and to electron (100 ms) and reduce to the level of elementary particle physics. This dichotomy would also have fractally scaled up variants made possible by the hierarchy of Planck constants. The analog of Fourier transform would be the negentropic unentanglement of sub-CDs (assignable to quarks) to single mental image inside electron's CD. The analog of function itself would be a collection of sub-CDs representing separate unentangled mental images assignable to individual nerge pulses in millisecond time scale. Also the topological quantum computations assigned to the intronic portions correspond to different time scales due and reflect quark-lepton dichotomy. The quarks in question could be the quarks assigned to the ends of flux tubes in the model of DNA as topological quantum computer.

5. This raises some questions. Could the gene expressions of the two strands somehow reflect this dichotomy? For instance, could the flux tube structures assignable to the amino-acid sequences correspond to the millisecond and 100 ms scales assignable to quarks and electron have the property that also the functioning of these proteins is characterized by these typical time scales? According to [I68] the time scales of protein folding vary from .1 s to 10^3s. According to Wikipedia [I16] the typical time scale is 1 millisecond which suggests that the time scales correspond to two ranges beginning from ms and 100 ms respectively. There are also short proteins for which the folding takes place in microsecond time scales which might relate to the CD of proton.

What can one say about the function of neurotransmitters?

Can one say anything interesting about the function of neurotransmitters if one combines this highly speculative picture- which can be defended only by the belief on fractality as universal principle- with the idea that bound state and negentropic entanglement make possible the fusion of mental images.

1. Suppose that the fusion of neuronal mental images is required to build higher level mental images that we experience. Suppose that neuronal mental images involve DNA in an essential manner. Suppose that magnetic flux tubes serve as correlates for the entanglement so that the transmission of nerve pulse from pre-synaptic neuron to post-synaptic one creates a flux tube

connection between neurons possibly extending to the genome of the post-synaptic neuron. The transmitter at the end of flux tube attached to the receptor acting as a plug would build this connection to some part of DNA specialized to receive particular kind of sensory data from a particular region of cell membrane with complementary strand activating as a response a motor function inducing gene expression at cell membrane level. Gene expression as build-up of proteins would not be necessary and is also too slow for neural activities.

2. Suppose that the entanglement between neurons generated in this process is always negentropic as the interpretation as the idea about neural correlate for a conscious association suggests. One could also ask whether the neurons could entangled entropically and whether the entropic-inhibitory association could make sense. This does not lead to anything interesting and entropic entanglement between neurons should be regarded as a pathological condition. Note that neuron-neuron entanglemement would be naturally time-like and in this case only negentropic entanglement might be meaningful.

    (a) To gain some perspective consider the activation of cell in general by some external perturbation from the resting state to the active state (here I have learned a lot from email correspondence with Vladimir Mateev) In the resting state the proteins inside cell are passive -or rather, forced to be passive- as one might expect on basis of the general vision about homeostasis. The unfolded proteins and unfolded portions of the folded proteins are connected by hydrogen bonds to ordered water so that the folding occurring otherwise spontaneously is prevented. One can say that the cellular winter prevails. The situation is however nearly critical and if external perturbation occurs cell liberates metabolic energy melting the ice and spring comes. Also the outer surfaces of globular proteins are hydrogen bonded and when the ordered water melts, spontaneous melting of the protein takes place leading to a partial unfolding.

    The resulting folded proteins and partially unfolded globular proteins interact by forming aggregates and this activity would naturally involve $\hbar$ reducing phase transitions and flux tube reconnections. In TGD based model the mechanism of both folding and melting would be the liberation of metabolic energy destroying the hydrogen bonds and the energy for this comes from the ATP containing positive energy negentropic bond between O=s of phosphates.

    (b) Similar situation could prevail at the cell membrane. One can imagine that cell membrane is like a particle at the bottom of a small potential well. At the other side there is a deep well representing the generation of nerve pulse and at the other side a high wall corresponding to hyper-polarization requiring energy. Both polarization and hyper-polarization are prevented by the freezing of protein activities needed to induce them. The flux tubes connecting the presynaptic neuron and receptor and possibly genome are always negentropic and their formation can as such serve as the signal leading to the partial melting of the ordered water making possible to generate action leading to either de-polarization or hyper-polarization. The signal could be just the additional metabolic energy making it possible for these transitions to occur.

    (c) This picture does not require any communications from the receptor to the genome and in the simplest situation the resulting action could be seen as the analog of reflex action. These communications could of course be present and the negentropic entanglement could make it easier to induce de-polarization also now. Also the question whether excitatory-inhibitory dichotomy for the receptors has some deeper meaning apart from taking the neuron nearer to or farther from criticality for firing remains unanswered.

10.9 Two ways to learn and what goes wrong with vulgar skeptics?

I had with two fellows - I call them A and B - an "entertaining" although not totally pleasant discussion, which taught a lot, I hope also for A and B -, and actually gave a good example of two

kinds of learning. Learning by conditioning and learning by discovery. It also led to a possible understanding about what goes wrong in what I would call ultra-skeptic cognitive syndrome.

Remark: This discussion by the way gave me good laughs. A summarized his academic background by "studied strings" an B was a Bachelor in computer science but pretending to be M-theorist. They tried to demonstrate that I am a crackpot. They carried out an "investigation" following the principles of the investigations made for witch candidates at middle ages. The victim had two options: she drowns or not in which case she is burned at stake. I guess that my feelings during the examination were very similar to those of witch candidates.

The highly emotional discussion was initiated by a totally non-sense hype about transferring consciousness of C Elegance to computer program (see `http://tinyurl.com/y8wnyxxr`). I told that the news was hype and this raised the rage of A and B. The following considerations have very little to do with this article. Note however that I have done some work AI in general and even with with the basic ideas of deep learning. For instance, we had two years ago a collaboration about AI, IIT approach to consciousness, and about a possible connection with remote mental interactions together with Lian Sidorov and Ben Goertzel, who is behind Sophia robot. There two chapters related to this [L30, K93] (see `http://tinyurl.com/zwqbj8y` and `http://tinyurl.com/zq8k3jl`). I think that the latter chapter is published in a book by Goertzel. There is also a critical article inspired by Sophia robot about which Ben Goertzel wrote an enthusiastic article and sent to Lian Sidorov and me [L32] (`http://tinyurl.com/y75246rk`).

10.9.1   The two ways to learn

Learning by conditioning

The first kind of learning is learning by conditioning, which deep learning algorithms try to mechanize (for TGD view see [L32, L30]). Second kind of learning is learning by discovery impossible for computers because they obey deterministic algorithm and are unable to do anything creative.

Emotions play a strong role in the learning by conditioning in the case of living systems and in the simplest form it is learning of X-good and X-bad type associations helping C elegance to survive in the cruel world. In the case of humans this kind of associations can be extremely dangerous as for instance the recent course of events in USA has shown.

Very large part of our learning is just forming of associations: this is what Pavlov's dogs did. In school we learn to associate to "2×3=" symbol "6". In our youth we learned also algorithms for sum, division, multiplication and division, and even for finding the roots second order polynomial. Often this is called learning of mathematics. Later some mathematically gifted ones however discovered that this is just simple conditioning of an algorithm, and has very little to do with genuine mathematical thinking. The discovery of the algorithm itself would be mathematical thinking. The skill to code for algorithm - usually given - is also an algorithm and it can be also coded in AI.

If we are good enough in getting conditioned we get a studentship in University and learn science. This involves also learning of simple conditionings of type X-good and X-bad. In this learning social feedback from others reinforces learning: who would not like to earn the respect of the others!

For X-bad conditionings X can be homeopathy, water memory, cold fusion, telepathy, remote viewing, non-reductionistic/ non-physicalistic world view, quantum theories of consciousness, TOEs other than M-theory, etc... For X-good conditionings X can be physicalism, reductionism, strong AI, superstrings, Witten, etc...

The student learns also to utter simple sentences demonstrating that he has learned the desired conditionings. This is important for the career. Proud parents, who hear their baby say he first word encourage the child. In the same manner environment reinforces the learning of "correct" opinions by a positive feedback. The discussion with A and B gave a quite a collection of these simple sentences. "I guessed that he is a crank" from A is a good example intended to express the long life experience and wide wisdom of the youngster.

These conditionings make it also easy "recognize" whether someone is a crank/crackpot/etc... and even to carry out personal "investigations" whether some-one is a crank or not. This is what A and B in their young and foolish arrogance indeed decided to carry out.

I have considered the TGD view about learning and the role of emotions in learning [L43,

L47]. The recent surprising experimental findings about the role of RNA in learning by conditioning inspire the view that emotions are involved even at the molecular level [L40]. Together with the TGD based model of bioharmony [L18, L45] inspired by the fact that music both expresses and induces emotions, this leads to a concrete model. For the general philosophic background see [L44].

Learning by Eureka experience

There is also second kind of learning. Learning by discovery. Computers are not able to do this. I mentioned in the discussion what happens when you look certain kind of image consisting of mere random looking spots in plane. After enough staring suddenly a beautiful 3-D patterns emerges. This is a miracle like phenomenon, Eureka experience. Quantum consciousness based explanation is the emergence of quantum coherence in the scale of the neuronal cognitive representation in visual cortex at least. New 3-D mental image emerges from purely 2-D one. One goes outside the system, so to say.

The increase of dimension might provide an important hint about what happens more generally: and this would indeed occur for the dimension of extension of rationals in Eureka quantum jump in TGD based model of what could occur. Physically this would correspond to the increase of the effective Planck constant $h_{eff} = n \times h_0$, $h = 6 \times h_0$ (this is the best guess [L26, L42]) assignable to the mental image created by the image. n is indeed the dimension of extension of rationals and would increase and also scale of quantum coherence would increase from that for single spot to that for the entire picture. The increase of n requires metabolic energy and learning in this manner is actually essentially what it is to be alive. Most of this Eureka learning would be analogous to re-discovery in molecular length scales.

This kind of learning by Eureka is probably very common for children since they live a very intense period of personal evolution: they are often said to be genii. Later the increasing dominance on the learning by conditioning often supresses this mode of learning, and we become gradually collections of existing programs. The irony is that the worst outcome is a mainstream scientist, who has become a hard-nosed skeptic. What is worrying that our society strongly reinforces this degeneration to mere automatons in the name of effectiveness.

Solving genuine problems rather than applying existing algorithms is the manner to gain these learning experiences but they come only now and then. Some of them are really big: during my professional career there have been - I would guess about 10 really big experiences of this kind involving discovery of a new principle or totally new physical idea.

10.9.2 What goes wrong with vulgar skeptics?

For me the discussion with my inquisitors A and B was very useful since it led me to ponder why it is so hopeless to explain something extremely simple idea for skeptics. You give explain the problem patiently, you list the assumptions, you explain the solution. But all in vain: skeptic refuses to even read and shouts that every single assumption contains a fatal mistake. When you ask him to make a list about these fatal mistakes, he throws a personal insult. The discussion with these fellows A and B forced me to seriously ask what goes wrong with them, how to understand their intellectual rigidity, even intellectual paralysis implying inability to consider any alternative views. Perhaps one could speak about ultraskeptic cognitive syndrome, which involves also emotions very intensely.

There is a beautiful connection with a learning based on Eureka experience. Physically this corresponds in TGD to a phase transition increasing the scale of quantum coherence and algebraic complexity: more technically effective Planck constant h_{eff} increases at some levels. More intelligent mental images become possible and Eureka experience happens as in the situation when chaotic 2-D set of points becomes beautiful 3-D object.

Biological evolution at the level of species is based on this: we humans are more intelligent than banana flies. This evolution occurs at all levels - also at the level of individuals but it is not politically correct to say this aloud. Some of us are in their intellectual evolution at higher level than others, either congenitally or by our own efforts or both. This creates of cause bitter feelings. Intellectual superiority irritates and induces hatred. Maybe this partially explains why so many intellectuals spend most of their life in jail.

Take seeing as an example. If person has become blind at adult age, he understands that he is blind and also what it **feels** to see. Also congenitally blind person believes that he is blind: this because most people in his environment tell that it is possible to see and that he is blind. However, he does **not feel** what it is to see. Suppose now that most of us were blind and then comes some-one and tells that he sees. How many would believe him? They can **not feel** what it to see. Very probably they conclude that this fellow is a miserable fool.

Suppose now that certain person - call him MP - has used 4 decades to develop a TOE generalizing superstring model made 5 years before the first superstring evolution and expanding also to a theory of consciousness as a generalization of quantum measurement theory. MP tries his best to explain his TOE to A and B but finds it hopeless. They even arrange "investigation" following the best traditions of witch hunt to demonstrate his crackpotness. And indeed, they conclude that they were correct: all that this person writes is totally incoherent non-sense just as this 2-D set of random points.

These you guys are arrogant and full of the vanity of a young man. But this alone does not explain their behavior. To say that they are just evil, is not a convincing explanation. My proposal is that hey are simply intellectually blind and suffer what one might call ultra-skeptic syndrome. Expressing it more technically in TGD context: their personal hierarchy of Planck constants does not contain the required higher values. An Eureka experience would be required to jump to the level containing higher values of n, at which understanding is possible. What MP says is for them like this chaotic 2-D set of points: they are not able to see the beautiful 3-D pattern.

MP could of course cheat and tell that he believes in superstrings and even give a false hint suggesting that he is a good friend of Witten. This would certainly help but would only lead to a fake understanding. The fellows would take MP seriously only because MP agrees with Witten and claims to be a friend of Witten but still they would not have a slightest idea what TGD is. They cannot **feel** what it is to understand TGD.

The only hope is personal intellectual evolution increasing the needed Planck constants in the personal h_{eff} hierarchy of these guys. But this is possible only if these fellows admit that they are intellectually blind in some respects but if they are young arrogant skeptics they furiously deny this and therefore also the possibility of personal intellectual evolution. There could also suffer a genuine intellectual paralysis meaning inability to make this kind of quantum phase transition. There indeed is a personality disorder in which the patient has extremely rigid personality and is unable to consider any alternative views.

10.10 Could TGD Provide Justification For The Ideas Of Rupert Sheldrake?

Rupert Sheldrake [I63] has developed a theory of learning and memory based on the concepts of morphic fields and morphic resonance. In the following I describe briefly the theory of Sheldrake and consider a TGD variant of of the theory.

10.10.1 Sheldrake's Theory

The following summarizes very briefly the basic ideas of Sheldrake's theory.

1. The basic hypothesis is that learning occurs also at the level of species. If some individuals of the species have learned some habit, it becomes easier for the remaining individuals of the species to learn the same habit. The individuals who learned the habit first need not even live anymore or can live in a distant part of the world. Collective learning is claimed to occur in a morphic resonance analogous to a phase transition leading from a small seed of individuals with new habit to a population having the same habit. Morphic field provides a representation for a habit and resemble the concept of meme in this respect. Sheldrake states the basic assumptions of his theory in the following manner:

The idea is that there is a kind of memory in nature. Each kind of thing has a collective memory. So, take a squirrel living in New York now. That squirrel is being influenced by all past squirrels. And how that influence moves across time, the collective squirrel-memory both for form and for instincts, is given by the process I call morphic resonance. It's a theory of collective memory throughout nature. What the memory is expressed through are the morphic fields, the fields within and around each organism. The memory processes are due to morphic resonance.

2. Sheldrake defines morphic fields in the following manner:

   Basically, morphic fields are fields of habit, and they've been set up through habits of thought, through habits of activity, and through habits of speech. Most of our culture is habitual, I mean most of our personal life, and most of our cultural life is habitual. "We don't invent the English language. We inherit the whole English language with all its habits, its turns of phrase, its usage of words, its structure, its grammar. "

   "Alike likes alike" rule states that learning induces learning only in the members of same species. This suggests that the morphic fields correlate strongly with genome.

4. *Sheldrake represents the learning of language as a good example of morphic resonance.*

   Occasionally people invent new words, but basically, once we've assimilated it, it happens automatically. I don't have to think when I'm speaking, reaching for the next word. It just happens, and the same is true about physical skills, like riding a bicycle, or swimming, or skiing if you can ski, these kinds of things. So I think the more often these things happen the easier they become for people to learn. Things like learning language have happened over-well, we don't know how long human language has been around, at least 50, 000 years, so there's a tremendously well-established morphic field for language-speaking. Each particular language has its own field which is usually established over centuries at least.

5. *Sheldrake notices also that morphic resonance and morphic fields are not all what is needed to understand evolution.*

   The whole idea of morphic resonance is evolutionary, but morphic resonance only gives the repetitions. It doesn't give the creativity. So evolution must involve an interplay of creativity and repetition. Creativity gives new forms, new patterns, new ideas, new art forms. And we don't know where creativity comes from. Is it inspired from above? Welling up from below? Picked up from the air? What? Creativity is a mystery wherever you encounter it, in the human realm, or in the realm of biological evolution, or of cosmic evolution. We know creativity happens. And then what happens is a kind of Darwinian natural selection. Not every good idea survives. Not every new form of art is repeated. Not every new potential instinct is successful. Only the successful ones get repeated. By natural selection and then through repetition they become probable, more habitual.

10.10.2   TGD Based Interpretation Of Morphic Fields And Collective Memory

I have proposed for more than decade ago a TGD based formulation justifying the basic ideas of Sheldrake to some degree. The recent formulation involves several new elements. Zero energy ontology implying that WCW ("world of classical worlds") spinor fields allow an interpretation as memes or morphic fields, the model for living matter in which the notion of magnetic body plays a key role, and the model of DNA as topological quantum computer allowing to identify the morphic quanta relevant for living matter.

WCW spinor fields

In TGD framework zero energy states correspond to the modes of completely classical WCW spinor fields with fermionic second quantization at space-time level having purely geometric interpretation at the level of WCW . The analysis of the degrees of freedom involved demonstrates that WCW spinor fields are analogous to ordinary quantum fields but hav infinite number of components.

1. WCW decomposes to a sub- WCW s association with unions of causal diamonds (CDs). Individual CD is partially characterized by the moduli defined by the positions of its upper and lower tips. The proposal is that the temporal distances between the tips are quantized in octaves of CP_2 time scale and thus coming in good approximation as secondary p-adic time scales for primes very neary to power of two. The most general proposal is that also the position of the upper tip at proper time = constant hyperboloid of future light-cone M_+^4 is quantized for positive energy states. For negative energy states this happens to the lower tip. This disrete set would provide a discretized quantum version of Robertson-Walker cosmology with discretized lattice like structure replacing the continuum. The interpretation would be that lower tip corresponds to the usual Minkowski space-time of special relativity and the discretized position of upper tip to the space-time of cosmology. This implies very strong predictions such as the quantization of cosmic redshifts which is indeed observed [K98]. Similar quantization would take place in CP_2 degrees of freedom for either tip. WCW spinor fields for single CD would depend on these moduli and for positive (negative) states one would have wave functions in the space formed by sub- WCW s with wave function basis consisting of products of plane waves in M^4 with a wave function in the discrete subset of $M_\pm^4$. These degrees of freedom generalize those of a quantum field in Minkowski space.

2. The notion of generalized imbdding space forces to assign to a given CD a selection of quantization axis of energy and spin which in the case of M^4 boils down to a choice of a preferred plane $M^2 \subset M^4$ plus a choice of time direction (rest system). In the case of CP_2 the choice of quantization axes of color isospin and hypercharge means a choice of a homologically trivial geodesic sphere of CP_2 plus preferred isospin quantization axes. The space for possible choices of quantization axis defines additional moduli. The selection of quantization axes in state function reduction means a localization in these degrees of freedom. The space characterizing the selections of color quantization axis represents an example of so called flag manifold. It has already earlier appeared in TGD inspired biology with a motivation coming from the observation of topologists Barbara Shipman that the mathematical model for honeybee dance leads naturally to the introduction of this space. Shipman speculated that quarks have some role in biology [A12]. Dark matter hierarchy indeed makes indeed possible scaled up copies of QCD type theory in biological length scales.

3. WCW spinor fields restricted to a CD with fixed moduli have infinite number of bosonic and fermionic degrees of freedom. Spin-like degrees of freedom for these fields correspond to WCW spinors, which describe many-fermion states consisting of quarks and leptons and bosons defined as their bound states. This Fock state is assigned to each 3-surface and the dependence on 3-surface defines purely bosonic ("orbital") degrees of freedom, which can be coded by using a state basis whose elements have well-defined spin and color quantum numbers. The bosonic and fermionic degrees of freedom are super-symmetrically related.

WCW spinor fields as morphic fields?

The interpretation of the WCW spinor fields as memes or morphic fields is encouraged by two observations.

1. Zero energy states have an interpretation as Boolean rules $A \to B$ as well as self-organization patterns. Fermion number 1 and 0 for a given fermion mode represents values of one particular Boolean statement in positive *resp.* negative part of the state. The instances of A are assigned to the positive energy (initial) state and those of B to the negative energy (final) state and the quantum superposition of the paired instances defines the rule. Since time-like entanglement coefficients define M-matrix, the interpretation as a law of physics coded to the structure of the physical state itself is possible. Fermionic degrees of freedom correspond to the spin indices of WCW spinor fields. Besides this there are "orbital" degrees of freedom in the moduli space for CDs and in the space of deformations of light-like 3-surfaces. It is natural to assign these degrees of freedom to sensory perception.

2. The p-adic description of cognition involves a generalization of the notions of number and of embedding space. The hierarchy of Planck constants means a further generalization of

the notion of embedding space by replacing it with a book like structure. It seems that the discrete intersection of real and p-adic partonic 2-surfaces consisting of points in algebraic extension of rationals is crucial from the point of view of consciousness theory. This is true also for the intersection of real and p-adic variants of WCW identified as 3-surfaces whose mathematical representation makes sense in both real and p-adic number fieldsin preferred coordinate fixed by symmetries.

The first intersection is expected to be relevant at quantum field theory limit, which involves the replacement of the partonic 2-surfaces with a discrete subset of points carrying quantum numbers. The second intersection is relevant in the full quantum theory. The notion of number theoretic Shannon entropy having negative values makes sense in both intersections since entanglement probabilities must make sense in both number fields so that they are rational or belong to an algebraic extension of rationals. In these intersections of realities and various p-adicities the evolution of memes is expected to take place.

One manner to understand the special role of rationals and algebraics relies on the observation that rationals represent islands of order in the sea of chaos defined by reals since their pinary expansion is predictable and analogous to a periodic orbit of a dynamical system whereas for a generic real number there is no manner to predict the pinary expansion.

If one defines morphic field so that also ideas and imagined things, simply memes, are included within the scope of definition, one is led to ask whether the p-adic description of imagination as space-time WCW spinor fields in the space of 2-surfaces allowing continuation by strong form of holography to some p-adic sectors but not necessarily to real sector could represent morphic fields in this generalized sense.

One can however criticize the proposed definition as quite too general: every zero energy state would define morphic field!

10.10.3 Magnetic Body As Morphic Field

The second option is more concrete and assumes that morphic fields correspond to space-time surfaces which in ZEO are analogous to behavioral patterns and functions. Since magnetic body carrying dark matter is intentional agent in TGD Universe, morphic fields of Sheldrake [I63, I64] could be therefore replaced with field body: magnetic body and the "topological light rays" serving as correlates of dark photon beams are involved and are parallel to flux tubes and topologically condensed at them.

Magnetic body - and even more so topological light rays - are essentially 4-D objects, a temporal pattern of topologically quantized fields associated with a pair of 3-D magnetic bodies at the opposite boundaries of CD. Magnetic body having an ion-like structure would serve as a template for the biological system and its evolution. The lowest layers of the onion would correspond to flux tubes connecting biomolecules. DNA and nuclear and cell membranes would have magnetic bodies having connections to larger magnetic bodies, such as magnetic Mother Gaia.

The findings of Levin [I52] and others about what happens to cut planaria can be understood if the replication of of magnetic body precedes the replication of the biological body [L19]. The replication of magnetic body would be analogous with the decay of particle in the vertex of Feynman diagram (particles are replaced with 3-surfaces in TGD).

The experiments indicate that also memories interpreted as learned behaviors are replicated in the sense that the new worms resulting from the pieces of the cut worm have the memories of uncut worm and the replication of magnetic body in the sense of ZEO would explain this (the pair of 3-surfaces at opposite ends of CD would replicate). The replication of behaviours could be seen as replication of memes. This would help to understanding how skills can be discovered by several individuals simultaneously and how learning of skill becomes easier when it is already possessed by several individuals.

The following is an attempt to define morphic resonance using language of TGD.

1. Morphic resonance would relate to the presence of collective levels of consciousness. They could have direct counterparts as a hierarchy of genomes in which genomes of cells could form coherent units in the sense that their magnetic bodies fuse to larger ones. Also the genomes of different organisms could fuse to single super-genome in this manner. In this case, then

morphic resonance could manifest itself as a collective gene expression. One manifestation would a discovery of same thing in separate places simultaneously due to the fact that the problem solving would also take place at collective level.

2. Negentropic entanglement resources generated in the quantum evolution would give rise to "Akashic records", which would serve as universal library from which any-one could loan a book. Independent discovery of same idea at different places and times would not be actually independent since the needed information could derive from "Akashic records".

3. In ZEO 3-D self-organization becomes 4-D self-organization for spatio-temporal patterns since also the geometric past changes in quantum jump. At space-time level this means that space-time surfaces representing temporal patterns of various fields would becomes the basic patterns. Quantum states would correspond to superpositions of these temporal patterns. This would mean that morphic resonance would be essentially 4-D: behaviors/skills could be learned from "Akashic records".

4. Morphic resonance would also correspond to resonance in concrete sense. Only the flux tubes of two magnetic bodies having the same value of magnetic field and thus same cyclotron frequency scale and same thickness could fuse by reconnection. Also the values of h_{eff} should be same. This might also explain $h_{eff} = h_{gr}$ as a condition guaranteeing the resonant interaction between biological organisms with conscious entities in scale of Earth and Sun.

Morphic fields relevant to living matter

All zero energy states have interpretation as memes or quanta of morphic fields in TGD framework. One can however ask what zero energy states are relevant for biological systems.

1. The memes relevant to living matter must have a very concrete connection to biology. DNA as topological quantum computer hypothesis states the magnetic flux tubes connecting nucleotides to lipids of nuclear and cell membranes define braid strands needed to realize topological quantum computations. Nerve pulse patterns induce fluid flows of cytoplasma and of lipids in turn inducing time-like braidings defining running topological quantum computation programs and their memory representations as space-like braidings in the final state. These programs living (in very literal sense) in the brains of geometric future and past define a 4-D population of memes. The intronic part of the genome is specialized to topological quantum computations and the time scale in this case can be and must be faster than for the chemical gene expression. The repetitive character of many intronic DNA sequences regarded as evidence for their junk character does not mean any restriction for topological quantum computation.

2. The notion of magnetic body has a central role in TGD inspired biology. Magnetic body has an onion-like fractal structure and astrophysical size with wavelength of EEG wave defining the size scale of the magnetic body with which it is associated. Magnetic body acts as as an intentional agent using biological body as a motor instrument and sensory receptor. Magnetic body receives sensory and other information from biological body through EEG and its fractal counterparts and controls biological body via EEG type signals sent to the genome, where they induce chemical or electromagnetic gene expression. This allows to imagine also a mechanism of collective learning. The spatio-temporal nerve pulse patterns defining topological quantum computations are mediated via EEG and its fractal counterparts to the magnetic body of organism and from it to the magnetic body of another organism. The magnetic body of Earth - magnetic Mother Gaia- could serve as a relay station and Schumann resonances and alpha band could allow broadcasting of the nerve pulse pattern to a large number of magnetic bodies of organisms. From the latter magnetic body the field representation of nerve pulse pattern would induce via EEG type signal from magnetic body to the receiver genome the original nerve pulse pattern in the brain of the receiver. Nerve pulse patterns would be quite generally induced by magnetic bodies via appropriate part of the intronic genome as electromagnetic gene expression. This mechanism could be also involved with telepathy and remote mental interactions.

3. Morphic resonance and alike likes alike rule can be understood from the condition that the intronic parts of genomes must be similar enough to allow the realization of the topological quantum computation. Also neuronal pathways involved must resemble each other in order that spatial nerve pulse patterns can be re-produced faithfully enough. Also the evolutionary levels must be more or less the same in order that the topological quantum computation has same meaning for the receiver and sender. Therefore the collective memory might be restricted to the level of species. This might be however too strong an assumption. For instance, shamanism could represent an example of interspecies memory. The TGD based view about memory allows also the possibility to use the memories of the already deceased members of species which can in principle continue to exist in the geometric past.

4. The general vision about evolution as recreation of the quantum Universe implies that creativity is in very literal sense a basic aspect of TGD Universe. The U process represents the creative aspect of consciousness generating quantum super-position of Universes from which generalized state function reduction process selects the outcome. Both volitional actions and sensory perception involves the selection but quantum statistical determinism implies that sensory percepts are usually predictable.

Collective memory, geometric memory and self hierarchy

The notion of species memory is rather radical departure from the teachings of standard neuroscience so that TGD based view about memory deserves a separate discussion.

TGD predicts infinite hierarchy of selves and if this hierarchy has levels between living systems and entire universe, the idea about collective memory makes sense and generalizes to an entire hierarchy of them.

Geometric memory provides a promising candidate for the mechanism of a long term memory. Geometric memory is made possible by the fact that self can have multitime experiences such that the space-time sheets associated with various values of the geometric time give contributions to the experiences and past contributions are experienced as memories. In zero energy ontology these space-time sheets are associated with sub-CDs of CD associated with self. Both time-like entanglement between sub-CDs of recent and past implying sharing and fusion of mental images an classical communications between these CDs are possible and give rise to episodal memories (direct re-experiences) and symbolic memories.

Since both geometric past and future change in each quantum jump these memories are not stable: long term memories are certainly unreliable. The memory formation mechanism of brain however tends to stabilize these memories. There is in principle no upper bound for the span of the geometric memories and one can consider the possibility of racial memory and even species memory. Under suitable conditions organism could be able to have the space-time sheets of the geometric past as its sub-selves and experiences these memories. Thus geometric memory is consistent with Sheldrake's claims and to some degree supports them.

Language learning and morphic resonance

The easiness of children to learn language could have explanation in terms of morphic resonance. The strong quantum entanglement between the child and parents, especially mother, could make the morphic resonance possible in the proposed sense. One can even imagine that mother's magnetic body directly induces nerve pulse sequences representing linguistic memes in the brain of child.

One can of course wonder why it is so difficult for the older people to learn language. Do we force us to learn the language at reflective level although it could occur at proto-level also. Older people learn rules but find difficult to apply them whereas child learns to apply the rules without learning the rules themselves. Are older people so far from quantum criticality that the large fluctuations leading to the generation of the new level of self-organization are not possible anymore? The reason could also relate to the degeneration of the magnetic flux tubes circuits due to ageing so that new topological quantum computation programs are not establishes so easily anymore.

Self hierarchy, bio-feedback and sociofeedback

Magnetic bodies act as intentional agents in the proposed model. They form also a hierarchy analogous to master-slave hierarchy. The proposed mechanism of collective learning involves the magnetic body of Earth in an essential manner. Also magnetic bodies of larger structures could be involved: there is indeed evidence that remote cognition involves galactic magnetic fields [K82] , [J88].

The phenomenon of bio-feedback provides direct evidence for this phenomenon in a length scale familiar to us. By monitoring the behavior of say single neuron, it is possible to learn to affect the behavior of neuron volitionally. No knowledge about how this happens is needed: the volition is enough. The explanation would be that the information provided by the monitoring goes to the magnetic body of the person which reacts by sending control signals to the brain. The already existing magnetic flux tube connections guarantee that the volitional act affects the neuron. The possibility of biofeedback suggests the possibility of socio-feedback and feedback even at the level of species and entire biosphere.

An interesting test for the idea that people very close to each other could directly affect the brain function of each other would be biofeedback in which subject person tries to affect the behavior of a neuron of a close friend or relative. Mother and child might be an optimal choice in this respect.

Chapter 11

p-Adic Physics as Physics of Cognition and Imagination

11.1 Introduction

TGD as a generalized number theory vision stimulates the hypothesis about p-adic physics provides the physical correlates of cognition and imagination. This interpretation has far reaching implications for both TGD inspired theory of consciousness and for the general world view provided by TGD. cognition is predicted to be present in all length scales and the success of the p-adic physics in elementary particle length scales forces to conclude that cognition is present even at this level. In this chapter these implications are studied from the point of view of cognitive consciousness.

The view about cognition relies also heavily on the developents that have occurred during the last ten years in the understanding of TGD. The vision about life and conscious information and intelligence as something in the intersection of real and p-adic worlds is certainly the most important aspect in this respect and the very fact that the notion of conscious information makes sense only in this intersection supports the proposed interpretation of p-adic physics. Zero energy ontology and the notion of causal diamond (CD) with zero energy states having interpretation as memes in very general sense is also of central importance. The hierarchy of Planck constants assigned with a hierarchy of quantum criticalities as an explanation of dark matter and energy as macroscopic quantum phases even in astrophysical scales and implying that dark matter is a key actor in the drama of life is the third key element.

11.1.1 Clarifying Some Basic Concepts

Before continuing it is could to clarify basic conceps.

The earlier view was that p-adic space-time surfaces are correlates for both cognition and intentionaity. The recent view is that p-adic space-time sheets correspond only to cognition and that their intersections with real space-time sheets in the intersection of real and p-adic worlds (intersection briefly) define cognitive representations. These representations are defined in terms of the data coming from the rational and algebraic points common to real and partonic 2-surfaces with the algebraic extension in question characterized by the mathematical representation of the partonic 2-surfaces making sense for both real and p-adic 2-surfaces simultaneously. The immediate powerful implication is that the algebraic extensions of rationals define a cognitive hierarchy. One can also understand preferred p-adic primes as so called ramified primes of the extension and NMP suggests strongly an extension of p-adic length scale hypothesis.

The original view was that cognitive representations as p-adic space-time surfaces are built and define images of real space-time surface [K122]: the problems with symmetries forced to challenge this view. The recent view is adelic. Space-time surfaces are adeles with a book-like structure with pages representing preferred extremals of Kähler action in various number fields, and real and p-adic space-time sheets serve as correlates of sensory experience and cognition are present in all length scales and for all systems, even elementary particles. The success of p-adic mass calculations conforms with this assumption.

TGD must be number theoretically universal in order to have a first principle description of conscious intelligence and cognition and the algebraic continuation from the intersection to various number fields from the back of Big Book allows to realize this idea.

The earlier view about discretization was that space-time surfaces are replaced with discrete point sets defined by points of surface for which embedding space coordinates are in an extension of rationals. This led to problems with symmetries and general coordinate invariance. Discretization is more abstract than originally believed and occurs at the level of "world of classical worlds" (WCW). Co-dimension two rule holds true. n-dimensional object is discretized as a collection of $n-2$-dimensional objects. In the case of space-time surfaces the lower-dimensional objects are string world sheets and partonic 2-surfaces: co-dimension 2 rule is equivalent with the strong form of holography. The discretization is physically: physics itself defines its representation with finite resolution. Discretization occurs for the parameters (conformal moduli) characterizing these 2-surfaces and the parameters - naturally conformal moduli - are in some algebraic extension of rationals so that the space-time surfaces themselves are not discretized. This allows to get of rid of difficulties as one tries to map real and p-adic space-time surfaces to each other locally.

The classical non-determinism of Kähler action quite generally implies that space-time surfaces define what might be called symbolic representations realizing quantum classical correspondence. This applies irrespective of the number field used and in p-adic context p-adic non-determinism is an additional ingredient. For instance, nerve pulse patterns define symbolic real physics representations of the sensory input but do not give rise to sensory qualia which reside at the level of the primary sensory organs (contrary to the expectations raised by various findings of neuro-science). Sensory experience is always a multiverse experience since sensory qualia have quantum number increments as quantum correlates, and is thus not reducible to the level of space-time.

I have use also the notions of meme and morphic field. One could defend the identification of the geometric correlates of memes and morphic fields as p-adic space-time sheets. On the other, all negentropic quantum states in zero energy ontology have the character of a rule A→B, where quantum superposition represents various instances $a \rightarrow b$ of the rule and one could say that every negentropic zero energy state can be seen as a meme. I leave the choice between these interpretations for the reader.

11.1.2 Basic Vision

It is useful to summarize the recent TGD inspired view about quantum biology and conscious intelligence since it serves as background for the chapter.

Magnetic body as intentional agent and experiencer

The notion of magnetic body has a central role in TGD inspired biology. Magnetic body has an onion like fractal structure and astrophysical size with wavelength of EEG wave defining the size scale of the magnetic body with which it is associated. Magnetic body acts as as an intentional agent using biological body as a motor instrument and sensory receptor. Magnetic body receives sensory and other information from biological body through EEG and its fractal counterparts and controls biological body via EEG type signals sent to the genome, where they induce chemical or electromagnetic gene expression. This allows to imagine also a mechanism of collective learning. The spatio-temporal nerve pulse patterns defining topological quantum computations are mediated via EEG and its fractal counterparts to the magnetic body of organism and from it to the magnetic body of another organism [K33].

The magnetic body of Earth - magnetic Mother Gaia - could serve as a relay station and Schumann resonances and alpha band could allow broadcasting of the nerve pulse pattern to a large number of magnetic bodies of organisms. From the magnetic body the field representation of nerve pulse pattern would induce via EEG type signal from magnetic body to the receiver genome the original nerve pulse pattern in the brain of the receiver. Nerve pulse patterns would be quite generally induced by magnetic bodies via appropriate part of the intronic genome as electromagnetic gene expression. This mechanism could be also involved with telepathy and remote mental interactions.

Magnetic flux tubes and flux sheets are basic building bricks of the magnetic body and DNA as topological quantum computer hypothesis assumes that DNA nucleotides are connected to cell membrane by flux tubes defining braids playing a key role in topological quantum computation [K2]. Therefore magnetic body is essential for realizing the software of biological intelligence. The essential assumption is that magnetic body carries dark matter consisting of ordinary with a non-standard value of Planck constant. The phase transition changing the value of Planck constant change the size scale of the flux tube and this process together with reconnection of the flux tubes would define mechanisms of bio-catalysis.

Zero energy ontology, causal diamonds, and identification of memes

In zero energy ontology (ZEO) physical states are replaced by pairs of positive and negative energy states assigned to the past *resp.* future boundaries of causal diamonds (CDs) defined as pairs of future and past directed light-cones ($\delta M_\pm^4 \times CP_2$). The net values of all conserved quantum numbers of zero energy states vanish. Zero energy states are interpreted as pairs of initial and final states of a physical event such as particle scattering so that only events appear in the new ontology.

Communication with the geometric past using negative energy signals and time-like entanglement are crucial for the TGD inspired quantum model of memory and both make sense in zero energy ontology. ZEO leads to a precise mathematical characterization of the finite resolution of both quantum measurement and sensory and cognitive representations in terms of inclusions of von Neumann algebras known as hyperfinite factors of type II$_1$ [K120]. The space-time correlate for the finite resolution is discretization in terms of string world sheets and partonic 2-surfaces forced also by the well-definedness of em charge for Kähler-Dirac action [K121].

At the embedding space-level CD serves as a correlate of self whereas space-time sheets having their ends at the light-like boundaries of CD - more precisely, partonic 2-surfaces and the distributions of the 4-D tangent spaces of space-time sheet associated with them - are the correlates at the level of 4-D space-time. The hierarchy of CDs within CDs corresponds to the hierarchy of selves. Zero energy ontology leads also to an argument explaining why the arrow of subjective time induces an apparent arrow of geometric time as a result if intentional action and why the contents of sensory consciousness is restricted to such a narrow time interval (located near the future boundary of CD) [K116, K7].

The original interpretation of the space-time correlates of mental images was as "mind-like" space-time sheets identified as space-time sheets with a finite temporal size. In zero energy ontology all space-time sheets have a finite size and serve as correlates for zero energy states, which could be interpreted as representations of laws of physics as superpositions of pairs of initial and final states given by M-matrix. In state function reduction process these states are reduced to states for which only negentropic time-like entanglement is possible and one might say that the negentropy measures the conscious information associated with the final state of the reduction process. One can interpret negentropic quantum states as memes or morphogenetic fields [K87]. [I63] These negentropic quantum states are possible only in the intersection of real and p-adic worlds so that living systems are the systems carrying information and intelligence.

Boolean mind and fermions

The connection of fermionic Fock space basis with Boolean algebra was one of the first ideas related to the quantum modelling of intelligent systems. The state basis for the fermionic Fock space has a natural interpretation as Boolean algebra (fermion number $=1/0 \leftrightarrow$ yes/no). In this way ordinary Boolean algebra is extended to a vector space spanned by fermionic states. Fermion number conservation poses an obvious problem for this scenario in positive energy ontology. Zero energy ontology resolves this problem quite generally and zero energy states resulting as an outcome of state function reduction process represent Boolean statements of type A$\rightarrow$ B in terms of time-like negentropic entanglement in fermionic degreees of freedom.

The original proposal was to use cognitive fermion pairs instead of fermions with fermion and anti-fermion located at the opposite throats of wormhole contact. In the recent formulation of quantum TGD bosons and their super counterparts correspond to wormhole contacts. An interesting question is whether one could consider ordinary Boolean logic as some kind of limit for

the complex quantum logic and whether our logical mind could have something to do with Boolean algebra. For instance, could primary "this is true" experiences correspond to Boolean qualia having increments of fermionic quantum numbers as physical correlates. Boolean truth values could also correspond to spin directions of fermions. In this case fermion number conservation does not pose any constraints and the macroscopic realization replaying single spin as a representative of bit with a magnetized ensemble of fermions, makes the realization robust.

Negentropic entanglement (NE) means that qubits are always fuzzy and the fuzziness depends on the situation. The positive aspect is that the quantum superposition gives rise to an abstraction, rule about pairing of say initial and final states represented as positive and negative energy parts of zero energy state with the pairs of superposition representing the instances of the rule. p-Adic-real entanglement with positive definite number theoretical entanglement entropy in the intersection could give rise the experience of understanding and makes possible cognitive quantum computation like processes. Interestingly, negentropic entanglement corresponds to an entanglement matrix characterized by a unitary matrix encountered in quantum computation.

p-Adic physics as physics of cognition and imagination

The vision about p-adic physics as physics of cognition has gradually established itself as one of the key idea of TGD inspired theory of consciousness. There are several motivations for this idea.

The strongest motivation is the vision about living matter as something residing in the intersection of real and p-adic worlds. One of the earliest motivations was p-adic non-determinism identified tentatively as a space-time correlate for the non-determinism of imagination. p-Adic non-determinism follows from the fact that functions with vanishing derivatives are piecewise constant functions in the p-adic context. More precisely, p-adic pseudo constants depend on the pinary cutoff of their arguments and replace integration constants in p-adic differential equations. In the case of field equations this means roughly that the initial data are replaced with initial data given for a discrete set of time values chosen in such a way that unique solution of field equations results. Solution can be fixed also in a discrete subset of rational points of the embedding space. Presumably the uniqueness requirement implies some unique pinary cutoff. Thus the space-time surfaces representing solutions of p-adic field equations are analogous to space-time surfaces consisting of pieces of solutions of the real field equations. p-Adic reality is much like the dream reality consisting of rational fragments glued together in illogical way or pieces of child's drawing of body containing body parts in more or less chaotic order.

The obvious looking interpretation for the solutions of the p-adic field equations would be as a geometric correlate of imagination. Plans, intentions, expectations, dreams, and cognition in general could have p-adic space-time sheets as their geometric correlates. A deep principle could be involved: incompleteness is characteristic feature of p-adic physics but the flexibility made possible by this incompleteness is absolutely essential for imagination and cognitive consciousness in general.

The original idea was that p-adic space-time regions can suffer topological phase transitions to real topology and vice versa in quantum jumps replacing space-time surface with a new one is given up as mathematically awkward: quantum jumps between different number fields do not make sense. The new adelic view states that both real and p-adic space-time sheets are obtained by continuation of string world sheets and partonic 2-surfaces to various number fields by strong form of holography.

The idea about p-adic pseudo constants as correlates of imagination is however too nice to be thrown away without trying to find an alternative interpretation consistent with strong form of holography. Could the following argument allow to save p-adic view about imagination in a mathematically respectable way?

1. Construction of preferred extremals from data at 2-surfaces is like boundary value problem. Integration constants are replaced with pseudo-constants depending on finite number pinary digits of variables depending on coordinates normal to string world sheets and partonic 2-surfaces.

2. Preferred extremal property in real context implies strong correlations between string world sheets and partonic 2-surfaces by boundary conditions a them. One cannot choose these

2- surfaces completely independently. Pseudo-constant could allow a large number of p-adic configurations involving string world sheets and partonic 2-surfaces not allowed in real context and realizing imagination.

3. Could imagination be realized as a larger size of the p-adic sectors of WCW? Could the realizable intentional actions belong to the intersection of real and p-adic WCWs? Could the modes of WCW spinor fields for which 2-surfaces are extandable to space-time surfaces only in some p-adic sectors make sense? The real space-time surface for them be somehow degenerate, for instance, consisting of string world sheets only. Could imagination be search for those collections of string world sheets and partonic 2-surfaces, which allow extension to (realization as) real preferred extremals? p-Adic physics would be there as an independent aspect of existence and this is just the original idea. Imagination could be realized in state function reduction, which always selects only those 2-surfaces which allow continuation to real space-time surfaces. The distinction between only imaginable and also realizable would be the extendability by using strong form of holography.

Although p-adic space-time sheets as such are not conscious, p-adic physics would provide a beautiful mathematical realization for the intuitions of Descartes. The formidable challenge is to develop experimental tests for p-adic physics. The basic problem is that we can perceive p-adic reality only as "thoughts" unlike the "real" reality, which represents itself to us as sensory experiences. Thus it would seem that we should be able generalize the physics of sensory experiences to physics of cognitive experiences.

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

In the p-adic context one must modify Shannon's definition of entropy by replacing the ordinary logarithm based on p-adic norm. This definition gives rise to a real valued entropy in both real and p-adic contexts if entanglement coefficients are rational/algebraic numbers. For irrational/non-algebraic entanglement standard Shannon formula and its p-adic variant must be used and gives rise to non-negative entropy. Unlike Shannon entropy, the p-adic entropies (one for each p) can be also negative so that the entanglement entropy defines a genuine information measure whose sign tells whether the system contains information or dis-information. For the p-adic entropies Negentropy Maximization Principle (NMP) [K56] tends to preserve the quantum coherence if p divides the common denominator of the entanglement probabilities. The states with rational/algebraic entanglement can be regarded as new kind of states analogous to bound, which are not at all fragile like the states with non-algebraic entanglement are. In particular, these states need not be bound due to the binding energy.

For instance, the problematic notion of high energy phosphate bond might be understood in terms of negentropic entanglement making possible correlations without binding energy so that the ATP→ADP process defining fundamental step of metabolism could be interpreted in terms of negentropy transfer. Negentropic entanglement is highly stable in state function reduction process so that the randomness of quantum jump does not apply to it. Weak form of NMP [K56, K119] supports this view and allows also to derive a generalization of p-adic length scale hypothesis.

Although the entropy of second law is ensemble entropy and one cannot expect second law to be in conflict with NMP, breakdown of the second law of thermodynamics might be implied by NMP in the scale defined by the size of CD involved: consider only transformation of thermal ensemble to single dark particle for which original particles are negentropically entangled. Certainly it requires a generalization to take into account the possibility that the arrow of geometric time changes in volitional acts meaning death of self at some level of self hierarchy.

I have proposed that sub-selves lose consciousness as ordinary entropic bound state entanglement is generated but experience expansion of consciousness when negentropic entanglement is generated. Positive emotions like love, experience of understanding would naturally accompany the generation of negentropic entanglement.

These observations suggest a purely number-theoretic characterization of life: life is in the intersection of real and p-adic worlds: life corresponds to islands of rational/algebraic numbers in the seas of real and p-adic continua. This vision have rapidly become the most important source of insight in attempts to develop TGD based vision about conscious intelligence and cognition.

As explained, strong form of holography following from strong form of GCI allows to identify the intersection of reality and p-adicities as string world sheets and partonic 2-surfaces for which defining parameters (relevant WCW coordinates characterizing them physically) are in some algebraic extension of rationals defining also algebraic extension of p-adic numbers. Parameters correspond to conformal moduli, which are GCI invariants.

These surfaces define space-time surfaces by holography, and general space-time surfaces in various number fields are obtained by algebraic continuation of parameters to reals and various p-adic number fields. Also adelic scattering amplitudes are obtained in the similar way from those in the intersection. Induced spinor fields are localized to these 2-surfaces - this guarantees the well-definedness of em charge - and fermions can be interpreted as correlates for Boolean cognition. The hierarchy of algebraic extensions of rationals becomes the characterizer of the fundamental cognitive hierarchy. So called ramified primes define preferred p-adic primes and NMP allows to deduced generalization of p-adic length scale hypothesis. Hence rather concrete view about number theoretical aspects of cognition emerges.

11.1.3   Topics Of The Chapter

The topics of the chapter is as follows.

1. The relationship between p-adic physics of cognition is discussed on general level. Possible evidence for p-adic cognition is considered.

2. In the mathematical sections the relationship between cognition and number theory is discussed. Also the relationship between p-adic and real physics is discussed at general level with basic vision being that the intersection of real and p-adic space-time sheets in the intersection of real and p-adic worlds consists of points belonging to the algebraic extension of rational needed to guarantee that the mathematical representation of the partonic 2-surface makes sense both in real and p-adic sense.

3. Frontal lobes are known to be the seat of the higher level cognition and also responsible for intentional action and are discussed from p-adic point of view.

4. A generalization of the memetic code to cognitive codes is discussed and some proposals about codes are made. This generalization is based on p-adic length scale hypothesis and the condition that the time scales involved correspond to time scales assignable to the CDs of the known elementary particles does not favor the generalization. On the other hand, the dark matter sector could allow entire fractal hierarchy of elementary particle physics whose existence is reflected as fundamental bio-rhythms and cognitive codes.

5. The intersection of real and p-adic partonic 2-surfaces defining space-like cognitive representations consist of algebraic points. The hypothesis that these intersections obey various kind of symmetries identifiable as molecular symmetries is discussed.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L17].

11.2   P-Adic Physics And Cognition

The basic vision based on adelic TGD is that p-adic space-time sheets serve as correlates for cognition. The original idea that the transformation if intention to action is realized as a quantum jump replacing p-adic space-time region with a real one is given up for both mathematical difficulties and the fact that there is no need for this in Zero Energy Ontology (ZEO), where development of intentions and volitional action can be understood differently.

11.2.1   The Three Non-Determinisms

TGD Universe is characterized by a "holy trinity" of non-determinisms. The first non-determinism is associated with quantum jumps between quantum histories and is what makes possible subjective existence and consciousness. One achieve determinism by giving up the assumption that initial values at fixed time define the time evolution and replaces 3-dimensional sections of space-time surface with what I have called mind-like space-time sheets. The attempt to realize this picture geometrically led to ZEO.

Second non-determinism is classical non-determinism of Kähler action and is closely related to quantum criticality. It is also relevant for symbolic representations and perhaps serves as a correlate for macroscopic volition. The third non-determinism is inherent to all p-adic field equations and might relate to the non-determinism of imagination and thus makes possible cognition and intentionality. There is no conscious experience associated with classical nor with p-adic non-determinism as dualist might think. These three non-determinisms have are candidates for be basic building bricks of TGD inspired theory of consciousness.

The original identification of the geometric correlates of selves was as "mind-like" space-time sheets. In zero energy ontology (ZEO) all space-time sheets satisfy the criterion for mind-likeness and therefore serve as correlates for selves.

Classical and p-adic non-determinisms inspired the the notion of association sequence defined as a sequence of space like 3-surfaces with time like separations determining uniquely the preferred extremal going through these 3-surfaces. In the case of CP_2 vacuum type extremals discrete association sequences become in principle continuous sequences of 3-surfaces but topological condensation is expected to reduce this non-determinism to its discrete version. It has however turned out that the notion of association sequence is redundant. The hierarchy of causal diamonds (CDs) defining kind of spot-lights of consciousness and serving as correlates of selves is the natural notion. Mind-like space-time sheets correspond to space-time surfaces inside CDs.

11.2.2   Classical Non-Determinism And Symbolic Representations

In the special case that classical non-determinism gives rise to macroscopic multi-furcations of the time development of 3-surface, it is tempting to identify the branches of the multi-furcations as alternative choices involved with volitional acts. Contrary to the long held beliefs, it however seems that classical non-determinism is most naturally associated with symbolic representations understood in a very general sense (one could even understand classical space-time surfaces as symbolic representations of quantum dynamics). The assignment of sensory experiences with real mind like space-time sheets explains why the contents of sensory experiences are localized with respect to geometric time.

The book "Gödel, Escher, Bach" by Douglas Hofstadter about self-reference has been perhaps the most fascinating of my intellectual arm chair adventures and it stimulated the dream about the identification of the physical counterpart of self-reference. The physics as a generalized number theory vision stimulated concrete ideas about how this self-reference might be realized in terms of quantum universe repeatedly re-creating itself. The quantum jump building sensory and cognitive representations about the Universe means the replacement of the Universe with a new one containing these representations. Hence the paradoxical infinite regress resulting from the assumption that it is possible to be conscious about what one is conscious of is avoided with a simple modification of this assumption by replacing "is" with "was". By quantum classical correspondence this vision requires also the failure of classical determinism in the conventional sense of the word.

In accordance with the crossing symmetry of standard quantum field theories, one can interpret the elements of M-matrix (generalization of S-matrix in TGD framework) as time-like entanglement coefficients between positive and negative energy parts of the zero energy state with incoming and outgoing particles having positive and negative energies respectively. Thus the classical non-determinism and zero energy ontology make possible for the TGD Universe according to represent the laws of physics in the structure of the zero energy physical states. That all possible vacua provide representation for physics is very much akin to the ideas of Eastern philosophies, and is bound to have deep implications from the point of view of TGD inspired theory of consciousness.

11.2.3   Basic Vision About Qualia

Before proceeding it is useful to summarize the basic view about sensory qualia [K39].

1. Geometric qualia correspond to the increments of WCW zero modes in quantum jump and are cognitive qualia. Shape, size, length duration, ... etc. are good examples of geometric qualia. Real geometric qualia could be also called symbolic qualia. The universe of symbolic representations is completely classical if a complete localization in the zero modes occurs in each quantum jump. It is not completely clear whether this must be the case also in the real WCW degrees of freedom. In p-adic WCW degrees (WCW, "the world of classical worlds") of freedom it must take place so that cognition would be completely classical. The moduli space for CDs is an excellent candidate for the fundamental geometric qualia [K89, K83].

2. Sensory qualia correspond to the increments of quantum numbers related to the quantum fluctuating degrees of freedom, non-zero modes. They are genuine multi-verse qualia since the final states of quantum jumps are superpositions of space-time surfaces with varying values of non-zero modes. One cannot understand color red in terms of space-time geometry.

3. The trinity sensory-symbolic-cognitive is central for understanding consciousness in TGD framework. Also the division to fermionic (WCW spinor) and WCW degrees of freedom at the level of qualia is important. Fermionic qualia correspond to Boolean qualia and are number theoretical universal. WCW qualia correspond to geometric and sensory qualia. If cognition and sensory experience is restricted to the intersection also these qualia would be number theoretically universal. The original idea was that sensory qualia could be assigned with real physics. One can also speak about geometric qualia having both real and p-adic counterparts. These would be abstact qualia like position, velocity, etc...

11.2.4   The New View About Intentional Actions

The original rather naïve view that volitional acts involve a quantum jump transforming p-adic space-time sheet to a real one has turned out to be mathematically unfeasible. The new adelic view about the fusion of real and p-adic physics makes this idea also un-necessary. Cognition is present always and everywhere and ZEO based view about quantum jump allows to understand volitional act as initiated by the first state function reduction at the opposite boundary of CD in which self dies and re-incarnates. Intention develops during the sequence of repeated state function reductions and is how NMP forcing this reduction to eventually occur is experienced consciously. It has both cognitive and sensory components (plan and desire). One can say that sensory perceptions and motor actions are time reversals of each other and correspond to opposite boundaries of CD.

Volitional act as a quantum jump transforming p-adic space-time sheet to a real one?

If one accepts the idea that real and p-adic space-time regions are correlates for matter and cognition, one encounters the question how matter and mind interact. As already noticed, the first guess for this interaction was the quantum jump replacing real space-time regions with p-adic ones and vice versa. p-Adic-to-real phase transition would have interpretation as a transformation of thought into a sensory experience (dream or hallucination) or intention to an action. The reverse phase transition would relate to the transformation of the sensory experience to cognition.

It turned out that this idea raises mathematical challenges, which are probably too heavy. Instead, one can assume that the Universe is adelic. Real and p-adic existences form a Cartesian product so that an adele is obtained. Cognitive aspects of existence correspond to various p-adic variants of the space-time surface.

p-Adic space-time sheets would indeed define a theory about real space-time sheets. The interaction between real and p-adic number fields would mean that p-adic space-time surfaces define cognitive representations of real space-time surfaces (preferred extremals). One could also say that real space-time surface represents sensory aspects of conscious experience and p-adic space-time surfaces its cognitive aspects. Both real and p-adics rather than real or p-adics.

Strong form of holography implied by strong form of General Coordinate Invariance (GCI) leads to the suggestion that partonic 2-surfaces and string world sheets at which the induced spinor fields are localized in order to have a well-defined em charge (this is only one of the many reasons)

and having having discrete set as intersection points with partonic 2-surfaces define what might called "space-time genes". Space-time surfaces would be obtained as preferred extremals satisfying certain boundary conditions at string world sheets and carrying vanishing super-symplectic Noether charges in a sub-algebra for which conformal weights are n-multiples of those for the entire algebra. Space-time surfaces are defined only modulo transformations of this algebra acting as conformal gauge transformations so that one can talk about conformal gauge equivalences classes of space-time surfaces.

The map assigning to real space-time surface a cognitive representation would be replaced by a correspondence assigning to the string world sheets preferred extremals of Kähler action in various number fields: string world sheets would be "space-time genes". String world sheets would be in the intersection of realities and p-adicities in the sense that the parameters characterizing them would be algebraic numbers associated with the algebraic extension of p-adic numbers in question. It is not clear whether the preferred extremal is possible for all p-adic primes but this would fit nicely with the vision that elementary particles are characterized by p-adic primes. It could be also that the classical non-determinism of Kähler action responsible for the conformal gauge symmetry corresponds to p-adic non-determinism for some particular prime so that the cognitive map is especially good for this prime.

Volitional actions as first state function reductions to the opposite boundary of CD

Adelic vision forces to modify the original view about intentional action. Ontology (ZEO) volitional action begins with the first state function reduction to the opposite boundary of causal diamond (CD) involving "death" of corresponding self and re-incarnation at opposite boundary [**?**, K7]. Intention develops during the sequence of state function reductions at same boundary of CD as a mental state of self. Basically NMP gradually forces self to make the first state function reduction to the opposite boundary and this is experienced as gradually maturing decition to realize the act of volition. In this profess self dies and re-incarnates at opposite boundary. We experience these deaths as disappearances of mental images.

A more concrete picture about the acts of volition would rely on generation of negative energy MEs representing signals propagating backwards in geometric time when the first state function reduction at the opposite boundary of CD changes the arrow of geometric time.

1. Although ZEO in principle allows a creation of zero energy states with arbitrarily large energies of positive energy part of the state as analogs of quantum fluctuations, the condition that the entanglement is negentropic poses energetic constraints. The interpretation of metabolic energy transfer as transfer of negentropic entanglement (NE) allows to understand the somewhat foggy concept of energetic phosphate bond central for ATP-ADP process [**?**]. What is transferred in this process would be negentropy rather than mere energy.

2. Em fields, in particular ELF em fields, are crucial for TGD inspired model of brain and a natural question. I have proposed the generation MEs as a mechanism of coherent locomotion made possible by the maximally coherent momentum carried by ME and resulting as a recoil momentum of material system absorbing second ME. In fact, the mechanism is optimal since the momentum of ME is completely coherent. Thus a possible interpretation is as a transformation of intention to real motion. Of course, it is difficult to say whether this mechanism occurs in cellular or micro-tubular length scales or perhaps even in macroscopic lengths scales. And there are certainly also other mechanisms.

A more refined picture about the realization of volitional action emerges, when one asks how a precisely targeted intention could be realized at the atomic or molecular level.

1. The change must involve energetic changes in the scale of the entire system so that the quantum numbers characterizing the positive energy part of the state change. This includes energy and momentum. It seems safe to assume that zero energy states are created in rather small length scales and that macroscopic systems cannot transform between real and p-adic states. Hence the bottle neck step of the process would be the generation of zero energy states from vacuum as sub-CD with a rather short characteristic time scale and their subsequent interaction with the existing state inducing the desired action.

2. This favors the generation of zero energy states representing elementary particles and electrons and quarks are excellent candidates in this respect for reasons that should be already clear. The sub-CD created from vacuum could be p-adic and transform to a real one and interact with the background to induce the transition. Protons and electrons are key actors in bio-catalysis and TGD forces to consider the possibility that at least electron and quarks exist only in the sense of zero energy ontology.

3. The creation of sub-CD can be interpreted direction of attention of CD to a particular spatiotemporal region inside it. If this region is near vacuum extremal it is critical and the subsequent interaction of sub-CD with 4-D environment can induce a large change of the entire system.

Another view about motor action is as negative energy signal sent to the geometric past and inducing a neural activity leading to the motor action as a consequence. This view conforms with the findings of Libet and others [J34]. It should be possible to fuse these two views together.

1. The intention can be realized in a precisely targeted manner only for the transitions which do not occur spontaneously, and thus involve the emission of negative energy MEs. For a transition involving emission of positive energy, the direction of ME is random so that targeted intentional action is not possible.

2. The emission of negative energy ME translates to a quantum jump in which the energy of the positive energy part of zero energy state increases in the interaction with sub-CD or some other CD. The generation of negative energy MEs would utilize the quantum credit card mechanism of metabolism implying extreme flexibility.

3. Quantum credit card mechanism requires the existence of a system analogous to a population reversed laser. The TGD based model for metabolism assumes that electrons or protons kicked to a small space-time sheet provide this system and that their dropping to a larger space-time liberates zero point kinetic energy as metabolic energy. Hence sensory, cognitive and memory representations would be realized in terms of positive energy MEs spontaneously whereas intentionality and motor actions would be much like time reversed sensory representations and realized in terms of negative energy MEs.

Motor actions as time reversed perceptions

ZEO view about self allows to see motor actions as time reversed perceptions. This allows a simple view about imagined motor activities. Imagined motor actions would be sensory percepts with stimulus generated at some level above muscles - rather than at brain! - and proceed to the cortex as time reversed activities as far as the MEs controlling these activities are considered. If looked in standard time direction they would start from brain and end at some level before ending to the muscles. In a symmetric manner, imagination would correspond to virtual percepts with sensory input generated at level of neural pathways above sensory organs involving perhaps virtual sensory input from higher level.

Negative energies make possible precisely targeted intention. There is no need to stop the imagined motor action so that it is not a safety risk. It is possible to learn motor actions by initiating them from a level above the muscles. Time reversal means negative energies for MEs and buy now-let others pay mechanism implies extreme flexibility. Time reversed dissipation can be interpreted as a healing mechanism since entropy decreases in the standard direction of the geometric time. ZEO view about self organization allows to see motor action as a carving of a four-dimensional statue by a gradual refinement and error corrections using dissipation as a Darwinian selector. No detailed planning is needed: only a rough sketch is enough in the time scale of the motor action and Nature takes care of the rest.

p-Adic fractality suggests that cognitive representations realized in the intersection of realities and p-adicities and reducing by strong form of holography to string world sheets and partonic 2-surfaces plus fermions at them are present at all length scales. In particular, MEs in the intersection are excellent candidates for defining cognitive representations. Nothing forbids a repertoire of simple MEs serving as symbols, typically frequencies or field patterns, and generating neural activities in turn amplified to macroscopic actions.

11.2.5   P-Adic Physics As Correlate For Cognition

The original vision was that p-adic non-determinism could serve as a correlate for imagination. The recent view is much more cautious. Certainly imagination does not reduce to p-adic non-determinism since it has also real physics correlates. Real and p-adic space-time surfaces are also extensions of same basic objects (string world sheets and partonic 2-surfaces) to 4-D surfaces and therefore highly correlated rather than almost independent. One might however consider that the classical non-determinism and p-adic non-determinism serve as correlates for quantum non-determinism which makes possible both volition and imagination.

Could p-adic non-determinism serve as a correlate for imagination?

p-Adic non-determinism follows from the fact that functions with vanishing derivatives are piecewise constant functions in the p-adic context.

1. p-Adic pseudo constants depend on the pinary cutoff of their arguments and replace integration constants in p-adic differential equations. In the case of field equations this means roughly that the initial data are replaced with initial data given for a discrete set of time values chosen in such a way that unique solution of field equations results. Since the fundamental formulation of quantum TGD [K120] indeed relies on the notion of finite measurement resolution, a highly attractive interpretation of this cutoff is in terms of measurement resolution of some kind.

2. Solution can be fixed in a discrete subset of rational (algebraic) points of the embedding space. In the case of space-time surfaces this set is expected to have inherent cutoff since the condition of rationality (or algebraicity in the extension of p-adic numbers used) posed separately for all embedding space coordinates is very strong. Note that preferred embedding space coordinates are required and this kind of coordinate systems indeed existence thanks to the isometries of the embedding space.

   Clearly, the space-time surfaces representing solutions of p-adic field equations are analogous to space-time surfaces consisting of pieces of solutions of the real field equations. p-Adic reality is much like the dream reality consisting of rational fragments glued together in illogical manner or pieces of child's drawing of body containing body parts in more or less chaotic order.

   A possible interpretation for the solutions of the p-adic field equations would be as geometric correlates of cognition and perhaps even intentionality. Plans, intentions, expectations, dreams, and possibly also cognition as imagination in general could have p-adic cognitive space-time sheets as their geometric correlates. A deep principle seems to be involved: incompleteness is the characteristic feature of p-adic physics but the flexibility made possible by this incompleteness is absolutely essential for imagination and cognitive consciousness in general.

   If one accepts the idea that real and p-adic space-time regions are correlates for matter and cognitive mind, one encounters the question how matter and mind interact. The original candidate for this interaction was as a phase transition leading to a transformation of the real space-time regions to p-adic ones and vice versa. These transformations would take place in quantum jumps. p-Adic-to-real phase transition would have interpretation as a transformation of thought into a sensory experience (dream or hallucination) or to an action. The reverse phase transition might relate to the transformation of the sensory experience to cognition. Sensory experiences could be also transformed to cognition by initial values realized as common rational points of a real space-time sheet representing sensory input and a p-adic space-time sheet representing the cognitive output. In this case the cognitive mental image is unique only in case that p-adic pseudo constants are ordinary constants.

   It turned out that this interpretation leads to grave mathematical difficulties: one should construct U-matrix and M-matrix for transitions between different number fields, and this makes sense only if all the parameters involved are rational or algebraic. A more realistic view is that the interaction between real and p-adic number fields is that p-adic space-time surfaces define cognitive representations of real space-time surfaces (preferred extremals). One could also say that real space-time surface represents sensory aspects of conscious experience and p-adic space-time surfaces its cognitive aspects. Both real and p-adics rather than real or p-adics. The notion of p-adic manifold [K122] tries to catch this idea mathematically.

Strong form of holography implied by strong form of General Coordinate Invariance leads to the suggestion that partonic 2-surfaces and string world sheets at which the induced spinor fields are localized in order to have a well-defined em charge (this is only one of the reasons) and having having discrete set as intersection points with partonic 2-surfaces define what might called "space-time genes". Space-time surfaces would be obtained as preferred extremals satisfying certain boundary conditions at string world sheets. Space-time surfaces are defined only modulo transformations of super-symplectic algebra defining its sub-algebra and acting as conformal gauge transformations so that one can talk about conformal gauge equivalences classes of space-time surfaces.

The map assigning to real space-time surface cognitive representation would be replaced by a correspondence assigning to the string world sheets preferred extremals of Kähler action in various number fields: string world sheets would be indeed like genes. Mathematically this formulation is much more elegant that based on p-adic manifold since discretization seems to be un-necessary at space-time level and applies only to the parameters characterizing string world sheet.

String world sheets and partonic 2-surfaces would be in the intersection of realities and p-adicities in the sense that the parameters characterizing them would be algebraic numbers associated with the algebraic extension of p-adic numbers in question. It is not clear whether the preferred extremal is possible for all p-adic primes but this would fit nicely with the vision that elementary particles are characterized by p-adic primes. It could be also that the classical non-determinism of Kähler action responsible for the conformal gauge symmetry corresponds to p-adic non-determinism for some particular prime so that the cognitive map is especially good for this prime.

The idea about p-adic pseudo constants as correlates of imagination is however too nice to be thrown away without trying to find an alternative interpretation consistent with the strong form of holography. Could the following argument allow to save p-adic view about imagination in a mathematically respectable manner?

1. The construction of preferred extremals from data at 2-surfaces is like boundary value problem. Integration constants are replaced with pseudo-constants depending on finite number pinary digits of variables depending on coordinates normal to string world sheets and partonic 2-surfaces.

2. Preferred extremal property in real context implies strong correlations between string world sheets and partonic 2-surfaces by boundary conditions a them. One cannot choose these 2- surfaces completely independently. Pseudo-constant could allow a large number of p-adic configurations involving string world sheets and partonic 2-surfaces not allowed in real context and realizing imagination.

3. Could imagination be realized as a larger size of the p-adic sectors of WCW? Could the realizable intentional actions belong to the intersection of real and p-adic WCWs? Could the modes of WCW spinor fields for which 2-surfaces are extendable to space-time surfaces only in some p-adic sectors make sense? The real space-time surface for them be somehow degenerate, for instance, consisting of string world sheets only.

   Could imagination be search for those collections of string world sheets and partonic 2-surfaces, which allow extension to (realization as) real preferred extremals? p-Adic physics would be there as an independent aspect of existence and this is just the original idea. Imagination could be realized in state function reduction, which always selects only those 2-surfaces which allow continuation to real space-time surfaces. The distinction between only imaginable and also realizable would be the extendability by using strong form of holography.

I have the feeling that this view allows respectable mathematical realization of imagination in terms of adelic quantum physics. It is remarkable that strong form of holography derivable from - you can guess, strong form of General Coordinate Invariance (the Big E again!), plays an absolutely central role in it.

Cognition at elementary particle length scales?

The success of p-adic mass calculations [K52, K23, K57] does not leave much room for the interpretations if one identifies p-adic physics as a physics of cognition: cognitive representations must

be present already at elementary particle level. The adelic vision is the most elegant manner to describe the situation mathematically.

This means that the creation of zero energy states representing photons and perhaps even electrons and quarks could occur routinely in living matter. In the standard physics framework the interpretation would be as quantum fluctuations generating fermion pairs from vacuum. In TGD framework these quantum fluctuations become quantum states with precisely defined characteristics.

Intentional action could be present also in elementary particle length scales if the adelic vision makes sense. Time reversals should occur so often that the effects related to the arrow of time disappear on the average. The extreme situation is the each state function reduction occurs at opposite boundary of CD so that the life time of self is vanishingly short. In this case one cannot speak of any kind of intentional action or volition but already a sequence of few state function reductions generates self and can give rise to intentions.

What makes this hypothesis testable is the prediction that the time scales of CDs assignable to electron and quarks should define fundamental time scales of living matter. This seems to be the case. kHz neuronal synchrony is only one example. kHz frequency and 10 Hz frequency would be associated also with "dead" matter if cognition is present at elementary particle level. A particular prediction is the failure of second law below these time scales. This kind of failure has been indeed observed [D5] and the effect indeed involves millisecond and .1 second time scales [K56].

The experience has taught that physical system can be understood throughly only after the characteristic time and length scales have been understood. In case of biology the prevailing reductionistic attitude has led to the belief that living matter is a basic example of a "non-tidy" system so that the time and length scales associated with living matter are more or less accidental as also genetic code and the miracles of bio-chemistry. My own belief is that this attitude is wrong and explains why the progress in the theoretical understanding of living matter has been so slow.

Cognitive degeneracy and the survival of the fittest

Physical systems with large degeneracy would be favored since intuitively one expects this to give a high representational power. 4-D spin glass degeneracy suggests that these systems correspond to small deformations of vacuum extremals. If the final states of quantum jumps have roughly the same probabilities, this means that quantum jumps lead with highest probability to those states for which cognitive degeneracy is highest. The mere ability to imagine would mean winning in the fight for survival.

The hierarchy of Planck constants associated with the hierarchy of quantum criticalities involves degeneracy and its connection with conscious information in much more concrete manner. The density matrices for the outcomes of state function reductions are higher-dimensional projection operators and one can can assign to them negentropy and conscious information. The interpretation is as a consciously experienced abstraction or rule with its instances represented as state pairs in the superposition.

The emergence of symbols

p-Adic non-determinism gives rise to cognitive representations whereas the non-determinism of the real Kähler action gives rise to symbolic representations in terms of association sequences consisting of space like 3-surfaces with time like separations: the individual space like 3-surfaces play the role of words of sentence.

Conscious activities are indeed highly symbolic: a push of button can initiate a nuclear war. The reduction of the p-adic-to-real phase transitions to some fundamental level, perhaps to the level of nerve pulse transmission, indeed makes possible a build-up of very complex actions by using a repertoire of very simple basic actions serving p-adic memes translatable to symbols in case that system is initial value sensitive. Dark MEs with preferred frequencies inducing transitions provide an excellent candidate for the buttons.

This idea is developed concretely in the model of bio-photons as decay products of dark photons at flux tubes having $\hbar_{eff} = \hbar_{gr} = Gmm/v_0$ [K12, K73]. The cyclotron energies of charged particles are proportional to h_{gr}/m and thus independent of the mass of the particle. Therefore the cyclotron energy spectrum of emitted dark photons and bio-photons resulting from

them is universal and in the range of visible and UV photons where also molecular transition energies are. Hence bio-photons define an optimal control too. This leads to a vision in which each biomolecule is symbolically represented by a collection of cyclotron frequencies characterizing its magnetic body and directed attention between molecules corresponds to a resonance interaction involving emission and absorption of cyclotron photons. This idea have been develop further in the geometric model of harmony leading to a proposal that genetic code is realized in terms of triplets of cyclotron frequencies for dark photons [K80]. Molecules - at least DNA and proteins- would be symbolically represented by "music pieces" consisting of sequence of 3-chords- somewhat like characters in Wagner's operas correspond to themes.

What cognitive representations are and how they develop?

It is far from clear what cognitive representations are and how they develop. The recent vision about generalized embedding space and about life as something in the intersection of real and p-adic worlds provides one possible answer to the question based on adelic physics supported also by p-adic mass calculations.

For a long time I believed that discretization of space-time by a subset of algebraic points and with cutoff makes sense at space-time and embedding space level: this vision was concretized in the proposal what p-adic manifolds as cognitive charges of real manifolds - now preferred extremals- could be [K122]. The intersection of realities and p-adic world was at the space-time level identified as discretized space-time surfaces with points having coordinates which are numbers in some algebraic extension of rationals. These discrete point sets were assumed to be continuable to preferred extremals of Kähler action containing them. This introduces a lot of non-uniqueness interpreted in terms of a finite measurement resolution.

The first problem is that this discretization is highly non-unique and one is forced to introduce preferred coordinates. Second problem was that there is a tension between symmetries and continuity. The identification via common rationals (or numbers in algebraic extension of rationals defining an extension of p-adic number fields) would respect symmetries represented by rational matrices but would be totally discontinuous. The canonical identification is continuous but does not respect symmetries. The proposal was a compromise involving pinary cutoffs.

The discretization at space-time level is abstracted to a discretization at the level of WCW reducing by strong form of holography to a discretization for the parameters characterizing partonic 2-surfaces and string world sheets. By conformal and modular invariances these parameters should corresponds to finite-dimensional space of conformal moduli (Teichmueller parameters and punctures representing intersections of string world sheets with partonic 2-surface [K23, K52]). As far as scattering amplitudes are considered, all calculations could be carried out at this level without continuation to 4-D space-time surfaces. p-Adic variant of Teichmueller space was actually used in p-adic mass calculations already two decades ago [K52].

The correspondence between real and p-adic space-time sheets would be induced by the continuation of string world sheets and partonic 2-surfaces to preferred extremals so that canonical identification is not needed. The tension between symmetries and continuity would disappear since there is no map from reals to p-adics or vice versa but only algebraic continuation from the intersection. Space-time discretization is not present except for partonic 2-surfaces but has purely physical meaning since the discrete points correspond physically to the ends of boundaries of string world sheets carrying fermions. Also measurement resolution can be formulated elegantly in terms of pinary cutoffs at this level.

The partonic 2-surfaces are in the intersection of realities and p-adicities in the sense that the parameters appearing in their mathematical representations are in extension of rationals so that they make sense both in real sense and p-adically. Restriction to algebraic points, which is clumsy at the level of space-time, occurs now at the level of "world of classical worlds" (WCW). These 2-dimensional objects would define the fundamental cognitive and symbolic representations at the same time.

One should answer several questions.

1. What are the basic types of cognitive representations? One can imagine two basic correspondences between reals and p-adics induced by common rationals and canonical identification or some map akin to it. One can ask whether self-representations could be induced by common rationals whereas representations of the external world could be induced by a proper

generalization of canonical identification mapping rationals to themselves up to some power of p. In both cases there is some pinary cutoff determining the goodness of the representation. For the identification based on common rationals or algebraics the geometry of the surfaces would dictate the resolution inherently.

More than decade after writing the above lines adelic view has replaced the original vision and the situation looks much simpler. Both real and p-adic space-time sheets are obtained as preferred extremals by strong form of holography from the partonic 2-surfaces and string world sheets in the intersection of reality and various p-adicities. Thus the representations are fixed to a high degree and provide kind of kaleidoscopic view about existence. How refined these representations are, depends on how complex the algebraic extension of rationals is. Evolution indeed corresponds to a gradual increase of the complexity of extension [K119].

2. How do cognitive representations in p-adic sectors relate to sensory representations in real sector? In the adelic view [K119] there is no step of this kind since p-adic and real sectors accompany automatically each other. p-Adic non-determinism might mean that p-adic preferred extremals depend on pseudo constants so that strong form of holography would not be highly non-unique in p-adic sectors. There could be large number of space-time surfaces associated with a given string world sheets and partonic 2-surfaces distinguished by different pseudo constants. This would mean that cognitive representations are not so trustworthy but does not seem to relate naturally to imagination.

3. Cognitive representations evolve in the sense that they become gradually more precise. What does this mean in the adelic vision? The complexity of the algebraic extension of rationals for the 2-surfaces in the intersection is the natural measure for a level of cognitive and symbolic representation. Evolution would involve a gradual increase of the complexity of the extension [K119] leading to the emergence of new preferred p-adic primes as ramified primes of the extension.

   In strong form of holography p-adic continuations of 2-surfaces to preferred extrmals identifiable as imaginations would be easy due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K64]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes. Whether the preferred primes satisfy p-adic length scale hypothesis or its generalization from $p = 2$ to small primes remains an open question.

   The value of effective Planck constant $h_{eff}/h = n$ corresponds to the number of sheets of some kind of covering space defined by the space-time surface. The discretization of the space-time surface identified as a monadic manifold [L29] with embedding space preferred coordinates in extension of rationals defining the adele has Galois group of extension as a group of symmetries permuting the sheets of the covering group. Therefore $n = h_{eff}/h$ would naturally correspondto the dimension of the extension dividing the order of its Galois group.

   Weak form of NMP would allow the emergence of highly negentropic entanglement, when the dimension of the projector for the outcome of projection is power of large prime. The phase transitions reducing quantum criticality and increasing h_{eff} would generate NE and extend the scale of macroscopic quantum coherence. The evolution would also involve the emergence of new strings connecting partonic 2-surfaces. These strings would carry super-symplectic Noether charges creating many-fermion states, which in turn would provide representation of Boolean algebra bringing in Boolean cognition.

4. What is the relationship to the memetics of Susan Blackmore [J137]? Susan Blackmore sees memes as independent objects using brain as a tool of replication.

   Memes could be identified as mental images able to utilize the metabolic energy resources associated with brains and to replicate themselves in communications. They must correspond to self-organization patterns able to induce the birth of their almost copies in communications. Selves have magnetic bodies and also memes should have them.

The replication of magnetic body - analogous to what happens in 3-vertex of Feynman diagram - is what induces the replication of biological sense in TGD inspired biology [K77]. The replication vertex is indeed the generalization of fundamental 3-vertex in TGD context. There is strong temptation to assume that also memes are magnetic bodies replicating in this concrete sense. Thus magnetic bodies serving as analogs of the morphic fields of Rubert Sheldrake [K77] would be the physical correlates for memes: this makes sense since they carry dark matter and NE, and can be said to act as an intentional agents using biological bodies as motor instruments and sensory receptors.

The original idea that p-adic cognitive representations could serve as the physical realization of memes is not feasible in the adelic framework. In the adelic picture p-adic cognitive representations are not independent elements but determined to a high extent by the string world sheets and partonic 2-surfaces as real sensory representations. One cannot say that p-adic representations use brain as at tool for the materialization and replication.

11.2.6 Quantization Phenomena In Psychophysics

p-Adicity might provide understanding of some phenomena of psychophysics related to the discrimination between different intensities of stimuli and to threshold phenomena of sensory perception.

When over-learning occurs in tasks involving temporal discrimination, the memory images about the intensity of sensation as a function of stimulus deviates from smooth logarithmic form in small scales by becoming piecewise continuous function [J80] such that the plateaus where response remains constant are octaves of each other. This suggests that the memory image about the sensation depends only on the 2-adic norm of the 2-adic image of the ratio I/I_0 of the intensity of the stimulus to the threshold stimulus under canonical identification.

This observation suggests a generalization inspired by 2-adic version of music metaphor. Primary quale has multiple of cyclotron frequency as its correlate and, being integer valued, is essentially 2-based logarithm of the 2-adic norm for the 2-adic counterpart of the intensity of the sensory input. Hence the increase of intensity of the sensory input by octave correspond to a jump-wise replacement of the n: th harmonic by n+1: th one and should be seen in EEG. Our experience usually corresponds to the average over a large number of this kind of primary experiences so that underlying 2-adicity is smoothed out. In case of over-learning or neurons involved act unisono and the underlying 2-adicity is not masked anymore. At the level of ELF selves this would mean generation of higher harmonic when the number of nerve pulses per unit of time achieves threshold value allowing the amplification of corresponding frequency by the mechanism discussed already earlier.

11.3 Various Aspects Of Cognition

In the following various aspects of cognition are discussed further. The representation differs from the earlier one in some important aspects. Adelic view about sensory-cognitive representations replace the idea about weakly dependent sensory and cognitive representations: in the new view real and p-adic space-time sheets are determined by strong form of holography from string world sheets and partonic 2-surfaces - "space-time genes". ZEO allows a precise formulation of various ideas related to time reversed cognition. The replication of magnetic bodies suggests itself as a counterpart for the replication of memes. The idea about quantum jumps transforming p-adic space-time sheets to real ones or vice versa is given as mathematically awkward one.

11.3.1 P-Adic Physics And Imagination

p-Adic non-determinism makes it natural to interpret p-adic space-time sheets as geometric correlates of cognitions. A natural guess is that p-adic physics is also physics of imagination but one must very carefully define what this means and whether it can make sense. The original idea that imagination corresponds to building of p-adic variants of the action transformed to real ones. This idea meets however grave mathematical difficulties and is un-necessary.

In the adelic picture the p-adic representations automatically accompany all physical systems, even elementary particles: this is consistent with the success of p-adic mass calculations.

One can also ask whether p-adic nondeterminism really plays any important role in imagination. One can of course imagine that the assignment of space-time surfaces to 2-D space-time genes is not unique due to the presence of pseudo-constants. But what this non-uniqueness could mean?

If sensory organs are the seats of the primary sensory qualia, one can understand imagined sensory experience as a perception, which does not start from the level of sensory organs but some higher level and gives rise only to cognitive representations. Dreaming and hallucinations would involve a feedback to the primary sensory organs "qualiafying" the cognitive representations. If motor action can be identified as a time reversal of the sensory perception in a relevant time scale for MEs then imagined motor actions would differ from real ones only in that they would be initiated from some higher level than muscles and proceed to brain and from brain to magnetic body. Imagined would be almost realized.

11.3.2   How Dreams And Hallucinations Relate To Sensory Experiences?

If primary sensory qualia are realized at the level of sensory organs, then dreams and hallucinations would be virtual sensory experiences with sensory input from magnetic body and brain instead of external world. Rapid eye movements and oto-acoustic sounds would be a signature of this process. Spontaneous movements during dreaming would in turn be the signature of the imagined motor activities. I have proposed this view about dreams already earlier and explains nicely the observations of Claude Rifat about lucid dreaming [J42]. The strange piecewise logical consistency of dreams is consistent with smaller value of Planck constant $h_{eff} = n \times h$ implying shorter time scale of memories and planned actions. The original interpretation was that it reflects p-adic non-determinism.

This view about dreaming is in accordance with the observations (reviewed in [J110]) that dreaming is not produced by random inputs from brain stem to cortex but is cognitive skill learned gradually during infancy. The most primitive dreams represent static pictures, then these pictures become dynamical, and at the age of about eight the dreamer becomes a participant of the dream. In lucid dreaming the dreamer has taken active role in transforming cognitive representations to sensory experiences.

One must actually distinguish between two kinds of "hallucinations": a genuine sharing of sensory mental images involving no "qualiafication" and interpretable as telepathy, and the receival of cognitive information, which is then qualiafied by the receiver like during dreaming. The presence/absence of a feedback to the sensory organs allows to discriminate between these options. The semitrance model for the bicameral mind [K91] relies on the idea that these experiences are communicated by higher levels of the self hierarchy during semitrance. This communication could be purely telepathic.

11.3.3   Cognition, Sensory Experience, And Boolean Mind

Thoughts have not color and pure thoughts seem to be free of emotions, with aesthetic experiences induced by abstract ideas being perhaps an exception. Pure thoughts involve often the experience that something is true or false but not beautiful or ugly or right or wrong. These simple observations provide tests for the identification of the p-adic physics as physics of cognition and for the model of sensory qualia, Boolean qualia, and emotions. These observations also suggest a concrete identification of the physical correlates for the Boolean algebras of ethics, aesthetics, and logics.

Are qualia number theoretically universal?

Sensory qualia were originally identified as averages of quantum number increments associated with the quantum jump sequence defining the sub-self representing sensory mental image. The recent view inspired first by the sensory capacitor model of qualia [K39, K33] and then suggested strongly by ZEO based definition of self reducing to the TGD inspired quantum measurement theory leads to a somewhat different view.

Qualia correspond to quantum number flows between subsystem defining sub-self and environment continuing as long as the mental image representing the qualia defined by quantum

numbers of flowing particles. Quantum numbers of flowing particles instead of quantum number increments define qualia. There is high temptation to assume that qualia involve a transfer of negentropic entanglement. Also the flow of metabolic energy is proposed to involved it. This raises the question whether fundamental qualia are associated with metabolites- not only metabolic energy but also important bio-molecules carrying NE: certainly this would be very natural.

In the recent view all qualia related to fermions are number theoretically universal so that one cannot regard them a p-adic or real: this at least in the intersection of reality and p-adicities. Strong form of holography in any case demands that fermionic qualia can be assigned with string world sheets and partonic 2-surfaces at the fundamental level. The strong form of holography suggests that the qualia associated with quantum numbers in bosonic WCW degrees of freedom can be also localized to these 2-surfaces.

What about geometric qualia carrying geometric information? Do they make sense as it would seem? It is not at all clear whether sensory capacitor model applies to them. Rather, it would seem that string world sheets and partonic 2-surface define kind of conscious skeleton of space-time surface allowing conscious localization of various qualia. Does this mean that one can assign even geometric qualia to the 2-D objects - say their positions and velocities.

What is then the role of the space-time surfaces? How do they contribute to conscious experience? The answer to this question should be based on quantum classical correspondence realized as the analog of AdS/CFT correspondence in TGD. The zero modes of space-time surfaces provide a dual classical representation of quantum states necessary to interpret quantum measurements. The space-time surface generates correlations between the 2-surfaces otherwise absent and could bind the experiences to a coherent whole. Here quantum gravitational quantum coherence could play crucial role as the model for bio-photons as decay products of dark photons suggests. Could it be that cognition builds the 4-D representation from the 2-D representation as theoretical physicist might argue?

Here the question about uniqueness of the holographic correspondence becomes important. In particular, in p-adic case this could give rise to additional degeneracy which might however have interpretation as gauge degeneracy.

Does cognition involve emotions?

It is a fact of neuroscience that emotions and information are closely related [J43]. I have considered two views trying to mathematisize this finding.

1. Emotions could correlate with the rates of change for the negentropies associated with various quantum number increments in quantum jump sequence determining self. It seems that it is not possible to classify emotions or qualia to real and p-adic ones: number theoretical universality holds true.

2. Emotions could also correlate directly with the negentropy of the entanglement. Negentropic sub-selves would define mental images with positively colored emotions and entropic ones those with negatively colored emotions.

A naïve view about three dichotomies

Beautiful/ugly, right/wrong, and true/false dichotomies relate to the comparison of experience with some standard. Beautiful/ugly relates to sensory experience, right/wrong characterizes deeds, and true/false logical statements. What comes in mind that these dichotomies could be interpreted as Boolean qualia assignable to quantum jumps in purely fermionic degrees of freedom. The first guess is that these dichotomies could reduce to negentropic/entropic dichotomy.

1. Right/wrong relates to intentional actions - deeds - and therefore to the first quantum jump to the opposite boundary of CD in which old sub-self disappears and new one is born. This dichotomy could be understood in terms of weak form of NMP allowing free will and possible quantum correlates for ethics and moral [K116]. Strong form NMP would state that the reduction is always such that negentropy gain is maximal: the final state sub-space has a dimension for which the negentropic entanglement gain is maximal. Weak form of NMP allows also to choose some sub-space of any eigen-space of density matrix. Weak NMP

can also allow in some situations larger negentropy gain than the strong form of NMP and explains the generalized p-adic length scale hypothesis. The higher the negentropy gain, the more right the choice would be.

2. Beautiful-ugly dichotomy relates to sensory experience and should accompany the sequence of state function reductions at the same boundary of CD giving rise to self. What is interesting that the weak form of NMP impies that for a *fixed* fermionic Fock basis there are $2^n - 1$ sub-spaces, which can be selected in the reduction if the eigen-space is n-dimensional. This corresponds to a Boolean algebra with the physically non-realizable element (having empty set as set theoretic counterpart) thrown away. Could this give an emotional realization of Boolean algebra so that various choices would each give rise to some negentropy gain allowing to order them with respect to negentropy. Could this correspond to the aesthetic dimension? How to map this representation to a fermionic representation. Could the n-sheets of the singular covering of the space-time surface for which both ends collapse to single 3-surface carry the fermions and negative energy antifermions at the ends?

3. One should explain also the true-false aspect. Fermionic Fock states define Boolean basis and one can decompose it to independent states and their conjugates. True statements should correspond to some preferred basis with preferred direction of say fermion spin defining quantization axis.

11.3.4 Replication Of Memes, And Morphic Fields

What are the counterparts of memes in TGD framework? The identification of memes as zero energy states assignable to string world sheets and partonic 2-surfaces is one possible identification at fundamental level but so general that it does not say much. At the space-time level the magnetic bodies assignable to physical systems are a very natural candidates. String world sheets and partonic 2-surfaces accompany them and define the intersection of reality and p-adicities. The original idea was that p-adic space-time sheets could correspond to memes but it seems that memes corresponds to an entire adelic structure for which sensory-cognitive representations reside in the intersection.

Replication of sensory-cognitive representations

Memes are in central role in the theory of Susan Blackmore [J137] and magnetic bodies are excellent candidates for the space-time correlates memes understood in a more general sense. The replication of memes would reduce to a replication of 3-surfaces occurring at partonic 2-vertices and would be completely analogous to what happens in 3-vertex of Feynman diagram. This replication would also induce ordinary biological replication as visible matter self-organizes around the replicas of the magnetic body. This leads to a new view about genetic code as something realized at the level of dark magnetic bodies and becoming visible via this self-organization [K42].

Contrary to the vision of Susan Blackmore, memes would be conscious selves rather than unconscious deterministically behaving objects, and brain would not be an un-conscious machine used by memes but serving as a vehicle making possible for meme replication.

Although the notions of the meme and meme replication are very attractive, the mechanism of imitation is only partially known. The so called mirror neurons are certainly an important of it. Learning by imitation could be understood as a process in which a sensory-cognitive representation as in sensory perception is formed as particular magnetic body and then replicates.

Time reversed cognition and reverse speech

Time reversed cognition and reverse speech are interesting phenomena allowing possibility to test these ideas.

1. Time reversed cognition

Time reflection yields time reversed and spatially reflected sensory-cognitive representations. When mental image dies it is replaced with its time-reversal at opposite boundary of its CD. The observation of these representations could serve as a test of the theory.

There is indeed some evidence for this rather weird looking time and spatially reversed cognition.

1. I have a personal experience supporting the idea about time reversed cognition. During the last psychotic episodes of my "great experience" I was fighting to establish the normal direction of the experienced time flow. Could this mean that for some sub-CDs the standard arrow of time had reversed as some very high level mental images representing bodily me died and was re-incarnated?

2. The passive boundary of CD corresponds to static observing self - kind of background - and active boundary the dynamical - kind of figure. Figure-background division of mental image in this sense would change as sub-self dies and re-incarnates since figure and background change their roles. Figure-background illusion could be understood in this manner.

3. The occurrence of [J100] is a well known phemonenon [J100] (my younger daughter was a reverse writer). Spatial reflections of MEs are also possible and the arrow of geometric time might determine the direction in mirror writing.

4. Reverse speech would be also a possible form of reversed cognition. Time reversed speech has the same power spectrum as ordinary speech and the fact that it sounds usually gibberish means that phase information is crucial for storing the meaning of speech. Therefore the hypothesis is testable.

2. Reverse speech

Interestingly, the Australian David Oates claims that so called reverse speech is a real phenomenon [J25], and he has developed entire technology and therapy (and business) around this phenomenon. What is frustrating that it seems impossible to find comments of professional linguistics or neuro-scientists about the claims of Oates. I managed only to find comments by a person calling himself a skeptic believer but it became clear that the comments of this highly rhetoric and highly arrogant commentator did not contain any information. This skeptic even taught poor Mr. Oates in an aggressive tone that serious scientists are not so naïve that they would even consider the possibility of taking seriously what some Mr. Oates is saying. The development of science can often depend on ridiculously small things: in this case one should find a shielded place (no ridiculing skeptics around) to wind tape recorder backwards and spend few weeks or months to learn to recognize reverse speech if it really is there! Also computerized pattern recognition could be used to make speech recognition attempts objective since it is a well-known fact that brain does feature recognition by completing the data into something which is familiar.

The basic claims of Oates are following.

1. Reverse speech contains temporal mirror images of ordinary words and even metaphorical statements, that these words can be also identified from Fourier spectrum, that brain responds in unconscious manner to these words and that this response can be detected in EEG. Oates classifies these worlds to several categories. These claims could be tested and pity that no professional linguist nor neuroscientist (as suggested by web search) has not seen the trouble of finding whether the basic claims of Oates are correct or not.

2. Reverse speech is complementary communication mode to ordinary speech and gives rise to a unconscious (to us) communication mechanism making lying very difficult. If person consciously lies, the honest alter ego can tell the truth to a sub-self understanding the reverse speech. Reverse speech relies on metaphors and Oates claims that there is general vocabulary. Could this taken to suggest that reverse speech is communication of right brain whereas left brain uses ordinary speech? The notion of semitrance used to model bicameral mind suggests that reverse speech could be communication of higher levels of self hierarchy dispersed inside the ordinary speech. There are also other claims relating the therapy using reverse speech, which sound rather far-fetched but one should not confuse these claims to those which are directly testable.

Physically reverse speech corresponds to phase conjugate sound waves which together with their electromagnetic counterparts can be produced in laboratory [D6, D13]. Phase conjugate waves have rather weird properties due the fact that second law applies in a reversed direction of geometric time. For this reason phase conjugate waves are applied in error correction. TGD based description of both electromagnetic and sound wave phase conjugation is based on negative energy space-time sheets representing classically electromagnetic fields and Z^0 fields [K34].

Negative energy topological light rays are in a fundamental role in the TGD based model for living matter and brain. The basic mechanism of intentional action would rely on time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig. ??** in the appendix of this book) utilizing the TGD counterparts of phase conjugate waves producing also the nerve pulse patterns generating ordinary speech. If the language regions of brain contain regions in which the the arrow of psychological time is not always the standard one, they would induce phase conjugates of the sound wave patterns associated with the ordinary speech and thus reverse speech.

ZEO based quantum measurement theory, which is behind the recent form of TGD inspired theory of consciousness, provides a rigorous basis for this picture. Negative energy signals can be assigned with sub-CDs representing selves with non-standard direction of geometric time and every time when mental image dies, a mental images with opposite arrow of time is generated. It would be not surprising if the reverse speech would be associated with these time reversed mental images.

A connection with the ideas of Sheldrake

In [K87, K55] I have discussed a possible TGD based justification of Sheldrake's ideas about learning at the level of species.

If one assumes that memes correspond to magnetic bodies, that the replication of memes by topological replication of magnetic bodies is possible [K55], and that MEs involved can have even sizes of order Earth size and are associated with cyclotron transitions at magnetic bodies, it is not too difficult to imagine how species memory could be realized. Magnetic bodies cold take the role of the morphic fields in TGD framework and represent habits, skills, ideas, ... Susan Blackmore would call these morphic fields memes but basically only a naming convention and generalization is in question (amusingly, skeptics regard Sheldrake as a pseudoscientist but Blackmore as a serious scientist, perhaps because she has emphasized her skepticism in the publicity!).

The meme associated with the development of a particular skill could be realized in a particular brain and replicate itself. When the magnetic replicas would encounter other brains of the same species, the skill could be manifested as a real action and lead to learning without direct sensory communication.

Sheldrake's theory thus generalizes memetics and would thus make Sheldrake pseudo scientist! Labels are dangerous: needless to add that certainly Blackmore has not been using them. That a given meme could be realized only in brains of the same species might be understood in this framework by using resonance argument: morphic resonance is the notion used by Sheldrake which could reduce to cyclotron resonance for dark photons with frequencies in say EEG range but energies in the range of bio-photons and therefore maximally bio-active. The precise cyclotron frequencies - that is precise values of magnetic fields associated with the parts of magnetic body- would characterize species and make possible resonant communication restricted within species.

It is also possible that stochastic resonance [D8] to be discussed later in more detail could be involved with the morphic resonance. The individuals that learned the habit first, need not even live anymore since c memes remain and replicate even when the physical body dies.

11.4   Frontal Lobes And TGD

Negentropic entanglement (NE) is possible and is stable against self measurement if NMP holds true. Even weak form of NMP is enough and strongly favoured. This very encouraging finding suggests that cognition involves the p-adic aspects in an essential manner. For instance, number theoretic entanglement entropy would make it possible to understand what it is to understand! To

have an experience of understanding is to have a sub-self (cognitive mental image) with a positive entanglement negentropy.

Frontal lobes are regarded as seats of the highest mental functions such as cognition, intention, volition, attention, evaluation of actions, self model, and perception of and reaction to social situations. Long term memory and language are largely independent of frontal lobes whereas working memory can be located to the dorsolateral parts of prefrontal lobes. Thus the concrete model both the p-adic aspects of the physics of sensory experience, intention, and cognition might boil down to a model of frontal lobe function. Of course, also the notions of field body and magnetic body are needed to understand the highest levels of the control. In particular, social control could be performed basically by the multi-brained collective selves by activation of social habit routines as suggested by the fact that the persons who have lost these routines are able to deduce the correct social behaviour.

11.4.1 Basic Functional Anatomy Of Frontal Lobes

Frontal lobes involve the most complex association networks of brain. In fact so complex, that the diagnostics based on simple reflex schema and the idea about exact locations of mental functions applied to subjects having serious frontal lobe damage suggested that frontal lobes have no function at all! Only a view in which brain is regarded as self-regulating and self-organizing system allowed to develop diagnostic tools revealing the effects of frontal lobe damage.

Dorsolateral frontal lobes seem to be specialized with various aspects of cognition such as problem solving, judgement, reasoning, and discrimination. In particular, what is identified usually as working memory is located here. These areas are also involved with imagination and corresponding loops extend to sensory areas. In TGD framework dreams can be seen as a particular kind of imagination in which imagined sensory features are mapped to the magnetic sensory canvas.

The medial and ventral frontal lobes are involved with intention, planning, volition, and attention. These regions are also crucial for the routine perception of and reaction to social situations. Affect and motivation are crucial concepts here and the complex circuits connecting frontal lobes, amygdala/brain stem and cortex are essential for planning and decision making. Salience detection or rather, selective amplification of those aspects of percepts which are significant seems to be basic function of these loops. The lesion for these loops implies effective loss of volition as well as emotional flatness.

Phineas P. Gage is a classic example of a person with serious damage for the circuits. He did not lose either his intellectual abilities nor memory but lost the ability of planning and the access the previously acquired social conventions and rules, and became childish and irresponsible. Gage was also well aware that he did was not anymore able to react emotionally. Gage was also able to use to theoretically deduce what would be the appropriate behaviour in social situations but in everyday life this was impossible.

These findings suggest that frontal lobes perform high level control and habit routines are the basic tools of cognition and planning, and that frontal lobes both active, generate, modify and replace these habit routines by new ones. Using brain as computer metaphor one might say that working memory provides the initial values of the parameters of the habit routines.

11.4.2 Some Neurophysiological Findings Related To The Functioning Of Frontal Lobes

The notion of cortical tone characterizes the state of cortex and is maintained by CNS. In so called inhibitory phase state the tone is low and brain responds with similar response to both strong and weak stimuli. This phase is also called equalization phase. In paradoxal phase weak stimuli can give rise to strong responses and vice versa. In this state no organized thought appears and selective associations are replaced by non-selective and more or less random associations. REM sleep is regarded as an example of paradoxal phase. The interaction between medial frontal lobes, reticular activating system and cortex controls the cortical tone.

Gray Walter found that any expectation elicits characteristic slow waves emanating from frontal lobes and spreading to other regions. Expectancy wave diminishes if the probability of expected signal diminishes. When the instruction that elicited the expectation states is negated, the wave ceases. Similar wave phenomenon is detected during concentration, say during an attempt

to solve a complex mathematical problem. The interpretation as a correlate for binding by quantum entanglement suggests itself.

Orienting reaction is a vegetative and electrophysiological reaction to stimulus. Constriction of the vascular system to the arms, dilation of the vascular system to the head, galvanic skin changes and alpha wave amplitude reduction are involved. Habituation to the stimulus reduces orienting reaction. Orienting reaction can be however increased and stabilized by verbal instruction that links meaning to the stimulus. If frontal lobe lesion affects attention, the orienting reaction fails to be stabilized by this mechanism. The interpretation is that for polar, medial and mediobasal section of the frontal lobe, the physiological tools for the regulation of attention are deranged.

11.4.3 TGD Based View About Frontal Lobes

The TGD based model for how frontal lobes cognize forces some new interpretations of classic experiments. Also a new view about working memory is unavoidable.

Paper, pencil, and eraser metaphor

The inability to modify existing routines or replace them with new ones rather than loss of these routines seems to accompany the lesions of ventromedial frontal lobes. Or more precisely, new routines can be acquired but instantaneous replacement of active routines with new ones is not possible. In a classic experiment already performed by Pavlovian school a person having a frontal lobe lesion in the ventromedial area started to plane a plank and continued until there was no plank anymore and continued to plane of the bench. In the so called Wisconsin card sorting test the subject is presented with a series of stimulus cards and a deck of response cards. The cards bear coloured geometric patterns and can be matched by categories such as colour, form or number. The experimenter selects category but does not inform subject person who guesses rapidly the category by trial and error. After ten cards experimenter changes the category without informing the subject person about the change. Patient is not able to revise his strategy and continues to make wrong guesses.

These persons can adopt strategy but cannot change it. This is something very essential. The proposed interpretation is however that these persons do not have motor imagination and therefore cannot construct new habit routine. This seems to be wrong since in the beginning card experiment the subject was able to achieve this. Something more delicate is involved: patient is not able to replace an activated strategy with a new one instantaneously The activated strategy however becomes deactivated spontaneously sooner or later.

This leads to pencil, paper, and eraser metaphor as a model for what frontal lobes are doing. Creation of habit routines is creation of symbolic representations and frontal lobes both create and erase habit routines just as we do when we do our calculations or type text to computer file. The patient with dorsolateral frontal lobe lesion must wait until the erasure happens spontaneously to establish a new habit routine. Of course, sticking into habit routines seems to a part of human condition, in particular at the old age.

Interestingly, during psychedelic experiences frontal lobes are very active. Habit routines are what one gets rid in these experiences and also during meditation. The interpretation would thus be that a very intense erasure of old and generation of new habit routines is going on.

Working memory quantum mechanically

The notion of working memory does not seem to be an appropriate concept in TGD framework. The proper interpretation seems to be as erasure and replacement mechanism for habit routines. Short term geometric and subjective memories are automatic side products. Mirror mechanism is also now the natural mechanism for geometric memories but one cannot exclude the interpretation of working memory as subjective memory. Note that it does not make sense to construct long term memory representations of all intermediate stages of habit routine construction (just as it does not make sense to publish all intermediate and often erratic stages of a long mathematical calculation).

Erasure and replacement mechanism corresponds in spin glass metaphor to the kicking of the system out from the bottom of a potential well. In quantum framework this means a formation of

a de-localized state in zero modes followed by a localization to the bottom of some other potential well representing the new habit routine. Delocalized states in zero modes are however not possible. Rather, a generation of a bound state implying a temporary transformation of the zero modes in question to quantum fluctuating macroscopic quantum degrees of freedom is required. This is the TGD counterpart of Penrose-Hameroff mechanism. State of oneness, quantum computing macro-temporally quantum coherent system, moment of consciousness effectively lasting very many quantum jumps: all these characterizations apply to the resulting state.

The creation of new habit routine might even mean the changing synaptic connections. This would mean a multiverse state of multineuron system with different synaptic strengths such that one of these states is selected when the bound state decays. Interestingly, it is known that the synaptic connections related to the somatosensory representations of rat's whiskers change in an incredibly short millisecond time scale. The explanation as a macroscopic quantum effect strongly suggests itself.

Also quantum superposition of entangled axons with varying membrane potentials near axonal hillock and thus with a varying firing probability could be considered. Also the ends of axons might be in entangled quantum superposition: Ca^{++} waves and sol-gel transition might be involved.

Cognitive quantum computation like processes at neurolevel

If one assumes that an eigenstate of the density matrix or of the negentropy operator results in self measurement, the system must end up to an entangled state corresponding to some eigenspace of the density matrix. The requirement that the increase of entanglement negentropy is maximal, fixes this eigenspace uniquely. For the resulting state density matrix is proportional to unit matrix and entanglement negentropy is maximal $N_R = Nlog(p)$, when the number of states is $n = p^N n_0$, n_0 not divisible by p, $N > 0$: otherwise it vanishes. Quantum computers indeed operate with systems for which entanglement probabilities are identical. A very strong prediction is that the dimension of the state space should be divisible by p^N.

A possible neurolevel realization of a cognitive quantum computation is following.

1. Information is represented as a sequence of p-adic and real memetic qupits along axon. If the effective phase velocity ofME is sufficiently low quite high number of qupits can be realized as already found. Incoming p-adic and real memetic codewords can be taken to be identical un-entangled sequences of p-adic and real memetic codewords. The unitary time development is discrete with a time step of 1/1270 seconds and lasts an integer multiple of $T_2(127) = .1$ seconds (127 steps). Thus the minimal quantum computation involves $2^{127} - 1$ quantum jumps effectively glued to a single quantum jump by macro-temporal quantum coherence. The outcome of the cognitive self-measurement is a pair of memetic codewords representing the initial memetic codeword and the result of the cognitive quantum computation.

2. A conscious experience results, when the spin directions of the real oddball qubits flip to the direction of the external magnetic field at the cell membrane space-time sheet. The spatial sequences of qubits in the direction of the magnetic field are excluded because these states do not give rise to any spin flips. In this manner a quantum computer with $p = 2^{127} - 1$ results. The spin flips of the real qubits induce MEs which in turn induce membrane oscillations and perhaps even nerve pulses.

11.4.4   Goal Structures And Emotions

Daniel Pouzzner has proposed quite an interesting theory of emotions relating most emotions to cognitive models and goal structures [L43]. Goal structures are also cognitive models assumed to have correlates at the level of neurophysiology.

Quite many emotions originate basically from comparisons of expectations or goals with reality and Pouzzner's model of emotions relates emotions to the dynamics of the goal structure. The failure to reach a goal or giving up a goal is accompanied by a disappointment or sadness; realization of a goal is accompanied by a feeling of success; fear or rage is experienced when the achievement of a goal is threatened. The failure of a model is accompanied by a surprise; the success of a model, which has been questioned by experience involves a feeling of relief; etc..

There are of course exceptions: for instance, physical pain and pleasure, excitement, love and perhaps also pure rage without any object. The basic question is whether the comparison type emotion accompanies inherently comparison or whether emotions as such have nothing to do with comparisons and brain has only evolved to associated emotions to comparison results to guide the behaviour. In the model of Pouzzner the latter view is adopted and various neurotransmitters are identified as correlates of emotions. The problem is to understand how cognitive models and goals could be represented in real physics.

In TGD framework negative emotions relate to the increase of the entropies associated with various quantum number and zero mode increments defining qualia and are automatically generated in state function reductions in which sub-self representing mental image dies and re-incarnates at opposite boundary of CD. Contrary to the original believes one cannot assign emotions to any specific number field since they are number theoretically universal. Positively colored emotions relate to the increasing negentropies. The formation of negentropic generating sub-selves are obviously excellent candidates for quantum correlates of positive emotions. The challenge is two-fold.

1. Construct a concrete model for intentions and goal structures analogous to the model of long term memories. In fact, the two structures might differ only by time orientation and be represented by the active boundary of CD whereas the passive boundary would represent the self, kind of background to a figure.

2. Develop a model for the comparison process explaining why a quantum coherent sub-self results if the mental images about the predicted and actual states of the world are nearly identical and de-cohering sub-self results if these mental images are too different. Fractality of TGD Universe basically to quantum criticality allows to have scaled variants of sub-selves. The intelligent system must be able build scaled variants of its sub-selves having basically similar goal structures, and test statistically the average outcome of reduction to the opposite boundary from them. If the outcome of the real reduction is very different from that for the simulated reduction in shorter time scale, the outcome is disappointment or joy. In the simplest situation the goal is to yield negentropy and in this case the comparison between predicted and real events is simple.

A model of goal structures

The models for geometric memories and intentions should be very symmetrical the basic difference being that geometric past is replaced with the geometric future in the model for intentions: intentions are memories about geometric future in very precise sense. The new elements of the model are due to ZEO based notion of self. The static background contribution to self consciousness comes from the passive boundary of CD and the rest - such as intentions and memories - comes from the changing active boundary of CD.

Intention does not have p-adic space-time sheet as its correlate as the original idea went but something assignable to the evolution of sub-self by repeated state function reductions at passive boundary and involves both emotional and cognitive (real and p-adic) aspects. NMP forces the state function reduction to the opposite boundary to occur eventually and NMP must in some sense force the development of intention. Weak form of NMP however allows free choice. The one who chooses is the higher level self possessing the sub-self for which the state function reduction to opposite boundary occurs. We are gods of our mental images.

1. The content of intention or goal corresponds to the second member for the pair formed by the positive and negative energy parts of the zero energy state. Intentions and goals might also involve time like NE between the opposite boundaries of CD say that between the brain of the geometric now with the brain of the geometric future: in this case the intention involves abstraction. Whether the time like NE is necessary aspect of intention is not clear. NE between opposite boundaries of CD is would reflect finite measurement resolution and the degeneracy would be related to quantum criticality. M-matrix defined as a product of square root of S-matrix and real diagonal density matrix decomposing to a sum projection operators of various dimensions multiplied by real numbers would realize time-like NE.

2. It should be possible to speak about intention fields as analogs of perceptive fields and memory fields - characterizing various brain cells according to how long is the temporal distance T to the event of the geometric future representing the intention. The cells corresponding to the highest values of T should be found in frontal lobes. The value of T would correlate with quantum criticality and the value of $h_{eff} = n \times h$ and would be highest for frontal lobes defining kind of intelligence quotient. Large h_{eff} means that the size of the super-symplectic algebra represented as gauge symmetries is smaller so that the resolution of sensory and cognitive experience is better. It would seem that large value of h_{eff} must be assigned with the magnetic bodies of the cells, rather than cells and could be achieved by a large number of "deaths" and re-incarnations for the self assignable to he magnetic body.

In TGD cognitions and intentions should appear also at brain level and have definite correlates. A good guess is that cognitive representations are realized using memetic code in terms of MEs (of course, also em MEs might be involved). The model of music harmony and of genetic code provides a very concrete realization of this idea [K80].

How comparison type emotions could result?

What is needed is a concrete model for the comparison proces? One must answer several subquestions. What characterizes typical goals? What comparison means? What generates the positive or negative emotion in the comparison process? What is the fundamental quantum correlate of emotional coloring?

The challenge is to understand how comparison type emotions could result from the comparison of a sensory-cognitive model of reality with the reality. The model could be for a sub-self representing goal or ensemble of sub-selves representing scaled down variants of the sub-self. Fundamental goal helps self to say alive. Hence the death of goal sub-self must generate maximal negentropy gain to make NMP happy. Primary goal is expected to be such that its realization by a state function reduction at opposite boundary generates maximal negentropy gain meaning that it gives for self good changes to continue before the fatal state function reduction forced eventually by NMP, who wants NE by any means. There are also secondary goals formulated as concrete outcomes of state function reduction. There are hopes to achieve this if the achieved goal corresponds to a large negentropy gain.

1. The the mental image representing is sub-self whereas the prediction of the model is represented by scaled down variants sub-selves in shorter time scales. p-Adic length scale hierarchy and hierarchy of Planck constants allow to realize the scaling. Contrary to the original expectations p-adic space-time sheets are not in special role although they are essential part in adelic picture.

2. The members of the modelling ensemble of sub-selves are born and die and generate some average negentropy. If this average negentropy is large, there are good hopes that the goal assigned with sub-self can be realized. If this is not the case, self can modify the sub-self representing the goal to make it more realistic. Eventually the goal sub-self dies and generates the attempt to realize the goal. It the negentropy gain is smaller than expected, disappointment results. If its is higher, self has reasons to be happy. A more precise comparison would require a more precise characterization of the contents of goal.

11.4.5   Figure-Background Rivalry

The classical demonstration of figure-background rivalry (`http://tinyurl.com/y7nojvey`) is a pattern experienced either as a vase or two opposite faces. This phenomenon is not the same thing as bi-ocular rivalry in which the percepts associated with left and right eyes produced by different sensory inputs are rivalling. This phenomenon is not the same thing as bi-ocular rivalry in which the percepts associated with left and right eyes produced by different sensory inputs are rivalling. There is also an illusion in which one perceives the dancer to make a pirouette in either counter-clockwise or clockwise direction although the figure is static. The direction of pirouette can change. In this case time-reversal would naturally change the direction of rotation.

Figure-background rivalry gives a direct support for the TGD based of self relying on ZEO if the following argument is accepted.

1. In ZEO the state function reduction to the opposite boundary of CD means the death of the sensory mental image and birth of new one, possibly the rivalling mental image. During the sequence of state function reductions to the passive boundary of CD defining the mental image a boundary quantum superposition of rivalling mental images associated with the active boundary of CD is generated.

   In the state function reduction to the opposite boundary the previous mental image dies and is replaced with new one. In the case of bin-ocular rivalry this might be the either of the sensory mental images generated by the sensory inputs to eyes. This might happen also now but also different interpretation is possible.

2. The basic questions concern the time reversed mental image. Does the subject person as a higher level self experience also the time reversed sensory mental image as sensory mental image as one might expect. If so, how the time reversed mental image differs from the mental image? Passive boundary of CD define quite generally the background - the static observer - and active boundary the figure so that their roles should change in the reduction to the opposite boundary. In sensory rivalry situation this happens at least in the example considered (vase and two faces).

   I have also identified motor action as time reversal of sensory percept. What this identification could mean in the case of sensory percepts? Could sensory and motor be interpreted as an exchange of experiencer (or sub-self) and environment as figure and background?

   If this interpretation is correct, figure-background rivalry would tell something very important about consciousness and would also support ZEO. Time reversal would permute figure and background. This might happen at very abstract level. Even subjective-objective duality and first - and third person aspects of conscious experience might relate to the time reversal of mental images. In near death experiences person sees himself as an outsider: could this be interpreted as the change of the roles of figure and background identified as first and third person perspectives? Could the first moments of the next life be seeing the world from the third person perspective?

   An interesting question is whether right- and left hemispheres tend to have opposite directions of geometric time. This would make possible metabolic energy transfer between them making possible kind of flip-flop mechanism. The time-reversed hemisphere would receive negative energy serving as metabolic energy resource for it and the hemisphere sending negative energy would get in this manner positive metabolic energy. Deeper interpretation would be in terms of periodic transfer of negentropic entanglement. This would also mean that hemispheres would provide two views about the world in which figure and background would be permuted.

   A further interesting question relates to near death experiences (NDEs). In biological death the roles of boundaries of CD are changed and figure becomes background and vice versa. This could also mean that third person perspective becomes first person perspective and vice versa. In NDEs one indeed sees ones's own body from outside. Could this mean that in the beginning of reincarnation third person perspective dominates. One can go even further and ask whether the habit of children to talk about themselves as third person could relate to the dominance of third person perspective.

   Quantum TGD brings in also other new elements.

1. In the conceptual framework of the standard quantum mechanics there is no known mechanism making possible macroscopic quantum coherence in the time scales involved. If dark matter with large h_{eff} is involved with the formation of conscious percept there is no problem in understanding the time scales in question. Actually a hierarchy of rivalries of various kinds in various time scales is predicted corresponding to the p-adic time scale hierarchy and hierarchy of Planck constants.

2. Another ingredient which is new from the point of view of standard quantum mechanics is that the hierarchy of Planck constants implies self hierarchy. The fractal structure of state function reduction process means that it is possible have macroscopic quantum behavior in given time scale but dissipative self-organization in shorter time scales.

   This is actually not new: in hadron physics hadrons are described as quantum systems whereas parton dynamics in the shorter time scales is assumed to be dissipative. In the

recent case this means the possibility of quantum superposition of dissipative self-organization processes involved with the formation of neuronal correlates of percepts and proceeding in time scales of order milliseconds considerably shorter than the time scale of binocular rivalry.

11.4.6 Experimental Support For Binocular Rivalry As A Quantum Phenomenon

For years ago I constructed a quantum model for binocular rivalry and generalized it to a general model of volitional act as a quantum jump selecting not only between alternative motor actions but also between percepts. In this model different alternatives were represented as superpositions of neural firing patterns. The model allows to see sensory perception as an active volitional process (at some level of hierarchy of selves) and explains sensory rivalry as a quantum phenomenon.

The work of Efstratios Manaosakis

I learned from New Scientist [J152] that physicist Efstratios Manousakis has now published an interesting work [J62] about binocular rivalry providing experimental support for this model.

Recall that the classical demonstration of binocular rivalry [J5] is using different sensory inputs to left and right eye: figures can have different color or shape or be just different. Subject person does not see a superposition of figures but either or them. The two percepts alternate with some frequency and it is not possible to consciously experience both patterns simultaneously. This has led Manousakis to consider the idea that binocular rivalry could provide direct evidence for the notion of quantum consciousness. The obvious idea is that either of the percepts results by a state function reduction from the superposition of both percepts. As already explained this phenomenon need not have anything to do with figure-background rivalry.

The model predicts that the flip rate correlates with neuronal firing rate. The prediction is confirmed by using as subjects persons who have a reduced firing rate due to the use of LSD. The work of Manousakis might turn out to be an important step of progress in the development of theories of quantum consciousness and might help also main stream physicists to get rid of their atavistic fears relating quantum consciousness.

Justification for the model in TGD framework

TGD based model for rivalry and its generalization

The TGD based quantum model for binocular rivalry relies on the idea that the formation of quantum superposition of competing percepts is somewhat analogous to quantum computing in which large number of quantum parallel computations are carried out and one computation is selected as the computation halts. TGD however brings in also some new elements.

1. In ZEO the state function reduction in question means the death of the sensory mental image and birth of new one, possibly the rivalling mental image. During the sequence of state function reductions to the passive boundary of CD defining the mental image a boundary quantum superposition of rivalling mental images associated with the active boundary of CD is generated. In the state function reduction to the opposite boundary the previous mental image dies and is replaced with itself or with rivalling mental images and is assignable to the opposite boundary.

2. One could think that the two percepts correspond to two different quantum stats at active boundary of CD: the attention of self is directed to either left or right sensory input and superposition of these states is possible at active boundary of CD whereas at passive boundary either one is selected. This would make possible considerable metabolic economy since metabolic costs would be halved.

   The proposal for the space-time correlate of directed attention is flux tubes connecting the perceiver and perceived and involving resonant transfer of dark cyclotron photons. Different configurations of connecting and active flux tubes would serve as a concrete correlate for left and right-attention.

3. As proposed the opposite boundaries of CD would naturally correspond to figure and background. What could this mean in the case of sensory mental images in the case of bin-ocular rivalry?

The formation of quantum superposition of right and left percepts has evolutionary advantages which suggest also a generalization to a model of volitional action as a selection between neural firing patterns leading to alternative motor actions. As a matter fact, in ZEO motor actions and sensory percepts as mental images are time reversals of each other so that the suggestion is a prediction of ZEO.

1. The formation of superposition would be metabolically advantageous. In the classical world one should form both right and left percept simultaneously. The associated self-organization process requires a metabolic energy feed. When only single brain hemisphere forms the percept and one has quantum superposition of right and left percepts metabolic energy feed is reduced by factor 1/2. A highly synchronous neural firing distinguishes the perceived stimulus from non-perceived so that a quantum superposition of patterns of two neural firing patterns would be in question.

2. This picture leads naturally to a proposal that one function of sleep is to make possible quantum superposition of large number of neural firing patterns via quantum entanglement with external systems (perhaps other sleeping brains) so that sleep would be a process analogous to quantum computation.

3. The formation of alternative percepts would have an obvious evolutionary advantage in a situation in which several percepts are consistent with the sensory input. For instance, bipolar mood disorders seem to involve sticking of consciousness to either hemisphere. This generalizes also to cognition: of course, percepts actually consist of sensory input plus cognition.

4. This framework is behind TGD based model of volitional action applying to both motor actions and selection of sensory percepts. For a brain living in jungle it would be highly advantageous to develop in a difficult situation a quantum superposition of alternative motor actions and select the proper one only at the eleventh moment.

5. Sensory rivalry is analogous to an ability to move fluently between - say - skeptic and new age views about world. There is also a parallel at the level of society and in TGD framework the rivalry of various views (religions, political parties, competing scientific theories, ...) might perhaps be seen as counterpart of binocular rivalry at the level of collective consciousness. The complete dominance of only single view - be it religious or materialistic world view, market economy or communism, or super-string model or loop quantum gravity - would be something comparable to a bimodal mood disorder.

Alternative TGD based model for binocular rivalry

Science Alert reported an interesting result from neuroscience. The title of the popular article was "A New Brain Experiment Just Got Closer to The Origins of Consciousness" (see http://tinyurl.com/y9n9mbjm). The original article "Human single neuron activity precedes emergence of conscious perception" is published in Nature [J66] (see http://tinyurl.com/y7rhklsr).

The researchers in Tel Aviv University studied people suffering from epilepsy: the epilepsy as such is however not relevant for the research interests. During more than 20 sessions the volunteers stared at a pair of images. Each image was located in front of one eye. Because each eye saw only one image, the brains couldn't fuse the images into single picture. Instead, the brain choose one image to deal with at a time. This process is known as binocular rivalry. The article claims that this process allows to separate visual stimulation and conscious seeing for each other. I would however argue that the outcome of the experiment relates to binocular rivalry rather than generation of conscious percept itself.

The finding was that medial-frontal lobe becomes active two seconds before the subject sees the picture. A second zone becomes active second later in medial-temporal lobe (that is 1 second before the conscious visual percept). These time scales are rather long as compared to time scale

of 0.08-.1 seconds associated with sensory mental images - one might call this time scale a duration of sensory chronon.

As article explains, these experiments differ from the usual experiments studying the behavior of medio-temporal neurons in response to various modifications of the sensory input (flashing a different image to the other eye; backward masking, in which a briefly presented image is suppressed by the immediate presentation of a mask image; and the attentional blink, in which the second of two target stimuli appearing in close succession is often not perceived). Also these experiments study what happens at brain level as the visual percept changes but the change is now induced externally rather than internally as in binocular rivalry. The response of MTL neurons started about .2-.3 seconds after the external manipulation. There was no activation before the change.

If I understood correctly, the interpretation of the finding was based on computational paradigm. According to this interpretation it takes about 2 seconds to compute the new visual percept when the decision about new percept is made. One might however argue that this computation should take 2 seconds also in the case of externally induced change of percept. Actually the time for the emergence of the percept is .2-.3 seconds and there was no activation before the change.

In TGD framework this longer time scale would naturally correspond to a higher level in self hierarchy. In self hierarchy mental images correspond to sub-selves and self is sub-self of self at the higher level of the hierarchy. Each level is characterized by time scale and the higher the level in the hierarchy, the longer the time scale.

1. Could a higher level self direct its attention to alternative percepts in bio-ocular rivalry in more or less random manner? Could this re-directing of attention be seen as a motor action at some level of self hierarchy? This is the case when I turn my gaze from one object of the perceptive field to another one.

2. In TGD picture motor based on zero energy ontology (ZEO) [L39] motor actions are identified as sensory percepts in opposite time direction: a signal is sent to geometric past and initiates neural processing leading to the motor action. This explains Libet's finding that motor action is preceded by a neural activity beginning a fraction of second before the conscious decision about motor action. Could the situation be the same now except that the time scale would be now longer? The longer time scale would suggest that the decision maker is not "me" characterized by a fraction of second time scale but some higher level in the hierarchy of selves associated with my biological and magnetic body.

11.4.7   Quantum Cognition

The talks in the conference Towards Science of Consciousness 2015 held in Helsinki produced several pleasant surprises, which stimulated more precise views about TGD inspired theory of consciousness. Some of the pleasant surprises were related to quantum cognition. It is a pity that I lost most of the opening talk of Harald Atmanspacher (`http://tinyurl.com/pvb36jq`).

The general idea is to look whether one could take the formalism of quantum theory and look whether it might allow to construct testable formal models of cognition. Quantum superposition, entanglement, and non-commutativity, are the most obvious notions to be considered. The problems related to quantum measurement are however present also now and relate to the basic questions about consciousness.

1. For instance, non-commutativity of observables could relate to the order effects in cognitive measurements. Also the failure of classical probability to which Bell inequalities relate could have testable quantum cognitive counterpart. This requires that one should be able to speak about the analogs of quantization axis for spin in cognition. Representation of Boolean logic statements as tensor product of qubits would resolve the problem and in TGD framework fermionic Fock state basis defines a Boolean algebra: fermions would be interpretation as quantum correlates of Boolean cognition.

2. The idea about cognitive entanglement described by density matrix was considered and the change of the state basis was suggested to have interpretation as a change of perspective.

Here I was a little bit puzzled since the speakers seemed to assume that density matrix rather than only its eigenvalues has an independent meaning. This probably reflects my own assumption that density matrix is always assignable to a system and its complement regarded as subsystems of large system in pure state. The states are purifiable - as one says. This holds true in TGD but not in the general case.

3. The possibility that quantum approach might allow to describe this breaking of uniqueness in terms of entanglement - or more precisely in terms of density matrix, which in TGD framework can be diagonalized and in cognitive state function reduction reduces in the generic case to a 1-D density matrix for one of the meanings. The situation would resemble that in hemispheric rivalry or for illusions in which two percepts appear as alternatives. One must be of course very cautious with this kind of models: the spoken and written language do not obey strict rules. I must however admit that I failed to get the gist of the arguments completely.

One particular application discussed in the conference was to a problem of linguistics.

1. One builds composite words from simpler ones. The proposed rule in classical linguistics is that the composites are describable as unique functions of the building bricks. The building brick words can however have several meanings and meaning is fixed only after one tells to which category the concept to which the world refers belongs. Therefore also the composite word can have several meanings.

2. If the words have several meanings, they belong to at least $n = 2$ two categories. The category associated with the word is like spin $n = 2$ and one can formally treat the words as spins, kind of cognitive qubits. The category-word pairs - cognitive spins- serve building bricks for 2 composite worlds analogous to two-spin systems.

3. A possible connection with Bell's inequalities emerges from the idea that if word can belong to two categories it can be regarded as analogous to spin with two values. If superpositions of same word with different meanings make sense, the analogs for the choice of spin quantization axis and measurement of spin in particular quantization direction make sense. A weaker condition is that the superpositions make sense only for the representations of the words. In TGD framework the representations would be in terms of fermionic Fock states defining quantum Boolean algebra.

   (a) Consider first a situation in which one has two spin measurement apparatus A and B with given spin quantization axis and A′ and B′ with different spin quantization axis. One can construct correlation functions for the products of spins s_1 and s_2 defined as outcomes of measurements A and A′ and s_3 and s_4 defined as outcomes of B and B′. One obtains pairs 13, 14, 23, 24.

   (b) Bell inequalities give a criterion for the possibility to model the system classically. One begins from 4 CHSH inequalities (`http://tinyurl.com/y6ua44dk`) follow as averages of inequalities holding for individual measurement always (example: $-2 \leq s_1 s_3 + s_1 s_4 + s_2 s_3 - s_2 s_4 \leq 2$) outcomes by *assuming* classical probability concept implying that the probability distributions for $s_i s_j$ are simply marginal distributions for a probability distribution $P(s_1, 2_2, s_3, s_4)$. CHSH inequalities are necessary conditions for the classical behavior. Fine's theorem (`http://tinyurl.com/y8c8r22s`) states that these conditions are also sufficient. Bell inequalities follow from these and can be broken for quantum probabilities.

   (c) Does this make sense in the case of cognitive spins? Are superpositions of meanings really possible? Are conscious meanings really analogous to Schrödinger cats? Or should one distinguish between meaning and cognitive representation? Experienced meanings are conscious experiences and consciousness identified as state function reduction makes the world look classical in standard quantum measurement theory. I allow the reader to decide but represent TGD view below.

What about quantum cognition in TGD framework? Does the notion of cognitive spin make sense? Do the notions of cognitive entanglement and cognitive measurement have sensible meaning? Does the superposition of meanings of words make sense or does it make sense for representations only?

1. In TGD quantum measurement is measurement of density matrix defining the universal observable leading to its eigenstate (or eigen space when NE is present in final state) meaning that degenerate eigenvalues of the density matrix are allowed). In the generic case the state basis is unique as eigenstates basis of density matrix and cognitive measurement leads to a classical state.

   If the density matrix has degenerate eigenvalues situation changes since state function can take place to a sub-space instead of a ray of the state space. In this sub-space there is no preferred basis. Maybe "enlightened" states of consciousness could be identified as this kind of states carrying negentropy (number theoretic Shannon entropy is negative for them and these states are fundamental for TGD inspired theory of consciousness. Note that p-adic negentropy is well-defined also for rational (or even algebraic) entanglement probabilities but the condition that quantum measurement leads to an eigenstate of density matrix allows only projector as a density matrix for the outcome of the state function reduction. In any case, in TGD Universe the outcome of quantum measurement could be enlightened Schrödinger cat which is as much dead as olive.

   Entangled states could represent concepts or rules as superpositions of their instances consisting of pairs of states. For NE generated in state function reduction density matrix would be a projector so that these pairs would appear with identical probabilities. The entanglement matrix would be unitary. This is interesting since unitary entanglement appears also in quantum computation. One can consider also the representation of associations in terms of entanglement - possibly negentropic one.

2. Mathematician inside me is impatiently raising his hand: it clearly wants to add something. The restriction to a particular extension of rationals - a central piece of the number theoretical vision about quantum TGD - implies that density matrix need not allow diagonalization. In eigen state basis one would have has algebraic extension defined by the characteristic polynomial of the density matrix and its roots define the needed extension which could be quite well larger than the original extension. This would make state stable against state function reduction.

   If this entanglement is algebraic, one can assign to it a negative number theoretic entropy. This negentropic entanglement is stable against NMP unless the algebraic extension associated with the parameters characterizing the parameters of string world sheets and partonic surfaces defining space-time genes is allowed to become larger in a state function reduction to the opposite boundary of CD generating re-incarnated self and producing eigenstates involving algebraic numbers in a larger algebraic extension of rationals. Could this kind of extension be an eureka experience meaning a step forwards in cognitive evolution?

   If this picture makes sense, one would have both the unitary NE with a density matrix, which is projector and the algebraic NE with eigen values and NE for which the eigenstates of density matrix outside the algebraic extension associated with the space-time genes. Note that the unitary entanglement is "meditative" in the sense that any state basis is possible and therefore in this state of consciousness it is not possible to make distinctions. This strongly brings in mind koans of Zen buddhism. The more general algebraic entanglement could represent abstractions as rules in which the state pairs in the superposition represent the various instances of the rule.

3. Can one really have superposition of meanings in TGD framework where Boolean cognitive spin is represented as fermion number (1,0), spin, or weak isospin in TGD, and fermion Fock state basis defines quantum Boolean algebra.

   In the case of fermion number the superselection rule demanding that state is eigenstate of fermion number implies that cognitive spin has unique quantization axis.

For the weak isopin symmetry breaking occurs and superpositions of states with different em charges (weak isospins) are not possible. Remarkably, the condition that spinor modes have a well-defined em charge implies in the generic case their localization to string world sheets at which classical W fields carrying em charge vanish. This is essential also for the strong form of holography, and one can say that cognitive representations are 2-dimensional and cognition resides at string world sheets and their intersections with partonic 2-surfaces. Electroweak quantum cognitive spin would have a unique quantization axes?

But what about ordinary spin? Does the presence of Kähle magnetic field at flux tubes select a unique quantization direction for cognitive spin as ordinary spin so that it is not possible to experience superposition of meanings? Or could the rotational invariance of meaning mean $SU(2)$ gauge invariance allowing to rotate given spin to a fixed direction by performing $SU(2)$ gauge transformation affecting the gauge potential?

4. A rather concrete linguistic analogy from TGD inspired biology relates to the representation of DNA, mRNA, amino-acids, and even tRNA in terms of dark proton triplets. One can decompose ordinary genetic codons to letters but dark genetic codons represented by entangled states of 3 linearly order quarks and do not allow reduction to sequence of letters. It is interesting that some eastern written languages have words as basic symbols whereas western written languages tend to have as basic units letters having no meaning as such. Could Eastern cognition and languages be more holistic in this rather concrete sense?

11.5   P-Adic Cognition And Various Codes

I learned from Tidjani Negadi about some new ideas related to the attempt to understand the basic numbers of the genetic code [A39]. Some of these ideas stimulated some speculations about genetic code and its relationship to cognition and led to a discovery of two number theoretical miracles related to the realization of cognition at DNA and protein level. I have done a lot of work with genetic code [K41, K2, K115, K80] and the ideas below correspond to arelatively old layer in this work.

11.5.1   Symmetry Breaking Generates Conscious Information

What is very attractive in Negadi's approach is the interpretation of the reduction of the entropy in the symmetry breaking as information [A38]. This kind of a philosophy fits nicely with the general TGD based view about the generation of the macro-temporal quantum coherence and hierarchy of quantum criticalities and super-symplectic symmetry breakings as a source of negentropic entanglement and correlate for evolution.

The recent vision about fractal hierarchy of quantum criticalities brings the breaking of super-symplectic symmetries as gauge symmetries central element of evolution. The phase transitions reducing the sub-algebra of this algebra acting as gauge symmetries occur spontaneously and generate negentropic entanglement if weak form of NMP is accepted as the basic variational principle. The sub-algebras are characterized by an integer n telling that the conformal weights for its generators are n-ples of those for the full algebra isomorphic to the sub-algebra. A very detailed view reducing evolution to the hierarchy of algebraic extensions of rationals defining in turn those of p-adic numbers emerges from this picture. Preferred p-adic primes can be identified as so called ramified primes of the algebraic extension of rationals and also the generalization of p-adic length scale hypothesis emerges from the weak form of NMP.

In strong form of holography 2-surfaces are algebraically continued to preferred extremals. p-Adic continuations identifiable as imaginations would be due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K64]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes.

What this picture implies at space-time level is yet an open question. Certainly the representations of Galois groups are important but are realized rather abstractly at the level of conformal

invariants parameterizing string world sheets and partonic 2-surfaces rather than space-time surfaces. The discretization is at the level of this space and means that common points ore reality and p-adicities are at the level of parameter space.

Co-dimension 2 rule holds true for the discretization. Space-time is discretized in terms of string world sheets and partonic 2-surfaces (this is just strong form of holography implied by strong form of General Coordinate Invariance). Partonic 2-surfaces are discretized as discrete sets of points common the real and p-adic variants of the partonic 2-surface belonging to the algebraic extension of rationals in question. This means also discretization at space-time level and one might hope that some preferred very simple discrete geometries could be dynamically favored.

Weak form of NMP generalizes p-adic length scale hypothesis. p-Adic primes, which are near but below powers of prime are favored. The original form of p-adic length scale hypothesis states that the primes $p \simeq 2^k$ are preferred. Mersenne primes are the primes nearest to power of two and in this sense unique. For odd powers of primes this criterion cannot be satisfied so accurately as for Mersennes. The model for the hierarchy of codes containing also genetic code relies on Combinatorial Hierarchy $M(n + 1) = M_{M(n)}$, $M(1) = 3$, giving rise to Mersenne primes $3, 7, 127, 2^{127} - 1$. The remaining numbers in the hierarchy could but need not be Mersenne primes. $M_7 = 127$ corresponds to genetic code and M_{127} to what I have called memetic code possibly assignable to electron. If cognition is fundamental aspect of TGD present already at elementary particle length scales as already p-adic mass calculations and the adelic vision about tGD [K119] suggest, one indeed expects that the Universe is full of cognitive codes - even at the level of elementary particles. They would however correspond to the "dark" aspects of matter not observable by the existing experimental methods and related to the hierarchy of Planck constants predicted by TGD.

The considerations related to codes discussed in the sequel are written much before the emergence of this picture and I cannot guarantee full consistency with the proposed picture.

11.5.2 Cognitive Codes As A Realization Of The Information Generated By DNA-Protein SymmetryBreaking?

One can argue that before the establishment of the genetic code the assignments of DNA triplets to amino-acids are random. This would mean that the symmetry group is a direct product of the permutation groups permuting 64 DNA triplets and 20 amino-acids. The symmetry entropy is logarithm about the number of elements of the symmetry group

$$S_{max} = log(w) \quad , \quad w = 64! \times 20! \quad . \tag{11.5.1}$$

One obtains $S_{max} \simeq 4 \times 61.8789$.

The work of Negadi inspired the question about whether one could interpret protein-DNA symmetry breaking as a process in which the information $I = S_{max} - S$ is generated and represented in a concrete manner as an additional conscious cognitive information associated with DNA and protein sequences.

In case of DNA sequences the symmetry breaking would be maximal so that one has $I = S_{max}$. In case of protein sequences symmetry breaking would be partial and $I = S_{max} - S$, where S corresponds to the entropy due to the fact that DNA triplets coding for the same amino-acid are equivalent from the view point of protein: DNA sequences carry more cognitive information than protein sequences.

Weak form of NMP provides additional clues.

1. Unitary entanglement between two state spaces of dimension kp^N (in the sense that entanglement matrix is proportional to a unitary matrix) gives rise to negentropic entanglement with p-adic prime p [K56]. These dimensions are favored by weak form of NMP as highly negentropic (the maximum of number theoretic negentropy corresponds to p-adic prime p).

2. If p is Mersenne prime: $p = M_k = 2^k - 1$, temporal sequences of k spin directions /qubits could provide a concrete mechanism of quantum computation (for $k = 127$ associated with the memetic code at least. This suggests that DNA triplets or amino-acids could be accompanied by $p = M_k$-fold degeneracy resulting from the assignment of a sequence of k qubits to each DNA triplet and/or amino-acid.

3. This representation of information should relate somehow to the realization of the memetic code in terms of DNA and amino-acid sequences. In the model of the memetic code sequences of 21 DNAs are a natural candidate for the realization of the memetic code words since the number of different sequences is $64^{21} = 2^{126}$, which is the number of the memetic code words representing maximal number of forming a set theoretic inclusion hierarchy and logical implication hierarchy in the Boolean algebra represented by sequences of 127 bits. These statements correspond also to all statements consistent with a fixed atomic statement fixing the value of one bit. The sequences of 21 proteins are a natural candidate for defining the memetic counterpart of the DNA-protein translation if one assumes that the translation of genetic code induces directly the translation of the memetic code to proteins. A test is to find whether sequences of 21 DNAs/proteins might appear in the tertiary structure of DNAs/proteins.

4. The argument above suggests that one should try to find a representation of the cognitive information by assigning a temporal sequence of $p = M_k$ spin directions to each DNA/protein in the the sequence of 21 DNAs/proteins. This representation makes sense if the condition

$$I \quad = \quad 21 \times log(M_k) \simeq 21 \times k \times log(2) \tag{11.5.2}$$

giving

$$k \quad = \quad \frac{I}{21 \times log(2)} \quad , \tag{11.5.3}$$

is satisfied for k Mersenne prime. The condition is obviously extremely restrictive and a number theoretical miracle is required since k has exponential sensitivity to the value of I. Even more, this miracle is required to occur twice: for both DNA and proteins! The value of I can be calculated for both DNA and proteins and one can check whether the miracle occurs. That it indeed occurs gives a support for the realization of memetic code in terms of sequences of 21 DNAs and proteins.

11.5.3   Peptides As Molecules Of Emotion

The view about peptides and proteins as cognizing and intentional entities allows to translate to TGD language often used expressions like "emotions are expressed", "blocked emotions are released", "emotions are stored to the body as traumatic body memories", "peptides are molecules of emotion and information molecules". Most importantly, a concrete code for cognition emerges in which elementary intention represents inhibition or facilitation of gene expression.

Unasked questions

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 [I51].

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, a 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. If information molecules carry p-adic intentions about say gene level expression of emotions, situation changes since additional information transfer is involved.

The code of emotions

The expressions of emotions are usually symbolic. What it means that peptides are responsible for the expression of emotions? Perhaps information molecules transfer the information about the emotions to be expressed at molecular level between body parts. It is indeed known that nervous system, immune system, and endocrine system are in an intense information exchange using information molecules.

The original naïve speculation was that p-adic physics might be concretely involved here. The recent view is however more mundane looking.

1. The emotional expression - in fact all signalling in biosystems - involves pairs of magnetic flux tubes connecting the sender of the control signal and the target and serving as a correlate for directed attention. The reconnection of U-shaped flux tubes emanating from sender and the receptors of the target gives rise to the connecting pair of flux tubes. The connections would be between information molecules. For instance, messenger molecules would be connected to the sender and receptor of the target in this manner. Hormones and neurotransmitters would have similar connections.

2. The signal itself is transmitted along the flux tube pair and realized as dark photons propagating along massless extremals (MEs) parallel to flux tubes. Dark photons would have frequencies selecting only special targets by resonance mechanism. Dark photons would be cyclotron photons with a universal energy spectrum assignable to bio-photons in visible and UV range resulting as dark photons transform to ordinary photons. Universal energy spectrum is obtained if the value of h_{eff} satisfies $h_{eff} = h_{gr}$, where $\hbar_{gr} = GMm/v_0$ is so called gravitational Planck constant [K73] being proportional to the mass m of the charged particle appearing in cyclotron condensate so that cyclotron energy proportional to h_{eff}/m does not depend on the mass of the charged particle. The independence of gravitational Compton length on the mass of charged particle makes possible macroscopic gravitational quantum coherence.

The model for the music harmony and genetic code [K80] leads to a more detailed model for the representation of DNA codons and amino-acids in terms of "3-chords" defined by 3 frequencies.

Since music represents and generates emotions, it is natural to consider the possibility that this representation provides correlates for emotions.

1. DNA sequences and proteins correspond to sequences of 3-chords, music pieces one might say and are represented by a characteristic musical theme. An analogous dark photon representation could apply to all important biomolecules and serve as its name. What is interesting that 256 different harmonies defined by the possible 3-chords emerge. They could provide correlates for various kinds of moods at bio-molecular level and assignable to magnetic bodies carrying dark matter, which would represent completely new information processing level distinguishing biochemistry from the ordinary chemistry.

2. The model involves only 3-chords playing the role of passwords, and can be seen as a particular realization of the genetic code. Password code could be enough but the temporal patterns of the signal analogous to temporal coding of bit sequences make possible an additional message much like in the ordinary communications between computers. The signal could be sent using higher level code in a hierarchy of codes.

3. Combinatorial Hierarchy containing at least the primes $3, 7, 127, 2^{127} - 1$ could define such a sequence of codes having interpretation as a hierarchy of statements about statements. Above the genetic code with 6 bits would be memetic code with 126 bits, which could be assigned to dark electrons if the flux tube connecting the wormhole contacts involved corresponds to $h_{eff} = M_{127} \times h$. Electron could have dark side invisible using recent measurement technology but crucial for understanding biology - the size scale of electron CD is .1 seconds, the fundamental biorhythm.

4. An interesting question is whether DNA sequences consisting of 21 DNA triplets realizing memetic code could have some special role in the control part of the genome. The sequences of $10 \times n$ DNA triplets are special in that the net helical rotation along the sequence is a multiple of 2π. This suggests a connection with $p = 5$ finite geometry realized in terms of pentagon and involved also with the finite geometry defined by icosahedron characterizing genetic code. Could the sequences of 20 DNA and thus also of 20 amino-acids serve as units of genetic information? Note that the sequence of 21 DNA codons realizing memetic codon corresponds to same twist modulo 2π tetrahedron as single DNA nucleotide. 10 memetic codons correspond to full multiple of 2π twist: is there some kind of fractality involved?

   Clearly, the number 5 is the key number of genetic code and $p = 5$ finite geometries dimension 1 and 2 seem to be involved. The challenge is to undertand the full picture.

Of course, any code based on Mersenne primes and on prime near but below a power of prime p_1 might be involved. $p_1 = 2, 3, 5$ correspond to finite geometries realizable as Platonic solids and are especially interesting candidates in this respects. All primes are realizable as regular polygons. Since $h_{eff} = h_{gr}$ is proportional to the mass of charged particle, each charged particle would have its own frequency scale analogous to a user specific frequency band used in radio communications so that the communications would not interfere with each other. Temporal code could have several variations. Frequency modulation is however strongly suggested by the model for cell membrane as generalized Josephson junction [K81].

What could happen in information-molecule receptor complex?

I have considered at the general level the question about what might happen in receptor complex in [K105].

The general idea is that the receptor serves as a relay station. The attachment of U-shaped flux tube emanating from the sender to a receptor generates a flux tube connection between sender and target analogous to that generated by a tele-operator. The connection can be very long ranged since the size scale of the magnetic body can e very large as compared to that of biological body from the fact that time scale of .1 seconds defining universal biorhythm assignable to electrons corresponds to the size scale of the Earth.

In [K105] I have discussed a speculative model for the effect of psychedelics on consciousness considering the possibility that the claimed encounters with representatives of other civilizations

might be actually real remote sensory experience involving genuine communication rather than mere hallucination. The basic objection that the finite light velocity makes these encounters impossible is circumvented in ZEO. I do not of course expect that the reader would take this kind of speculation seriously. What however remains is the possibility that receptors would serve as kind of tele-operators at which the flux tubes can attach so that remote connection is generated.

It is known that membrane proteins serving as receptors are in a helical conformation such that the number of proteins in the portion connecting the cell exterior and interior is 20 [I26]. This is not quite 21, which is the number of DNA codons representing single memetic codon ($126 = 21 \times 6$ bits). What could this mean?

1. Could the number 20 relate somehow to the number of triangular faces of icosahedron playing a key role in the model of music harmony and genetic code?

Cell membrane receptors are especially important receptors. The active parts of the cell membrane receptors corresponds to the parts of the membrane proteins traversing the cell membrane. Often the receptors are proteins, which traverse the cell membrane many times and the interpretation would be that each portion of 20 amino-acids defines one elementary signal unit defining a portion of DNA sequence to be translated and initiating a process leading to an expression of some gene(s). 7-bit code suggests that the codeword activates control genes which promote or disfavor the expression of some gene(s).

Micro-tubular cytoskeleton which is piezoelectric structure claimed to allow 64 bit code [I24], [J59] could mediate the electric electric signal to the nucleus and activate the desired genes. Massless extremals could be involved. The generation of the second messenger would represent a standardized part (there are relatively few second messenger pathways) of the process of realizing gene expression now responsible for the transfer of the intention.

Failure to express emotions

The expression of emotions can fail at several levels. The intention to express emotion is not realized as action. No state function reduction to the opposite boundary of CD for the corresponding sub-self would take place so that the mental image representing emotion would become very long-lived. By NMP the death of the emotional mental image is however required in order to generate negentropic entanglement. The unexpressed emotion is stored to the body as kind of tension.

Second failure is that the information molecules are sent but fail to bind to their receptors for some reason or the transfer of information inside the receiving cell fails for some reason. In this case the emotion is expressed at the primary level but the desired effect is not achieved.

An important function of sleep and dreams might be the expression of the un-expressed emotions of the geometric past. Also meditation and various therapies might have the same effect. Neuropharmacological approach, as long as it tries to affect only the geometric now, cannot change the geometric past and would not seem therefore very useful healing method for emotional traumas. My own rather traumatic academic past provides a good testing ground for this hypothesis. As a scientific heretic I lost my academic human rights for long time ago. It became clear that if I react to this, I will be labelled as an asocial paranoid. Apart from few exceptions, when the psychic pain was simply too intolerable, I managed to avoid this. This left a lot of unexpressed emotion to my geometric past and the reward for a civilized behavior was a label of a stupid sissy. Gradually it became also clear that there is no hope: the academic decision makers have unlimited power. It is hard to imagine a more effective mechanism for generating deep frustration and long term depression! Gradually I however realized that the coin had also the other side: the role of an academic zombie gave me an unlimited intellectual freedom which those professors did not possess and I had actually ideal circumstances for carrying out my mission optimally. Besides the incredible stupidity of the academic power holders I have been wondering second strange phenomenon during these years. Why do I spend practically all my dream time in my past? Could a partial answer be that I have been busily trying to express these un-expressed emotions: during sleep it is easier to break the academic etiquette.

11.6   About Molecular Cognitive And Sensory Representations?

The challenge of understanding how intentions and cognitions are realized at the molecular level is a fascinating and potentially very rewarding challenge. The work with genetic and memetic codes based on the notion of Combinatorial Hierarchy [K41, K51, K80] represents first steps in this direction but does not yet involve p-adic aspects. The ideas of preceding section provide a lot of additional insight but do not provide any general theory. This section is devoted to an attempt to say something about the general theory of cognitive and symbolic representations at the molecular level assuming that even molecular structures have intentions and cognition and are able to transform intentions to actions.

The basic hypothesis is that molecules provide both static and dynamic symbolic representations for cognitive codes. Cognitive codes would be characterized by the symmetry groups of finite geometries and their projective counterparts. The requirement that cognitive quantum computation is possible raises the primes defining Mersenne primes to a preferred position. The symmetry groups of finite geometries are assumed to act as the symmetries of the molecular structures responsible for the symbolic representations. This leads to strong predictions as some examples treated below demonstrate and one might even speak about Golden Road to the understanding of cognition and intentionality at molecular level.

11.6.1   Number Theoretical Ideas

The predictive power of the model to be proposed derives basically from number theoretical constraints. Mersenne primes are in a unique position as far as p-adic quantum computation is considered. One can imagine a good reason for why Gaussian Mersennes should have a unique role. Fibonacci numbers characterize often the structure of biological systems, and there are reasons to believe that they might relate very intimately also to the evolution of cognitive representations.

Mersenne primes an cognitive hierarchies

The findings about new cognitive codes initiated by the idea of symmetry entropy of DNA-protein system can be compressed to a generalized notion of abstraction hierarchy, which was introduced years earlier. Any Mersenne prime M_p, p prime defines an abstraction hierarchy containing at most two levels. The $2^p - 1$ elements of the finite field $G(M_p, 1)$ represent all possible statements about p basic statements except the one which is not representable for some physical reason. Hierachies start from some prime which is $2, 5, 13, 17, 19, 31, 89, 107$ in the range of p-adic time scales of interest and can have several levels.

1. Combinatorial hierarchy $p = 2, 3, 7$ (single base pair), 127 (genetic code), M_{127} (memetic code whose mutually consistent statements are realized also as sequences of 21 DNAs) is the longest hierarchy. It is not known whether $M_{M_{127}}$ is prime: Hilbert conjecture states the entire infinite hierarchy consists of Mersenne primes. This would mean that universe possesses infinite ability of cognitive abstraction.

2. The next hierarchy starts from prime 5 and contains three levels $p = 5$, M_5=31, and $M_{31} = 2^{31} - 1 \simeq 2 \times 10^9$.

3. The remaining known to me hierarchies are two-step hierarchies and any Mersenne prime defines such a hierarchy. The largest Mersenne prime hierarchy of this kind relevant for human consciousness is M_{127} which is the p-adic prime characterizing electron and memetic code. M_{521} is the next Mersenne prime and corresponds to a completely super-astrophysical time scale.
   i) The first abstraction pair (p, M_p) corresponds to $p = 13$. Micro-tubuli are excellent candidates for the realization of M_{13}^{13} representations with $13^2 = 169$ bits of information (recall that $k = 169$ characterizes the p-adic length scale associated with neutrinos!).
   ii) Next Mersenne M_p prime corresponds to $p = 17$ and was deduced by the argument relating to the information gain in complete symmetry breaking of the DNA-protein system.
   iii) Also the Mersenne primes M_p associated with $p = 19, 31, 61, 89, 107$ should be there.

The beauty of Mersenne representations is that one can construct from them product representations containing M_p^k cognitive states and bits replaced by pinary digits M_p. Furthermore, by fractality any time scale $2^{pm/2}T_{M_p}$ is possible for sufficiently small primes p so that these representation can be present in and a wide spectrum of time scales ranging from the time scales relevant for the conformational dynamics of molecules to the time scales relevant for neural activity and EEG and even time scales measured in years.

What about Gaussian Mersennes?

The Gaussian Mersennes $G_n = (1+i)^n - 1$, n some prime, are expected to be also of fundamental importance and one expects that they give rise to complex cognitive representations. The Gaussian Mersennes possibly relevant to life correspond to primes $n = 2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113, 151, 157, 163, 167, 239, 241, 283$. The length scale range between cell membrane thickness and size of small bacterium contains only scaled up Compton lengths of electron for Gaussian Mersennes: they are $n = 151, 157, 163, 167$. The norm squared of the Gaussian Mersenne $G_{n=2k+1}$ is $p_n = 2^{21+1} + 2^{k+2} + 1$ and larger than 2^n.

One might guess that the number of Gaussian integers with norm smaller than the norm squared of Gaussian prime G_n defines the number of states in this kind of representation and that this number must be prime. Some very beautiful cognitive structures might be involved with Gaussian Mersennes and it remains to be found what this structure is. Obviously the idea that one could use sequences of n bits to realize $p_n = 2^n - 1$ points as phase transitions by spontaneous magnetization to an analogous representation of $p_{n=2k+1} = 2^{2k+1} + 2^{k+1} + 1$ points. One can write p_n in a form which gives hints about what kind of physics this representation might require:

$$p_{n=2k+1} \equiv N_1 + N_2 + N_3 \ ,$$

$$N_1 = 2^{2k+1} - 1 \ , \qquad N_2 = 2 \times 2^k - 1 \ , \quad N_3 = 2 \times 2 - 1 \ .$$

p_n is sum over numbers of magnetization phase transitions for three phases of the fermion system. N_1 corresponds to a system of $2k + 1$ fermions. N_2 corresponds to a system consisting of one fermion plus k Cooper pairs: by the indistinguishability of fermions the combinatorial factor k is absent from N_2. N_3 corresponds to a system consisting of one fermion and a Bose-Einstein condensate of all k Cooper pairs behaving like a single particle. Neutrinos at $k = 169$ space-time sheet suggest themselves strongly as a realization of this phase.

Fibonacci numbers and the evolution of cognition

Fibonacci numbers proliferate living matter (logarithmic spirals) and emerge in the simplest models of growth: living matter is full of logarithmic spirals and also micro-tubular structure involves the sequence $3, 5, 8, 13$ of Fibonacci numbers. The natural guess is that Fibonacci numbers are also involved with cognitive growth and evolution: especially so if this biological growth is basically intentional and involves growth of plans from rough sketches to more detailed ones and if this development is seen in the structure of intention. In particular, 21 DNA/protein codeword could decompose to ordered hierarchy of subsequents of $1, 2, 3, 5, 8, 13, 21$ DNAs and these sequences with increasing length gradually give better and better representation of codeword. The development of the full cognitive code word or intention, would be like an interactive growth of a population of 21 cognitive organisms, primitive intentions associated with single DNA. Older unit intentions react to the presence of new ones by generating new unit of intention each. When, say, a generation consisting of 5=2+3 unit has been established, 3 units of previous generation generate new units (5+3=8) as a response to the presence of new 2 units.

For intance, single micro-tubule would represent only the 13 first DNAs and would not give faithful coding of the codeword. The wall of a double micro-tubule with 21 tubulin strands at its wall would do it. Interestingly, triple micro-tubules seem to contain the total of 33 or 34 micro-tubules, whether the number is 34=21+13, the next Fibonacci in the micro-tubular series, is not clear on basis of material that I have seen. Because of its Fibonacci structure of micro-tubule could automatically represent 5, 8 and 13 DNA approximations to the full intention represented by a sequence of 21 DNAs.

11.6.2   Representations

Representations are fundamental notions in geometry and physics and, as it seems, also sensory, symbolic, and cognitive representations make sense. The basic idea is that Nature codes its mathematical cognition to various kinds of symbolic representations. The fascinating possibility is that practically every bio-structure which results in genetic expression represents some cognitive/intentional structure somehow. We have been used to think that our theories represent those structures we see: it might be fruitful to see the situation as just the opposite! DNA and proteins would be only particular hardware realization of finite geometries associated with cognition. This view might be general enough and certainly practical: one can deduce the symmetry groups associated with various structures and look whether one can assign them to finite geometries or their projective counterparts and thus to p-adic cognition.

Various types of representations

One can distinguish between several kinds of representations.

1. There are cognitive representations in terms of temporal sequences of p-adic neutrinos. Sequences of 21 DNA triplets could realize any representation defined by Mersenne prime since the temporal character of the sequences means that the density of neutrinos needed does not depend on the Mersenne prime. Thus there is no really deep reason for making too restrictive assumptions at this stage.

2. The symbolic representations can transform further to dynamical representations as either nerve pulses or oscillations of membrane potential. This representation generalizes: what is needed are two-state systems in an external field which forces a process analogous to spontaneous magnetization.

3. One can also consider the possibility of static geometric representations in terms of molecular geometry. These kind of representations could be realized for any prime p and in case that M_p is Mersenne prime, the structure characterized by p parts related by a cyclic symmetry Z_p could serve as a template for dynamical representations obtained by attaching a two-state system at every unit of the system. For instance, DNA triplets realize statically the set of 64 statements consistent with an atomic statement (single bit fixed) for $M_7 = 127$ cognitive representation and single DNA triplet could realize $M_3 = 7$ representation if each basepair can be in two states. Clathrin molecule gives 12-fold product of $p = 5$ representation in terms of 12 disjoint pentagon faces whose vertices carry a two-state system (the polarization of the triskelion protein could define the two states).

The basic principle for realizing dynamical representations

According to TGD inspired theory qualia, primitive qualia correspond to spin flips, and more generally, to phase transitions changing the direction of spin or some other quantity characterizing the state of the two-state system. In case of neutrino representations the essential elements are the presence of magnetic field, the fact that the neutrino is a two-state system which flips in the direction of externa magnetic field, and the fact that the number of representable states is $M_n = 2^n - 1$ rather than 2^n states since the state in which all spins are parallel does not give rise to spontaneous magnetization and conscious experience.

The replacement of single particle states with say spontaneously magnetized states guarantees rigidity and robustness. Spin glass type phase is optimal for the representative purposes and TGD universe is indeed a quantum spin glass. Dynamic representations can be realized in terms of molecular conformations instead of using fields. Micro-tubule representations provide a fundamental example but there are a lot of others. If magnetic flux tubes and electrets are indeed fundamental building blocks of living systems (they represent fundamental solutions of field equations of TGD), living system should be a huge fractal collection of these representations. Also cell membrane is expected to carry representations of this kind.

What this means is that the projective finite geometry with $M_n + 1 = 2^n$ points is represented dynamically by n two state systems such that the point at infinity is not realizable as spin flip

pattern since it corresponds to the spontaneous magnetization or electret state in which all n two-state systems have spin /polarization/... direction parallel to external field and nothing happens. This is indeed what is required by the realization of qualia as quantum number increments. At the level of set theoretical Boolean algebra representation the point at infinity corresponds to the empty set.

If the strength of the background field can be controlled, the representation could be generated by weakening the field temporarily so that there results either a spin glass phase at criticality optimal for the storage of bits or a phase above criticality optimal for signal propagation. The transformation inducing "spontaneous magnetization" responsible for the conscious experience could be generated by increasing the strength of the magnetic/electric field to its original value. For instance, in case of micro-tubular conformational representations reading would result by introducing strong electric field forcing the conformations to ground state conformations.

Magnetic flux tubes and their electric duals provide these background fields. In case of magnetic flux tubes cyclotron transitions are these transitions and spins of Cooper pairs define the bits. This allows a deeper understanding of also sensory representations.

Fractal hierarchy of time scales

The beauty of the realization of cognitive representation in terms of Mersenne primes is that all fractal powers $T(p, n) = p^{(n-1)/2}T_p$ of p-adic time scale T_p are a priori possible and correspond in good approximation to the square roots of the octaves of the fundamental time scale. The first implication is that the entire span of biologically relevant time scales can be realized using relatively few fundamental time scales defined by small Mersenne primes. This means also that for large Mersenne primes corresponding to relatively long time scales there can be several small Mersenne representations with essentially the same time scale. The signatures for these time scales are resonance frequencies corresponding to the time scales defining the duration of the codeword and also the duration of single bit. How much the duration of the codeword can vary around the p-adic time scale is still an open and important question: the width of alpha band suggests that the variation is about $\pm$ 20 per cent.

Is evolution 3-adic?

I received an interesting email from Jose Diez Faixat giving a link to his blog (`http://tinyurl.com/ycesc5mq`). The title of the article in the blog is "Bye-bye Darwin" and tells something about his proposal. The sub-title "The Hidden rhythm of evolution" tells more. Darwinian view is that evolution is random and evolutionary pressures select the randomly produced mutations. Rhythm does not fit with this picture. Faixat published 1993 the first article about his observations in the journal World Futures Vol. 36, pp. 31-56, edited by Ervin Lazlo with the title "A hypothesis on the rhythm of becoming" [I49, I50].

The observation challenging Darwinian dogma is that the moments for evolutionary breakthroughs - according to Faixat's observation - seems to come in powers of 3 for some fundamental time scale. There would be precise 3-fractality and accompanying cyclicity - something totally different from Darwinian expectations.

By looking at the diagrams demonstrating the appearance of powers of 3 as time scales of evolution, it became clear that the interpretation in terms of underlying 3-adicity could make sense. I have speculated with the possibility of small-p p-adicity. In particular, p-adic length scale hypothesis stating that primes near powers of 2 are especially important physically could reflect underlying 2-adicity. One can indeed have for each p entire hierarchy of p-adic length scales coming as powers of $p^{1/2}$. $p = 2$ would give p-adic length scale hypothesis. The observations of Faixat suggest that also powers p=3 are important - at least in evolutionary time scales.

Note: The p-adic primes characterizing elementary particles are gigantic. For instance, Mersenne prime $M_{127} = 2^{127} - 1$ characterizes electron. This scale could relate to the 2-adic scale $L_2(127) = 2^{127/2} \times L_2(1)$. The hierarchy of Planck constants coming as $h_{eff} = n \times h$ also predicts that the p-adic length scale hierarchy has scaled up versions obtained by scaling it by n.

The interpretation would be in terms of p-adic topology as an effective topology in some discretization defined by the scale of resolution. In short scales there would be chaos in the sense of real topology: this would correspond to Darwinian randomness. In long scales p-adic continuity

would imply fractal periodicities in powers of p and possibly its square root. The reason is that in p-adic topology system's states at t and $t + kp^n$, $k = 0, 1, ...p - 1$, would not differ much for large values of n.

A possible interpretation relies on p-adic fractality [K63] (`http://tgdtheory.fi/figu.html`). p-Adic fractals are obtained by assigning to real function its p-adic counterpart by mapping real point by canonical identification

$$\sum_n x_n p^n \rightarrow \sum_n x_n p^{-n}$$

to a p-adic number, assigning to it the value of p-adic variant of real function with a similar analytic form and mapping the value of this function to a real number by the inverse of the canonical identification, the powers of p correspond to a fractal hierarchy of discontinuities.

A possible concrete interpretation is that the moments of evolutionary breakthroughs correspond to criticality and the critical state is universal and very similar for moments which are p-adically near each other.

The amusing co-incidence was that I have been working with a model for 12-note scale [L21], [K80, K115] (`http://tinyurl.com/y7csuxaw`), which to my opinion is highly interesting from the point of view of consciousness theory. Already the mathematicians of ancient Greece speculated with a connection with the geometry of Platonic solid and music scale [J128].

The basic observation is that icosahedron is a Platonic solid containing 12 vertices. The scale is represented as a closed non-self-intersecting curve - Hamiltonian cycle - connecting all 12 vertices: octave equivalence is the motivation for closedness. The cycle consists of edges connecting two neighboring vertices identified as quints - scalings of fundamental by factor 3/2 in Platonic scale. What is amusing that scale is obtained essentially powers of 3 are in question scaled down (octave equivalence) to the basic octave by a suitable power of 2. There is of course slight discrepancy due to the fact that $(3/2)^{12} = 2^7$ is not quite true. This motivated the transition to the well temperated scale with half note corresponding to the scaling by $2^{1/12}$.

The faces of icosahedron are triangles and define naturally basic 3-chords. Triangle can contain either 0, 1, 2 edges of the cycle meaning that the 3-chords defined by faces and defining the notion of harmony contain 0, 1, or 2 quints. One obtains large number of different harmonies partially characterized by the numbers of 0-, 1-, and 2-quint icosahedral triangles since the total number of Hamiltonian cycles at icosahedron is 2^{10}. One must howe$h_{eff} = n \times h$ver notice that those related by an isometry of icosahedron are equivalent.

The connection with 3-adicity comes from the fact that Pythagorean quint cycle is nothing but scaling by powers of 3 followed by suitable downwards scaling by 2 bringing the frequency to the basic octave so that 3-adicity might be realized also at the level of music!

There is also another strange co-incidence. Icosahedron has 20 faces, which is the number of amino-acids. This suggests a connection between fundamental biology and 12-note scale. This leads to a concrete geometric model for amino-acids as 3-chords and for proteins as music consisting of sequences of 3-chords. Amino-acids can be classified into 3 classes using polarity and basic - acid/neutrality character of side chain as basic criteria. DNA codons would would define the notes of this music with 3-letter codons coding for 3-chords. One ends up also to a model of genetic code relying on symmetries of icosahedron from some intriguing observations about the symmetries of the code table.

At the level of details the icosahedral model is able to predict genetic code correctly for 60 codons only, and one must extend it by a fusion it with a tetrahedral code. The fusion of the two codes corresponds geometrically to the fusion of icosahedron with tetrahedron along common face identified as punct (punct) and coded by 2 stopping codons in icosahedral code and 1 stopping codon in tetrahedral code. Tetrahedral code brings in 2 additional amino-acids identified as so called 21st and 22nd amino-acid discovered for few years ago and coded by stopping codons. These stopping codons certainly differ somehow from the ordinary ones - it is thought that context defines somehow the difference. In TGD framework magnetic body of DNA could define the context.

The addition of tetrahedron brings one additional vertex, which correlates with the fact that rational scale does not quite closed. 12 quints gives a little bit more than 7 octaves and this forces to introduce 13 note for instance, A_b and $G_\#$ could differ slightly. Also micro-tubular geometry involves number 13 in an essential manner.

11.6.3 Finite Geometries And Cognition

Finite geometries defined by Galois fields $G(p, n)$ with p^n elements and identifiable as integers in an algebraic extension of p-adic numbers modulo p and corresponding projective geometries are the natural mathematical framework for simplest cognition. The primes p defining Mersenne primes $M_= 2^p - 1$ and Gaussian Mersennes and these primes themselves are preferred primes for the reasons already explained.

1. The evolution of mathematics represents the evolution of cognition if ontogeny recapitulates phylogeny also at the level of cognition. This means that ancient mathematicians constructed also models for the basic structures of cognition. The Platonic solids could represent basic cognitive structures rather than only vice versa as it is usually thought.

2. Symmetry group characterizes a given geometry. This group is cyclic group Z_p for the simplest finite geometries defined by finite fields $G(p, 1)$, p prime, and finite projective group for for their projective counterparts obtained by adding the point at infinity.

3. One can interpret spatial and temporal sequences of quark magnetization directions as representing points of finite geometries or their projective counterparts defined by Mersenne primes. The point at infinity corresponds to all spins in the direction of magnetic field so that no membrane oscillation is generated: infinity is un-reachable. Operational infinity is something which one is not able to achieve or perceive. This finding generalizes to a more general representational principle using two-state systems in an external field which forces the two-state systems to the same state. The cognitive state is coded to a conscious experience resulting in the phase transition to the ground state. If there are p two-state systems such that M_p is Fermat prime this system codes the points of the finite geometry M_p to conscious experiences.

Primes $p = 2, 3, 5$ define especially interesting finite geometries and they correspond to Platonic solids. These Platonic solids appear in the molecular physics of living matter abundantly and this suggests that the p-adic length scale hierarchies associated with this primes are of special importance. There is indeed evidence for this as will be found.

If this view is correct, the mathematicians were studying their own cognitive consciousness when they were proving theorems about Platonic and Archimedean solids or doing ruler and compass constructions. In fact, I realized for years ago that Pythagorean triangles which pop up naturally in p-adic context, represent the very early view about world as mere rational numbers. The simplest mathematical cognition relies on finger counting: amusingly, decimal code pops up already at the level of DNA: 10 DNA triplets correspond to a helical twist which is minimal multiple of 2π.

Finite geometries

Ordinary finite geometry understood as having a structure of number field involves only a set of p (prime) ordered points defining the finite field $G(p, 1)$ and subsets of points of this geometry. The projective counterpart involves also the point at infinity and contains thus $p + 1$ points. Also the algebraic extensions $G(p, n)$ of $G(p, 1)$ containing p^n points are possible but not discussed here. The symmetry group of the finite geometry $G(p, 1)$ is cyclic group Z_p and the sequences of magnetization directions of p quark blocks represent the subsets of $G(p, 1)$ as ordered sets. In case of projective finite geometry containing also the point infinity projective transformations induced by 2×2 unimodular matrices

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \qquad (11.6.1)$$

induce projective transformations via the formula

$$x \to \frac{ax + b}{cx + d} \quad . \qquad (11.6.2)$$

By studying the unimodularity condition $ad - bc = 1$ in finite field one easily finds that the number of elements in the projective group is

$$N = (p-1) \times \left[(p-1) \times (p-2) + 4 \times (p-1) + 2 \right] / 2 \ . \tag{11.6.3}$$

For $p = 5$ one obtains $N = 60$ corresponding to the number of vertices in truncated icosahedron representing thus the symmetry group of 6-point projective finite geometry consisting of the group A_5 of even permutations of five objects. For $p = 3$ the number of elements is $N = 224$ and corresponds to the group S_4 of permutations of four objects whereas for $p = 2$ the number of elements is $N = 6$ and corresponds to the group S_3 of the permutations of three objects.

The projective transformations of finite projective geometries are counterparts of Lorentz transformations. One can assign to finite geometries also a spinor structure. Spinors have two-components and the action of the projective transformation on the spinor is by matrix multiplication. It was actually this finding which led to the realization that there might be a deep connection between cognitive representations using fermion sub-CDs and finite (projective) geometries.

Representations of finite geometries

An interesting question is what finite geometries can be realized as polygons in plane or as Platonic or Archimedean solids. This requires that the symmetry group of the finite geometry or of its projective counterpart acts as a subgroup of the rotation group $O(3)$. For finite geometries having Z_p as a symmetry group regular polygons of plane with p vertices and edges provide this realization. At molecular level a realization by helical twisting is natural. If the number of units corresponding to a full helical twist of multiple of 2π is p or power of p one has a geometric realization of a finite geometry.

    1. Polygons obtainable by ruler and compass construction

Of special interest are the polygons which can be constructed using only ruler and compass: for these structures lengths of various edges are either integers or involve iterated square roots of integers. The well-known theorem of Euler states that the only structures of this kind correspond to regular polygons with n vertices and sides of identical length having vertices at circle. The allowed values of n are given by

$$n = 2^k \prod_k F_k \ ,$$

where k is any non-negative integer and F_k is Fermat prime

$$F_k = 2^{2^k} + 1 \ , \quad k = 1, 2, 3, 4 \ .$$

The list of Fermat primes is $3, 5, 17, 287, 2^{16} + 1$. Interestingly, the lowest three Fermat primes define Mersenne primes M_{F_k} so that they are expected to be of special interest from the point of view of cognition. These structures are not finite geometries but could be regarded as Cartesian products of finite geometries $G(2, k)$ and $G(F_i, 1)$. These structures can be seen as Cartesian products of finite geometries.

A possible geometric representation of these structures is based on many-sheeted space-time concept (see **Fig. ??** in the appendix of this book) so that various factors in the decomposition correspond to different space-time sheets characterized by appropriate p-adic topology (also real space-time sheets are characterized by p-adic prime). The hierarchical helical structures containing helices inside helices correspond to many-sheeted space-time structures and the numbers of basic units corresponding to single period at various levels could correspond to the prime factors appearing in the decomposition.

Bio-systems are full of helical structures. Five finger code and decimal code are included as almost simplest codes. 10 DNA molecules define a structures for which the total helical winding is multiple of 2π. Perhaps here is linear realization of the decimal code: that twist is multiple of 2π indeed says that one can form from DNA a loop where that cyclic group of 10 elements acts. One should look systematically through all helical structures and find the number of units which correspond to a minimal multiple of 2π rotation to see whether ruler and compass codes are realized.

2. Quantized Planck constant, dark matter, and Fermat polygons

One ends up with Fermat polygons from the quantization of Planck constant as $\hbar = \lambda \hbar_0$. Number theoretical arguments suggest a general formula for the allowed values of λ [K36] as $\lambda = n$ where the integer n characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [K120]. The values of n for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17, F_3 = 257, F_4 = 2^{16} + 1$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales.

The p-adic vision about cognition suggests that algebraic extensions of p-adic numbers define a cognitive hierarchy and the lowest levels of this hierarchy correspond to algebraic extensions of p-adic numbers involving only iterated square root operation. These should emerge first in the evolution and therefore dark matter systems assignable to Fermat polygons should be the most abundant ones.

There is a lot of evidence for the presence of integers characterizing Fermat integers in living systems. For instance, the so called scaling law of [I11] [K42] states that radiation with frequency f_l is accompanied by a radiation with frequency $f_h \simeq 2 \times 10^{11} f_l$. The scaling factor 2×10^{11} corresponds with 1.5 per cent accuracy to the integer $n_F = 2^{36} \times 3 \simeq 2.03 \times 10^{11}$ defining a Fermat polygon. This suggests an interpretation in terms of a decay of dark photon with a given wave-length to a bundle of n_F ordinary photons with the same wavelength. The energy of the dark photon would be by a factor n_F higher. This process could serve as an effective tool of bio-control. Dark photon could also transform to an ordinary photon with wavelength shorter by factor $1/n_F$. Quite generally, integers n_F defining Fermat polygons are a reasonable guess for the generalization of the scaling law of homeopathy and the search for these scaling factors could provide an experimental means of identifying the values of Planck constant relevant for living matter.

Even the time units of everyday life could reflect the properties of the dark matter hierarchy responsible for the control of living matter, in particular those of the sub-hierarchy defined by Fermat polygons. Indeed, one year corresponds to $n_F = 4 \times 3$ months, one month to $n_F = 2 \times 3 \times 5$ days, one day to $n_F = 8 \times 3$ hours, one hour to $n_F = 60 = 4 \times 3 \times 5$ minutes, and one minute to $n_F = 60$ seconds.

3. Chromosomes and exotic quarks?

Helices within helices could give rise to hierarchies of cognitive representations. Magnetic flux tubes can have complex helices inside helices hierarchies and in this case the number of units basically consisting of super-conducting ions or of their Cooper pairs per single period at given level of hierarchy should be prime for a given loop.

Chromosomes are characterized by this kind of hierarchy of coiling and looping which helps to pack chromosome DNA (about 2 meters in humans) in a small volume. This hierarchy could give also make possible a hierarchy of cognitive codes corresponding to the space-time sheets defining the hierarchy. What makes this hierarchy so interesting is that the p-adic length scales in question correspond to the miracle length scales defined by Gaussian Mersennes corresponding to $k = 151, 157, 163$ and 167. The diameter of the largest structure involved with chromosomes is about .7 micrometers whereas the smallest structure has diameter of 11 nanometers. Thus all three primary p-adic scaled up electron Compton lengths ($k = 151, 157, 163$) could be realized and three levelled hierarchy is possible.

1. If the principle of realization is same as for the memetic code based on the pair $k = 127, 120$ (electron CD containing a sequence of quark CDs), the following picture suggests itself. $k = 157$ codon has $n = 2^{157-151} = 64$ bits of duration $T(2, 151)$, $k = 163$ codon has $n = 64$ bits of duration $T(2, 157)$, and $k = 167$ codon has $n = 2^{167-163} = 4$ bits of duration $T(2, 163)$.

   The realization in terms of exotic light quarks quarks would involve only temporal sequences of n sub-CDs. The secondary p-adic time scales determining the time scale of the corresponding CD and thus the time duration of codon are rather long: about 2×10^6 s for $k = 151$ and 10^8 seconds for $k = 157$. A test for this idea is whether the numbers of the basic units per period of helix at various levels are given $n = 32, 32$, and 8 DNA nucleotides (not that these

numbers do not correspond to full number of codons).

2. The realization analogous to genetic code would involve $n = 157 - 151 = 6$ bits (genetic code), $n = 163 - 57 = 6$ bits, and $167 - 163 = 4$ bits.

3. One can also consider the possiblity that the number of bits is determined by the p-adic prime characterizing the space-time sheet involved and thus equal to $k = 151, 157, 163$. In this case the duration of bit would not correspond to a secondary p-adic time scale as it does for the memetic code.

Realization of finite projective geometries using Platonic and Archimedean solids

For projective geometries the realization as Platonic solids in the sense that the projective symmetry group acts as group of symmetries of the Platonic solid are possible only for $p = 2, 3, 5$ cases. The 5 Platonic solids are tetrahedron, cube and octhedron, and icosahedron and dodecahedron. The basic transformation is duality changing faces and vertices. tetrahedron (4 vertices and 4 faces) is self dual whereas cube (8 vertices and 6 faces) and octahedron (6 vertices and 8 faces) are duals of each other, as are also icosadedron (12 vertices and 20 faces) and dodecahedron (20 vertices and 12 faces). The number of edges is fixed by the Euler characteristic of sphere (solids are topologically spheres) given in terms of the numbers of vertices, edges, and faces by $V - E + F = 2$ and one has $E = V + F - 2$ giving for the number of edges $E = 6, 12, 30$ in the three cases respectively. Archimedean solids allow different types of faces and hexagons, octagons and decagons are possible (note that the number of vertices for faces is not prime anymore). Archimedean solids have same symmetry groups as Platonic solids from which they are obtained by "truncations".

It is interesting to look how the symmetry groups of finite geometries can be realized as symmetries of Platonic and some Archimedean solids.

1. For $p = 2$ the group of projective symmetries corresponds to the 6-element group S_3 of permutations of three objects acting on triangle and being generated by 2- and 3-fold symmetries. The 3 vertices represent the 3 points of the projective geometry and the generator of Z_2 acts as a reflection permuting any pair of these points with the third point representing the point at infinity. The three faces of tetrahedron give rise to a representation of $p = 2$ finite geometry too. By assigning to each of these vertices a two-state system one obtains a representation for M_2. Tetrahedron allows M_2^2 representation with information content of 4 bits.

2. $p = 3$ projective geometry has four points and has the permutation group S_4 of four objects as a symmetry group. This group is the symmetry group of tetrahedron and the vertices of any face realize the finite geometry with three points with the fourth vertex taking the role of the point at infinity. Also octahedron and cube having symmetry group generated by 2-, 3- and 4-fold symmetries allow realization of the $p = 3$ finite geometry but not an isometric realization of the projective geometry since the tetrahedron defined by the 3 vertices nearest to a given vertex is not regular. 3-fold symmetries are rotations along diagonals. M_3 cognitive representation results by assigning to the 3 vertices of triangle, tetrahedron or cube two-state systems.

3. The symmetry group of $p = 5$ finite projective geometry and thus also the geometry are represented by dodecahedron and icosahedron which are dual to each other by vertex-face transformation, as well as by a truncated icosahedron, "bucky ball", having 60 vertices and directly representing the projective group associated with the corresponding finite geometry [A11]. This group is isomorphic with the group A_5 of even permutations of 5 objects and contains 2-, 3-, and five-fold elements. The coset space of $A_5/Z_2 \times Z_5$ represents the projective space and consists of 6 pairs of opposite and disjoint pentagons representing the points of the finite projective geometry.

The points of the finite geometry are represented by a single pentagon as is clear from the fact that the cyclic group Z_5 acts on these pentagons) M_5 representation results by assigning to the vertices of any pentagon a two-state system. System allows actually much more: there are 12 disjoint pentagons so that M_5^{12} code can be realized with information content of 60 bits! Thus

truncated icosahedron has an exceptional capacity for coding intentions and this might be the reason for why it is the geometry of the clathrin molecules which take care of logistics in cellular systems.

All platonic solids except tetrahedron allow also lattice structures. Therefore cognitive structures allowing symbolic representations in terms of molecular and lattice structures based on Platonic solids are expected to be of fundamental importance. These correspond to correspond to 2, 3, and 5 bit codes and Mersennes M_2, M_3, M_5. M_2 corresponds to geometry of a line interval/triangle, M_3 to triangle/tetrahedron, and M_5 to pentagon/icosahedron, dodecahedron or truncated icosahedron depending on whether one requires projective extension or not. The codes would be represented by assigning to the substructures representing the finite geometry a two-state system. For instance, electric polarization of the protein structure in electric field at larger space-time sheet could define the spinlike variable. By using lattice like structure formed by basic units one obtains products of representations of type M_n^k.

Finite geometries appear naturally in p-adic context and Platonic solids suggests that the primes $p = 2, 3, 5$ and corresponding p-adicities are in special position. Generalized p-adic length scale hypothesis implied by NMP suggests that also the primes new powers of these primes are important. What is intriguing that the times assignable to jumps in biological evolution seems to correspond to powers of 3 for fundamental time scale (`http://tinyurl.com/ycesc5mq`) [I50]. The appearance of Golden mean in biology in turn suggests that 5-adicity is also present. Note however that Golden Mean requires algebraic extension of rationals containing $\sqrt{5}$. What is especially interesting that the model of music harmony and genetic code to be discussed in following involves icosahedron, which corresponds to $p = 5$ finite geometry.

Icosahedral model for music harmony and genetic code

The model for music harmony and genetic code [K80] represents the most recent work, which could be possibly interpreted in terms of discrete 2-D geometries assignable to partonic 2-surfaces. Platonic solids represent the most symmetric discrete geometries assignable to sphere. Icosahedron and tetrahedron represent two Platonic solids and appear in the model.

The work relies on two observations. The number of notes of 12-note scale is same as the number of vertices of icosahedron. Icosahedron has 20 faces, which is the number of amino-acids in standard genetic code. There are however some non-standard features: 2 additional amino-acids appear in Nature and the coding of stop codons is not always the same - as if two codes were present or code is context dependent.

So called quint rule allows to represent 12-note scale as a sequence of 3/2 scalings for the fundamental frequency of the scale. Nearest neighbors at the icosahedron would differ by quint as notes which would mean 3-adic notion of distance for frequencies. There is however a little problem: 12 scalings give 7 slightly more than 7 octaves. Well-tempered scale solves the problem but those with absolute ear like Pythagorean scale. The problem can be also solved by allowing 13:th note very near to one of the 12 notes.

The proposal is that 12-note scale corresponds to a self-non-intersecting closed (by octave equivalence) curve at icosahedron connecting neighboring points. Geometrically non-equivalent curves would correspond to different harmonies defined by the 3-chords assignable to the 20 faces of the icosahedron. These 20 faces would also correspond to amino-acids and also 20 DNAs which indeed consists of 3 nucleotides. The closed curves in question are known as called Hamiltonian cycles and there are 17 cycles altogether. 6 cycles do not have any symmetries. The remaining cycles have symmetry groups $Z_6, Z_4, Z_{2,rot}, Z_{2,refl}$ and their total number is 1+ 2+3+ 5=11.

60 DNAs can be regarded as a fusion of 3-harmonics corresponding to Z_6, Z_4 and Z_2 symmetry groups and one obtains 256 different bio-harmonies having possibly interpretations as correlates for emotional moods (music harmony both represents and generates emotions). It is proposed that the DNA codons are represented as chords defined by dark photon triplets and having frequency spectrum in the same region as ordinary music notes. The transformation between these two representation could take place routinely in living matter.

4 DNAs and also the 2 additional amino-acids are obtained in two ways. By fusing tetrahedron along its face to icosahedron and fusing the codes - this corresponds to adding 13:th note to the 12-note scale - or by keeping icosahedron and tetrahedron as distinct. One would have two separate genetic codes and this would explain the non-uniqueness of genetic code in some situations

as well as the 2 additional amino-acids. An interesting possibility is that the two DNA strands talk different languages so that the two codes would correspond to the two DNA strands!

Clathrin molecule and cognition

Icosahedral structure representing $p = 5$ finite geometry populate biology. Water molecular clusters have icosahedral structure or its dual dodecahedral structure defining also $p = 5$ finite geometry. Chlatrin molecule is a further example.

Clathrin molecule [J131] is involved with the transfer of various kinds of cargo through the cell membrane and also through intracellular membranes. Even viruses use clathrin molecule coating. Clathrin molecule induces a pit in the cell membrane and membrane pinches so that clathrin molecule providing coating for a piece of cell membrane and containing the cargo ends up to the cell interior. An area of cell membrane of football plane corresponding to that contained by entire brain is generated during one hour when clathrins coat cell membrane containing receptors and take it inside the cell. The generation of new cell membrane with this gigantic rate should involve huge dissipative losses unless macro-temporal quantum coherence is involved in the process.

Perhaps this argument alone convinces one day anyone about the presence of macro-temporal quantum coherence in brain. Clathrin molecule has the geometry of a truncated icosahedron, also the geometry of the soccer ball and fullerene or buckyball molecule C_{60} containing 60 carbon atoms arranged to the vertices of the truncated icosahedron. In clathrin molecule carbon atoms are replaced by three-legged triskelion molecules consisting of proteins. It is interesting to take a more careful look on the geometry of truncated icosahedron defining the geometry of the clathrin molecule, if not anything else, the for the purpose to get a glimpse about the amazing number theoretical regularities of this structure. Truncated icosahedron has 60=59+1 vertices, 90=89+1 lines, and 12=11+1 pentagonal and 20=19+1 hexagonal faces. Pentagonal faces are disjoint. 6 pentagonal face pairs can be naturally interpreted as points of a finite projective geometry associated with finite field $G(5, 1)$.

What it is interesting is that all these numbers are of form $p + 1$, p prime. With one exception (59) these primes also define Mersennes of Gaussian Mersennes. As a matter fact, the number of faces, edges, and vertices are of this form for all Platonic solids and also for several Archimedean solids. The interpretation in terms of a finite projective geometries suggests itself but the requirement that the symmetries of finite geometry are realizable as rotations excludes this interpretation since these substructures are not representations of the corresponding projective group realized in terms of rotations. Of course, one must keep mind open for the possibility that the embedding of the symmetry group to rotation group is not necessary.

Clathrin molecule is an excellent candidate for a very effective realization of molecular cognition. If the triskelion proteins at the vertices of disjoint pentagons are electrically polarizable, a dynamical M_5^{12} representation with information content of 60 bits becomes possible by controlling the electric field at the space-time sheet at which the triskelions are condensed at. This information could relate to the basic function of clathrin molecules but also the idea that clathrin molecules transfer also information besides matter must be considered. For instance, this representation could be involved with the transfer of not only the neurotransmitters but also of (micro-tubular?) information from post- to pre-synaptic neurons.

11.6.4 Application Of Ideas To Micro-Tubuli And Clathrin Molecules

The proposed general principle allow to develop detailed views about what kind of cognitive representations that various molecular structure can accommodate. There is a considerable freedom concerning the choice of the representative system and spin flips or analogous transitions can be amplified to magnetization type quantum phase transitions at higher levels of the self hierarchy.

Micro-tubular representations

Micro-tubuli [J59, J131] are formed as hexagonal lattices of tubulin dimers on cylinder. The two conformations of a tubulin dimer define the two states of the micro-tubular representations. In an external electric field along micro-tubule at the larger space-time sheet the second tubulin conformation is unstable and the codeword is realized as a phase transition leading to the ground

state. Spontaneous electric polarization of all tubulins in the same direction forced by an electric field in the direction of the micro-tubule defines the ground state. The ground state itself cannot give rise to conformational flips and thus cannot define a codeword and one obtains M_{13} rather than 2^{13} codewords realizable as a signal resulting in the flip to the ground state.

1. Basic picture Micro-tubuli have helical structure: there are two helical strands with 13-micro-tubule periodicity. A full 2π twist for a tubulin dimer strand corresponds to 13 dimers and corresponds to vertical distance of 8 resp. 5 micro-tubules for the two arrays involved. Thus a full 2π twist defines naturally the codeword and corresponds to 13-bit M_{13} codeword. Each tubulin dimer strand defines a codeword: M_{13}^{13} representations with an information content of $13^2 = 169$ bits associated with single 13-plet of codewords results.

The small value of $p = 13$ means an extreme flexibility concerning the duration of the cognitive code word. All $2^{13k/2} \sim 90.51^k$ multiples of T_{13} are possible. An interesting working hypothesis is that the number N of the tubulin strands contributing to the codeword defined by single connected structure defines the duration of the codeword as $T(N) = 2^{N \times 13/2} T_{13}$.

1. If the $k = 21$ micro-tubules at the wall of micro-tubule doublet contribute give rise to the DNA representation, this rule would predict the duration of the code word to be $T = 2^{(21-13) \times 13/2} T(169) \simeq 67.7$ seconds with the duration of bit about 5.6 seconds, which is somewhat longer than the mysterious time scale of 5 seconds associated with the Comorosan effect [K123]. $k = 20$ would give a codeword with a duration of .8 seconds and with the duration of bit about 62 milliseconds. DNA should control the behavior of micro-tubules in a rather long time scale (translation of single amino-acid takes 1/20 seconds) and these timescales sound rather reasonable.

2. For triplets of micro-tubuli the number of tubuli in the wall is something like 29 and the rule would predict completely unrealistic duration of the codeword about 10^7 years. It seems that the time scale should be same as for doublet: note that only pairs of tubuli have direct contact in the triplet.

3. Micro-tubular representation would correspond to the duration $T(13^2) = T(169)$ the cognitive codeword which is about 1.7×10^{-14} seconds, which is much shorter than the time scale of conformational dynamics and corresponds to the time scale of infrared transitions. This time scale is considerably shorter than the time scale $\sim .1$ nanoseconds associated with the protein conformational dynamics so that some other spin or rpolarization type variable should define the representation if it is realized at all. Neutrino spin is an excellent candidate in this respect. By increasing $k = 13$ to $k = 15$ gives time scale of order.1 nanoseconds. It seems that the working hypothesis could give rough ideas about orders of magnitude but cannot be taken literally.

2. Cilia and centriole

Centriole resp. cilia are arrangements of micro-tubules containing 9 bundles of 3 resp. 2 micro-tubules at the boundary of cylinder like structure and possibly also a doublet of micro-tubuli in the center [J131].

Micro-tubule doublets are associated with cilia crucial for the movement of monocellulars. Cilia consists of nine micro-tubule doublets at the surface of cylinder and one doublet in the center: also two separate micro-tubules are possible in the center. Some tubulin strands (usually three) are lacking from the second fused micro-tubule. According to some sources, the total number of tubulin dimer strands in doublet is 24 and 21 at the outer surface of doublet. 21 is Fibonacci number associated with the micro-tubular sequence of Fibonacci numbers and also the number of DNA triplets in cognitive codes. The complex of 21 tubulin dimer strands would be ideal for coding of M_{13}-bit sequences possibly associated with DNA or amino-acid sequences of 21 units and containing $21 \times 13 = 273$ bits of information. The code words associated with the wall of the cilium define $M_{13}^{9 \times 21}$ representation with $13 \times 9 \times 21 = 2457$ bits.

Centriole are crucial for the control of the movement of the cell and are present only in motile cells (not in plants). If nucleus controls the movement of cell, centrioles and cilia should communicate with DNA in both directions in the act of transforming intentions to actions. T

shaped centriole form an ideal antenna structure and could communicate both classically and quantally in terms of MEs. Centriole have 9 micro-tubule triplets at the boundary of a cylinder. Various sources give different values for the total number of strands but it seems that the total number of tubulin strands is about 33-34 and outer wall contains about 4 strands. Perhaps it deserves to be noticed that the total number of strands is near to Fibonacci number 34 associated with the micro-tubular sequence of Fibonacci numbers. In case of centriole the 9 fused triplets of micro-tubules at the boundary each triplet containing about 33 tubulin dimer strands should give rise to a representation $M_{13}^{9 \times 33}$ with $13 \times 9 \times 33 = 3861$ bits. Huge amounts of information are involved.

3. Neuronal micro-tubuli

Neurons, which are not motile cells, do not have the usual T shaped centriole structure. Micro-tubuli are however there and start from the region near nucleus and connect this region to the dendrites and to the end of the axon. The micro-tubuli associated with the axons can be very long, up to millimeters and are connected together by MAPs, micro-tubule associated proteins. This strongly suggests that micro-tubuli participate in an essential manner to neuronal communications or to short term information storage. For instance, the propagation of the nerve pulse could alter the electric field of the micro-tubule space-time sheet temporarily and give rise to spin glass state and thus induce representations of cognitive states in terms of tubulin conformations. The return of the membrane potential to the normal value would induce the conscious reading of the resulting representations. The minimal reason for this would be that axonal micro-tubules are responsible for the transfer of neurotransmitters to the axonal end and they must be cognizant about the overall nerve pulse activity.

Against the impressive representational capacity of micro-tubules the idea that nerve pulse involves the transfer of only single bit of information seems weird. Rather, the picture about micro-tubules would suggest that nerve pulse propagation are accompanied by a propagation of conformational spin glass state in the depolarized portion of the axon carrying information, and that one important function of the nerve pulse is to allow the propagation of the conformational wave carrying the information. Of course, also cell membrane could carry informational wave by same mechanism and one could see the events in the axonal membrane also as a realization of p-adic intentions basically. An objection against this view is related to the problem how the micro-tubular signal is transferred between micro-tubuli at MAPs. This is obviously needed if information from micro-tubuli is transferred to postsynaptic neuron. One must seriously consider the possibility is that the information is received only by micro-tubuli and their form an essential part of the conscious sensory pathway. This would explain why the lengths of micro-tubuli associated with sensory pathways are maximized (the information from given side of the body goes to the opposite brain hemisphere).

What about cell membrane?

Cell membrane electric field makes it ideal for the realization of cognitive representations. Lipid molecules and membrane proteins are natural good candidates for representing the bit sequences represented as two different electric polarizations of proteins. The propagation of nerve pulse could generate a representation during de-polarization phase which would be read when membrane potential has returned to its original value. The function of the nerve pulse would be thus to inform entire axon consciously.

11.7   Cognition And Number Theory

The identification of p-adic physics as physics of cognition and intention suggests strongly connections between cognition, intentionality, and number theory. The new idea is that also real transcendental numbers can appear in the extensions of p-adic numbers which must be assumed to be finite-dimensional at least in the case of human cognition. This idea, when combined with a more precise model for how intentions are transformed to actions, leads to a series of number theoretical conjectures. Also new insights about the number theoretical origin of the universal dynamics of conformally invariant critical systems emerge. The earlier approaches to the proof

of Riemann hypothesis can be understood in a unified manner and the assumption that Riemann Zeta exists in all number fields when finite extensions are allowed for p-adic numbers leads to the view that the zeros of Riemann Zeta correspond to the universal number theoretically quantized spectrum of scaling momenta associated with critical conformally invariant systems.

11.7.1 Conceptual And Technical Problems Related To P-Adicization

The following two ideas serve as guide lines in the attempt to relate cognition and number theory to each other so that number theory would allow to construct a more detailed view about the realization of intentionality and cognition.

One must face also several technical problems stimulating in turn ideas and in the following some of them are discussed.

1. Real and p-adic number fields form and adelic book like structure with pages represented by number fields glued together along rationals forming the rim of the book. For the extensions of p-adic numbers further common points result and the book becomes fractal if all possible extensions are allowed. This picture generalizes to the level of the embedding space and allows to see space-time surfaces as consisting of real and p-adic space-time sheets belonging to various extensions of these numbers. Gluing of the sheets to a book-like structure is however carried out at the level of parameter space defined by an algebraic extension of rationals. This generalized view about numbers gives hopes about an un-ambigious definition of what some number, say e, appearing in an extension of p-adic numbers really means.

   It is now clear that adelic view is the only mathematically feasible one and is made possible by the strong form of holography [K119]. The key notion is what I have called intersection of reality and various p-adicities. This intersection can be identified as string world sheets and partonic 2-surfaces parameterized by numbers in some algebraic extension of rationals. These extensions define a cognitive hierarchy since fermions reside at these 2-surfaces already from the condition that electric charge is well-defined.

   Discretization and real-p-adic correspondence via canonical identification as already in p-adic mass calculations for various group invariants - in particular the Lorentz invariants appearing in the scattering amplitudes - takes therefore therefore at more abstract level than originally thought. This allows to circumvent problems with various symmetries encountered if one maps real space-time surfaces to their p-adic counterparts locally. Only for partonic 2-surfaces the concrete discretization by common points in algebraic extension for real and partonic 2-surfaces makes sense.

   The roughest parametrization for the algebraic extension of rationals is by the degree of the polynomial defining it and the so called ramified primes. These parameters have a physical meaning too, and are expected to central for the understanding of cognitive hierarchy. Ramified primes indeed correspond to preferred p-adic primes for which additional degrees of freedom emerge.

   In strong form of holography p-adic continuations of 2-surfaces to preferred extrmals identifiable as imaginations would be easy due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K64]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes. Whether the preferred primes satisfy p-adic length scale hypothesis or its generalization from $p = 2$ to small primes remains an open question.

   The value of effective Planck constant $h_{eff}/h = n$ corresponds to the number of sheets of some kind of covering space defined by the space-time surface. The discretization of the space-time surface identified as a monadic manifold [L29] with embedding space preferred coordinates in extension of rationals defining the adele has Galois group of extension as a group of symmetries permuting the sheets of the covering group. Therefore $n = h_{eff}/h$ would naturally correspond to the dimension of the extension dividing the order of its Galois group.

2. The first new idea is roughly that the discovery of notion of any algebraic or transcendental number x (such as Φ or e) involves a quantum jump in which there is generated a p-adic space-time sheet for which the existing finite-dimensional extension of p-adic numbers is replaced by a finite-dimensional extension involving also x. Also some higher powers of the number are involved. For instance, for e $p-1$ powers are necessarily needed (e^p exists p-adically).

3. The points of M_+^4 with integer valued Minkowski coordinates using CP_2 length related fundamental length scale as a basic unit is a good guess for the subset of M_+^4 defining the rational points of the M_+^4 involved. CP_2 coordinates as functions of M_+^4 coordinates should be rational or belong to some finite-dimensional extension of p-adics. Of course, also rational points of M_+^4 are possible, and the evolution of cognition should correspond to the increase of the algebraic dimension of the extension.

4. A very powerful hypothesis is that the p-adic and real functions have the same analytic form. This makes possible to construct scattering amplitudes by algebraic continuations from the intersection of reality and p-adicities (the back of the book-like structure defined by 2-surfaces with parameters in algebraic extension of rationals). This assumption favors functions which allow at some point (most naturally origin) a Taylor series with rational valued Taylor coefficients.

Is e an exceptional transcendental?

Neper number is obviously the simplest one and only the powers e^k, $k = 1, ..., p-1$ of e are needed to define p-adic counterpart of e^x for $x = n$. In case of trigonometric functions deriving from e^{ix}, also e^i and its $p-1$ powers must belong to the extension.

An interesting question is whether e is a number theoretically exceptional transcendental or whether it could be easy to find also other transcendentals defining finite-dimensional extensions of p-adic numbers.

1. Consider functions $f(x)$, which are analytic functions with rational Taylor coefficients, when expanded around origin for $x > 0$. The values of $f(n)$, $n = 1, ..., p-1$ should belong to an extension, which should be finite-dimensional.

2. The expansion of these functions to Taylor series generalizes to the p-adic context if also the higher derivatives of f at $x = n$ belong to the extension. This is achieved if the higher derivatives are expressible in terms of the lower derivatives using rational coefficients and rational functions or functions, which are defined at integer points (such as exponential and logarithm) by construction. A differential equation of some finite order involving only rational functions with rational coefficients must therefore be satisfied (e^x satisfying the differential equation $df/dx = f$ is the optimal case in this sense). The higher derivatives could also reduce to rational functions at some step ($log(x)$ satisfying the differential equation $df/dx = 1/x$).

3. The differential equation allows to develop $f(x)$ in power series, say in origin

$$f(x) = \sum f_n \frac{x^n}{n!}$$

such that f_{n+m} is expressible as a rational function of the m lower derivatives and is therefore a rational number.

The series converges when the p-adic norm of x satisfies $|x|_p \leq p^k$ for some k. For definiteness one can assume $k = 1$. For $x = 1, ..., p-1$ the series does not converge in this case, and one can introduce and extension containing the values $f(k)$ and hope that a finite-dimensional extension results.

Finite-dimensionality requires that the values are related to each other algebraically although they need not be algebraic numbers. This means symmetry. In the case of exponent function this relationship is exceptionally simple. The algebraic relationship reflects the fact that exponential map represents translation and exponent function is an eigen function of a translation operator.

The necessary presence of symmetry might mean that the situation reduces always to either exponential action. Also the phase factors $exp(iq\pi)$ could be interpreted in terms of exponential symmetry. Hence the reason for the exceptional role of exponent function reduces to group theory.

Also other extensions than those defined by roots of e are possible. Any polynomial has n roots and for transcendental coefficients the roots define a finite-dimensional extension of rationals. It would seem that one could allow the coefficients of the polynomial to be functions in an extension of rationals by powers of a root of e and algebraic numbers so that one would obtain infinite hierarchy of transcendental extensions.

Does the integration of complex rational functions lead to rationals extended by a root of e and powers of π?

These cold showers suggest that the best one might hope is that the numbers like $log(p)$ and $log(\Phi)$ could be proportional to some power π with a coefficient which belongs to a finite extension of p-adic numbers containing e. This might make it possible to continue the theory to p-adic context and also make very strong predictions.

The elementary differential and integral calculus provides important hints for as how to proceed. Derivation takes rational functions to rational functions unlike integration since the integrals of $1/x$ and and $1/(1+x^2)$ give $log(x)$ and $arctan(x)$ leading outside the realm of rational numbers. One can go to complex plane and consider the integrals of complex rational functions with complex rational coefficients and here one encounters integrals over closed curves and between two points. The rational approach is to consider rational complex plane, and first restrict to Gaussian integers which allow primes.

1. The first observation is that residy calculus for rational functions gives always integrals which are of form $2\pi i q$, q a rational number.

2. The integral $I = \int_a^b dz/z$, $a = m_1 + in_1$, $b = m_2 + in_2$ in turn gives

$$I = log(a/b) = \tfrac{1}{2}\left(log(m_2^2 + n_2^2) - log(m_1^2 + n_1^2)\right)$$

$$+i(arctan(n_2/m_2) - arctan(n_1/m_1)) \ .$$

1. The strongest hypothesis would be that logarithm and arctan are also rationally proportional to π so that all integrals of this kind lead to an infinite-dimensional transcendental extension of p-adic numbers containing π. The strong hypothesis cannot be correct. Consider arcus tangent as an example. $arctan(m/n) = r\pi/s$ would imply $tan(r\pi/s) = m/n$, and this cannot hold true since it would imply that s: th powers of Gaussian integer $n + im$ would give an ordinary integer. This would be also true for Gaussian primes and the decomposition of Gaussian integers as products of Gaussian primes would become non-unique. There is this kind of uniqueness but this is due the units $exp(i\pi/4)$ and its powers. Indeed, $arctan(1) = \pi/4$ and proportional to π.

2. One can overcome this difficulty by replacing the ansatz with

$$arctan(q) = e^{q_1(q)}q_2\pi$$

such that $q_1(q)$ is non-vanishing for $q \neq \pm 1 \pm i$ corresponding to the units of Gaussian primes. This ansatz is completely analogous to the ansatz for $log(p)$. The beauty of this ansatz would be that the imaginary parts for the integral of $1/(z - z_0)$ between complex rational points would be proportional to π irrespective of whether the integration is over a closed or open curve. The real parts of complex integrals in turn would be proportional to $1/\pi$ of $log(p) \propto 1/\pi$ ansatz holds true.

The requirement that complex integrals are powers of π could also mean quantization of topology in TGD framework. For instance, the conformal equivalence classes of Riemann surfaces of genus g are represented by period integrals of 1-forms defining elements of cohomology group H^1 over the circles representing the elements of homology group H_1. Restricting the cohomology to a rational

cohomology, the periods with standard normalization would be quantized to complex rationals multiplied by a power of π. For surfaces characterized by a given power of π one might perhaps perform the p-adicization finite-dimensionally by suitable normalizations by powers of π.

11.7.2 Should One Allow Also Transcendentals In The Extensions Of P-Adic Numbers?

TGD inspired theory of consciousness leads to the identification of p-adic physics as physics of cognition. This identification leads to a rather fascinating new ideas concerning the characterization of intentional systems.

The basic ingredient is the new view about numbers: real and p-adic number fields are glued together like pages of a book along common rationals representing the rim of the book. This generalizes to the extensions of p-adic number fields and the outcome is a complex fractal book like structure containing books within books. This holds true also for manifolds and one ends up to the view about many-sheeted space-time realized as 4-surface in 8-D generalized embedding space and containing both real and p-adic space-time sheets. The transformation of intention to action corresponds to a quantum jump in which p-adic space-time sheet is replaced with a real one.

One implication is that the rationals having short distance p-adically are very far away in real sense. This implies that p-adically short temporal and spatial distances correspond to long real distances and that the evolution of cognition proceeds from long to short temporal and spatial scales whereas material evolution proceeds from short to long scales. Together with p-adic non-determinism due the fact that the integration constants of p-adic differential equations are piecewise constant functions this explains the long range temporal correlations and apparent local randomness of intentional behavior. The failure of the real statistics and its replacement by p-adic fractal statistics for time series defined by varying number N of measurements performed during a fixed time interval T allows very general tests for whether the system is intentional and what is the p-adic prime p characterizing the "intelligence quotient" of the system. The replacement of $log(p_n)$ in the formula $S = -\sum_n p_n log(p_n)$ of Shannon entropy with the logarithm of the p-adic norm $|p_n|_p$ of the rational valued probability allows to define a hierarchy of number theoretic information measures which can have both negative and positive values.

Since p-adic numbers represent a highly number theoretical concept one might expect that there are deep connections between number theory and intentionality and cognition. The discussions with Uwe Kämpf in CASYS′2003 conference in Liege indeed stimulated a bundle of ideas allowing to develop a more detailed view about intention-to-action transformation and to disentangle these connections. These discussions made me aware of the fact that my recent views about the role of extensions of p-adic numbers are perhaps too limited. To see this consider the following arguments.

1. Pure p-adic numbers predict only p-adic length scales proportional to $p^{n/2}l$, l CP_2 length scale about 10^4 Planck lengths, $p \simeq 2^k$, k prime or power of prime. As a matter fact, all positive integer values of k are possible. This is however not enough to explain all known scale hierarchies. Fibonacci numbers $F_n : F_n + 1 = F_n + F_{n-1}$ behave asymptotically like $F_n = kF_{n-1}$, k solution of the equation $k^2 = k+1$ given by $k = \Phi = (1+\sqrt{5})/2 \simeq 1.6$. Living systems and self-organizing systems represent a lot of examples about scale hierarchies coming in powers of the Golden Mean $\Phi = (1+\sqrt{5})/2$. According to Selvam [H3] also meteorological phenomena involve spiral waves characterized by Golden Mean.

   By allowing the extensions of p-adics by algebraic numbers one ends up to the idea that also the length scales coming as powers of x, where x is a unit of algebraic extension analogous to imaginary unit, are possible. One would however expect that the generalization of the p-adic length scale hypothesis alone would predict only the powers $\sqrt{x}p^{n/2}$ rather than $x^k p^{n/2}$, $k = 1, 2, ...$. Perhaps the purely kinematical explanation of these scales is not possible and genuine dynamics is needed. For sinusoidal logarithmic plane waves the harmonics correspond to the scalings of the argument by powers of some scaling factor x. Thus the powers of Golden Mean might be associated with logarithmic sinusoidal plane waves.

2. Physicist Hartmuth Mueller has developed what he calls Global Scaling Theory [B2] based on the observation that powers of e (Neper number) define preferred length scales. These powers

associate naturally with the nodes of logarithmic sinusoidal plane waves and correspond to various harmonics (matter tends to concentrate on the nodes of waves since force vanishes at the nodes). Mueller talks about physics of number line and there is great temptation to assume that deep number theory is indeed involved. What is troubling from TGD point of view that Neper number e is not algebraic. Perhaps a more general approach allowing also transcendentals must be adopted. Indeed, since e^p is ordinary p-adic number in R_p, a finite-dimension transcendental extension containing e exists.

3. Classical mathematics, such as the theory of elementary functions, involves few crucially important transcendentals such as e and π. This might reflect the evolution of cognition: these numbers should be cognitively and number theoretically very special. The numbers e and π appear also repeatedly in the basic formulas of physics. They however look p-adically very troublesome since it has been very difficult to imagine a physically acceptable generalization of such simple concepts as exponent function, trigonometric functions, and logarithm resembling its real counterpart by allowing only the extensions of p-adic numbers based on algebraic numbers.

4. Number theoretic entropies measured in bits are proportional to $log(p)/log(2)$. The idea that these entropies are rational fractions of bit is attractive and implies that $log(p)$ for all primes is proportional to the same transcendental number. This would mean that logarithm of the rational number field would be a transcendental multiple of rationals.

These considerations stimulate the question whether, besides the extensions of p-adics by algebraic numbers, also the extensions of p-adic numbers involving e, and perhaps even πandother transcendentals might be needed. The intuitive expectation motivated by the finiteness of human intelligence is that these extensions might have finite algebraic dimensions. On the other hand, if one is only interested in quantities derived from phases $exp(i2\pi/n)$, a finite-dimensional algebraic extension is enough. π is needed only if one wants to deal with say length of circle's circumference in the p-adic context, and one could argue that p-adic Riemann geometry is local and only about angles and infinitesimal distances.

Second question is whether there might be some dynamical mechanism allowing to understand the hierarchy of scalings coming in powers of some preferred transcendentals and algebraic numbers like Golden Mean. Conformal invariance implying that the system is characterized by a universal spectrum of scaling momenta for the logarithmic counterparts of plane waves seems to provide this mechanism. This spectrum is determined by the requirement that it exists for both reals and all p-adic number fields assuming that finite-dimensional extensions are allowed in the latter case. The spectrum corresponds to the zeros of the Riemann Zeta if Zeta is required to exist for all number fields in the proposed sense, and a lot of new understanding related to Riemann hypothesis emerges and allows to develop further the previous TGD inspired ideas about how to prove Riemann hypothesis [L1] , [H9].

11.7.3 Infinite Primes And Cognition

Somehow it is obvious that infinite primes must have some very deep role to play in quantum TGD and TGD inspired theory of consciousness. What this role precisely is has remained an enigma although I have considered several detailed interpretations, one of them above.

Infinite primes very briefly

Infinite primes have a decomposition to infinite and finite parts allowing an interpretation as a many-particle state of a super-symmetric arithmetic quantum field theory for which fermions and bosons are labelled by primes. There is actually an infinite hierarchy for which infinite primes of a given level define the building blocks of the infinite primes of the next level. One can map infinite primes to polynomials and these polynomials in turn could define space-time surfaces or at least light-like partonic 3-surfaces appearing as solutions of Chern-Simons action so that the classical dynamics would not pose too strong constraints.

The simplest infinite primes at the lowest level are of form $m_B X/s_F + n_B s_F$, $X = \prod_i p_i$ (product of all finite primes). The simplest interpretation is that X represents Dirac sea with all

states filled and $X/s_F + s_F$ represents a state obtained by creating holes in the Dirac sea. m_B, n_B, and s_F are defined as $m_B = \prod_i p_i^{m_i}$, $n_B = \prod_i q_i^{n_i}$, and $s_F = \prod_i q_i$, m_B and n_B have no common prime factors. The integers m_B and n_B characterize the occupation numbers of bosons in modes labelled by p_i and q_i and $s_F = \prod_i q_i$ characterizes the non-vanishing occupation numbers of fermions.

The simplest infinite primes at all levels of the hierarchy have this form. The notion of infinite prime might generalize to quaternionic and even octonionic context and one can consider the possibility that the quaternionic components represent some quantum numbers at least in the sense that one can map these quantum numbers to the quaternionic primes.

A connection with infinite primes?

Infinite primes are one of the mathematical outcomes of TGD [K102]. There are two kinds of infinite primes. There are the analogs of free many particle states consisting of fermions and bosons labelled by primes of the previous level in the hierarchy. They correspond to states of a supersymmetric arithmetic quantum field theory or actually a hierarchy of them obtained by a repeated second quantization of this theory. A connection between infinite primes representing bound statesandirreducible polynomials is highly suggestive.

1. The infinite prime representing free many-particle state decomposes to a sum of infinite part and finite part having no common finite prime divisors so that prime is obtained. The infinite part is obtained from "fermionic vacuum" $X = \prod_k p_k$ by dividing away some fermionic primes p_i and adding their product so that one has $X \to X/m + m$, where m is square free integer. Also $m = 1$ is allowed and is analogous to fermionic vacuum interpreted as Dirac sea without holes. X is infinite prime and pure many-fermion state physically. One can add bosons by multiplying X with any integers having no common denominators with m and its prime decomposition defines the bosonic contents of the state. One can also multiply m by any integers whose prime factors are prime factors of m.

2. There are also infinite primes, which are analogs of bound states and at the lowest level of the hierarchy they correspond to irreducible polynomials $P(x)$ with integer coefficients. At the second levels the bound states would naturally correspond to irreducible polynomials $P_n(x)$ with coefficients $Q_k(y)$, which are infinite integers at the previous level of the hierarchy.

3. At the lowest level the polynomials defined by infinite primes correspond to irreducible polynomials characterizing irreducible algebraic extensions. Infinite bound state integers in turn would characterize non-irreducible extensions. Since the algebraic extensions of rationals define a hierarchy identified as giving rise to evolutionary hierarchy based on increasing algebraic complexity and increasing representative capacity, there indeed would be a connection with the infinite primes at the first level of hierarchy at least.

4. What is remarkable that bound state infinite primes at any level of hierarchy would define maximally ramified algebraic extensions at previous level. One indeed has infinite hierarchy of infinite primes since the infinite primes at given level are infinite primes in the sense that they are not divisible by the primes of the previous level. The formal construction works as such. Infinite primes correspond to polynomials of single variable at the first level, polynomials of two variables at second level, and so on. Could the Langlands program could be generalized from the extensions of rationals to polynomials of complex argument and that one would obtain infinite hierarchy?

5. Infinite integers in turn could correspond to products of irreducible polynomials defining more general extensions. This raises the conjecture that infinite primes for an extension K of rationals could code for the algebraic extensions of K quite generally. If infinite primes correspond to real quantum states they would thus correspond the extensions of rationals to which the parameters appearing in the functions defining partonic 2-surfaces and string world sheets.

This would support the view that partonic 2-surfaces associated with algebraic extensions defined by infinite integers and thus not irreducible are unstable against decay to partonic

2-surfaces which corresponds to extensions assignable to infinite primes. Infinite composite integer defining intermediate unstable state would decay to its composites. Basic particle physics phenomenology would have number theoretic analog and even more.

6. According to Wikipedia, Eisenstein's criterion (`http://tinyurl.com/47kxjz`) allows generalization and what comes in mind is that it applies in exactly the same form also at the higher levels of the hierarchy. Primes would be only replaced with prime polynomials and the there would be at least one prime polynomial $Q(y)$ dividing the coefficients of $P_n(x)$ except the highest one such that its square would not divide P_0. Infinite primes would give rise to an infinite hierarchy of functions of many complex variables. At first level zeros of function would give discrete points at partonic 2-surface. At second level one would obtain 2-D surface: partonic 2-surfaces or string world sheet. At the next level one would obtain 4-D surfaces. What about higher levels? Does one obtain higher dimensional objects or something else. The union of n 2-surfaces can be interpreted also as $2n$-dimensional surface and one could think that the hierarchy describes a hierarchy of unions of correlated partonic 2-surfaces. The correlation would be due to the preferred extremal property of Kähler action.

One can ask whether this hierarchy could allow to generalize number theoretical Langlands to the case of function fields using the notion of prime function assignable to infinite prime. What this hierarchy of polynomials of arbitrary many complex arguments means physically is unclear. Do these polynomials describe many-particle states consisting of partonic 2-surface such that there is a correlation between them as sub-manifolds of the same space-time sheet representing a preferred extremals of Kähler action?

This would suggest strongly the generalization of the notion of p-adicity so that it applies to infinite primes.

1. This looks sensible and maybe even practical! Infinite primes can be mapped to prime polynomials so that the generalized p-adic numbers would be power series in prime polynomial - Taylor expansion in the coordinate variable defined by the infinite prime. Note that infinite primes (irreducible polynomials) would give rise to a hierarchy of preferred coordinate variables. In terms of infinite primes this expansion would require that coefficients are smaller than the infinite prime P used. Are the coefficients lower level primes? Or also infinite integers at the same level smaller than the infinite prime in question? This criterion makes sense since one can calculate the ratios of infinite primes as real numbers.

2. I would guess that the definition of infinite-P p-adicity is not a problem since mathematicians have generalized the number theoretical notions to such a level of abstraction much above of a layman like me. The basic question is how to define p-adic norm for the infinite primes (infinite only in real sense, p-adically they have unit norm for all lower level primes) so that it is finite.

3. There exists an extremely general definition of generalized p-adic number fields (see `http://tinyurl.com/y5zreeg`). One considers Dedekind domain D, which is a generalization of integers for ordinary number field having the property that ideals factorize uniquely to prime ideals. Now D would contain infinite integers. One introduces the field E of fractions consisting of infinite rationals.

Consider element e of E and a general fractional ideal eD as counterpart of ordinary rational and decompose it to a ratio of products of powers of ideals defined by prime ideals, now those defined by infinite primes. The general expression for the p-adic norm of x is $x^{-ord(P)}$, where n defines the total number of ideals P appearing in the factorization of a fractional ideal in E: this number can be also negative for rationals. When the residue field is finite (finite field G(p,1) for p-adic numbers), one can take c to the number of its elements ($c = p$ for p-adic numbers.

Now it seems that this number is not finite since the number of ordinary primes smaller than P is infinite! But this is not a problem since the topology for completion does not depend on the value of c. The simple infinite primes at the first level (free many-particle states) can be mapped to ordinary rationals and q-adic norm suggests itself: could it be that infinite-P

p-adicity corresponds to q-adicity discussed by Khrennikov [A8]. Note however that q-adic numbers are not a field.

11.7.4   Cognition, Logic, And P-Adicity

There seems to be a nice connection between logic aspects of cognition and p-adicity. In particular, p-valued logic for $p = 2^k - n$ has interpretation in terms of ordinary Boolean logic with n "taboos" so that p-valued logic does not conflict with common sense in this case. Also an interpretation of projections of p-adic space-time sheets to an integer lattice of real Minkowski space M^4 in terms of generalized Boolean functions emerges naturally so that M^4 projections of p-adic space-time would represent Boolean functions for a logic with n taboos.

2-adic valued functions of 2-adic variable and Boolean functions

The binary coefficients f_{nk} in the 2-adic expansions of terms $f_n x^n$ in the 2-adic Taylor expansion $f(x) = \sum_{n=0} f_n x^n$, assign a sequence of truth values to a 2-adic integer valued argument $x \in \{0, 1, ..., 2^N\}$ defining a sequence of N bits. Hence $f(x)$ assigns to each bit of this sequence a sequence of truth values which are ordered in the sense that the truth values corresponding to bits are not so important p-adically: much like higher decimals in decimal expansion. If a binary cutoff in N: th bit of $f(x)$ is introduced, B^M-valued function in B^N results, where B denotes Boolean algebra fo 2 elements. The formal generalization to p-adic case is trivial: 2 possible truth values are only replaced by p truth values representable as $0, ..., p - 1$.

p-Adic valued functions of p-adic variable as generalized Boolean functions

One can speak of a generalized Boolean function mapping finite sequences of p-valued Boolean arguments to finite sequences of p-valued Boolean arguments. The restriction to a subset $x = kp^n$, $k = 0, ..., p - 1$ and the replacement of the function $f(x)$ with its lowest pinary digit gives a generalized Boolean function of a single p-valued argument. If $f(x)$ is invariant under the scalings by powers of p^k, one obtains a hologram like representation of the generalized Boolean function with same function represented in infinitely many length scales. This guarantees the robustness of the representation.

The special role of 2-adicity explaining p-adic length scale hypothesis $p \simeq 2^k$, k integer, in terms of multi-p-acidic fractality would correlate with the special role of 2-valued logic in the world order. The fact that all generalizations of 2-valued logic ultimately involve 2-adic logic at the highest level, where the generalization is formulated would be analog of p-adic length scale hypothesis.

$p = 2^k - n$-adicity and Boolean functions with taboos

It is difficult to assign any reasonable interpretation to $p > 2$-valued logic. Also the generalization of logical connectivesandOR is far from obvious. In the case $p = 2^k - n$ favored by the p-adic length scale hypothesis situation is however different. In this case one has interpretation in terms B^k with n Boolean statements dropped out so that one obtains what might be called $\hat{B}^k$. Since n is odd this set is not invariant under Boolean conjugation so that there is at least one statement, which is identically true and could be called taboo, axiom, or dogma: depending on taste. The allowed Boolean functions would be constructed in this case using standard Boolean functionsandOR with the constraint that taboos are respected: in other words, both the inputs and values of functions belong to $\hat{B}^k$.

A unique manner to define the logic with taboos is to require that the number of taboos is maximal so that if statement is dropped its negation remains in the logic. This implies $n > B^k/2$.

Some calculational details

In the following the details of p-adic non-determinism are described for a differential equation of single p-adic variable and some comments about the generalization to the realistic case are given.

1. One-dimensional case

To understand the essentials consider for simplicity a solution of a p-adic differential equation giving function $y = f(x)$ of one independent variable $x = \sum_{n \geq n_0} x_n p^n$.

1. p-Adic non-determinism means that the initial values $f(x)$ of the solution can be fixed arbitrarily up to $N + 1$: th pinary digit. In other words, $f(x_N)$, where $x_N = \sum_{n_0 \leq n \geq N} x_n p^n$ is a rational obtained by dropping all pinary digits higher than N in $x = \sum_{n \geq n_0} x_n p^n$ can be chosen arbitrarily.

2. Consider the projection of $f(x)$ to the set of rationals assumed to be common to reals and p-adics.

   (a) Genuinely p-adic numbers have infinite number of positive pinary digits in their non-periodic expansion (non-periodicity guarantees non-rationality) and are strictly infinite as real numbers. In this regime p-adic differential equation fixes completely the solution. This is the case also at rational points $q = m/n$ having infinite number of pinary digits in their pinary expansion.

   (b) The projection of p-adic x-axis to real axis consists of rationals. The set in which solution of p-adic differential equations is non-vanishing can be chosen rather freely. For instance, p-adic ball of radius p^{-n} consisting of points $x = p^M y$, $y \neq 0$, $|y|_p \leq 1$, can be considered. Assume $N > M$. p-Adic nondeterminism implies that $f(q)$ for $q = \sum_{M \leq n \leq N} x_n p^n$, can be chosen arbitrarily. For $M \geq 0$ q is always integer valued and the scaling of x by a suitable power of p always allows to get a finite integer lattice at x-axis.

   (c) The lowest pinary digit in the expansion of $f(q)$ in powers of p in defines a pinary digit. These pinary digits would define a representation for a sequence of truth values of p-logic. $p = 2$ gives the ordinary Boolean logic. It is also interpret this pinary function as a function of pinary argument giving Boolean function of one variable in 2-adic case.

2. Generalization to the space-time level

This picture generalizes to space-time level in a rather straight forward manner. y is replaced with CP_2 coordinates, x is replaced with M^4 coordinates, and differential equation with field equations deducible from the Kähler action. The essential point is that p-adic space-time sheets have projection to real Minkowski space which consists of a discrete subset of integers when suitable scaling of M^4 coordinates is allowed. The restriction of 4 CP_2 coordinates to a finite integer lattice of M^4 defines 4 Boolean functions of four Boolean arguments or their generalizations for $p > 2$. Also the modes of the induce spinor field define a similar representation.

11.8 Cognitive representations for partonic 2-surfaces, string world sheets, and string like objects

Cognitive representations are identified as points of space-time surface $X^4 \subset M^4 \times CP_2$ having embedding space coordinates in the extension of of rationals defined by the polynomial defined by the M^8 pre-image of X^4 under $M^8 - H$ correspondence [L33, L34, L60, L55, L54, L50]. Cognitive representations have become key piece in the formulation of scattering amplitudes [L57] . One might argue that number theoretic evolution as increase of the dimension of the extension of rationals favors space-time surfaces with especially large cognitive representations since the larger the number of points in the representation is, the more faithful the representation is.

One can pose several questions if one accepts the idea that space-time surfaces with large cognitive representations are survivors.

1. Preferred p-adic primes are proposed to correspond to the ramified primes of the extension [L62]. The proposal is that the p-adic counterparts of space-time surfaces are identifiable as imaginations whereas real space-time surfaces correspond to realities. p-Adic space-time surfaces would have the embedding space points in extension of rationals as common with

real surfaces and large number of these points would make the representation realistic. Note that the number of points in extension does not depend on p-adic prime.

Could some extensions have an especially high number of points in the cognitive representation so that the corresponding ramified primes could be seen as survivors in number theoretical fight for survival, so to say? Galois group of the extension acts on cognitive representation. Galois extension of an extension has the Galois group of the original extension as normal subgroup so that ormal Galois group is analogous to a conserved gene.

2. Also the type of extremal matters. For instance, for instance canonically imbedded M^4 and CP_2 contain all points of extension. These surfaces correspond to the vanishing of real or imaginary part (in quaternionic sense) for a linear octonionic polynomial $P(o) = o$! As a matter of fact, this is true for all known preferred extremals under rather mild additional conditions. Boundary conditions posed at both ends of CD in ZEO exclude these surfaces and the actual space-time surfaces are expected to be their deformations.

3. Could the surfaces for which the number of points in cognitive representation is high, be the ones most easily discovered by mathematical mind? The experience with TGD supports positive answer: in TGD the known extremals [K8] are examples of such mathematical objects! If so, one should try to identify mathematical objects with high symmetries and look whether they allow TGD realization.

4. One must also specify more precisely what cognitive representation means. Strong form of holography (SH) states that the information gives at 2-D surfaces - string world sheets and partonic 2-surfaces - is enough to determine the space-time surfaces. This suggests that it is enough to consider cognitive representation restricted to these 2-surfaces. What kind of 2-surfaces are the cognitively fittest one? It would not be surprising if surfaces with large symmetries acting in extension were favored and elliptic curves with discrete 2-D translation group indeed turn out to be assigable string world sheets as singularities and string like objects. In the case of partonic 2-surfaces geodesic sphere of CP_2 is similar object.

All known extremals, in particular preferred extremals, are good candidates in this respect because of their high symmetries. By strong form of holography (SH) partonic 2-surfaces and string world sheets are expected to give rise to cognitive representations. Also cosmic strings are expected to carry them. Under what conditions these representations are large?

11.8.1 Partonic 2-surfaces as seats of cognitive representations

One can start from SH and look the situation more concretely. The situation for partonic 2-surfaces has been considered already earlier [L61, L53] but deserves a separate discussion.

1. Octonionic polynomials allow special solutions for which the entire polynomial vanishes. This happens at 6-sphere S^6 at the boundary of 8-D light-cone. S^6 is analogous to brane and has radius $R = r_n$, which is a root of the real polynomial with rational coefficients algebraically continued to the octonionic polynomial.

   S^6 has the ball B^3 of radius r_n of the light-cone M^4_+ with time coordinate $t = r_n$ as analog of base space and sphere S^3 of E^4 with radius $R = \sqrt{r_n^2 - r^2}$, r the radial coordinate of B^3 as an analog of fiber. The analog of the fiber contracts to a point at the boundary of the light-cone. The points with B^3 projection and E^4 coordinates in extension of rationals belong to the cognitive representation. The condition that $R^2 = x_i x^i = r_n^2 - r^2$ is square of a number of extension is rather mild and allows infinite number of solutions.

2. The 4-D space-time surfaces X^4 are obtained as generic solutions of $Im(P(o)) = 0$ or $Re(P(o)) = 0$. Their intersection with S^6 - partonic 2-surface X^2 - is 2-D. The assumption is that the incoming and outgoing 4-D space-time surfaces representing orbits of particles in topological sense are glued together at X^2 and possibly also in their interiors. X^2 serves as an analog of vertex for 3-D particles. This gives rise to topological analogs of Feynman diagrams.

   In the generic case the number of points in cognitive representation restricted to X^2 is finite unless the partonic 2-surface X^2 is special - say correspond to a geodesic spere of S^6.

3. The discrete isometries and conformal symmetries of the cognitive representation restricted to X^2 possibly represented as elements of Galois group might play a role. For $X^2 = S^2$ the finite discrete subgroups of $SO(3)$ giving rise to finite tessellations and appearing in ADE correspondence might be relevant. For genera $g = 01, 2$ conformal symmetry Z_2 is always possible but for higher genera only in the case of hyper-elliptic surfaces- this used to explain why only $g = 0, 1, 2$ correspond to observed particles [K23] whereas higher genera could be regarded as many-particle states of handles having continuous mass spectrum. Torus is an exceptional case and one can ask whether discrete subgroup of its isometries could be realized.

4. In TGD inspired theory of consciousness [L39, L53] the moments $t = r_n$ corresponds to "very special moments in the life of self". They would be also cognitively very special - kind of eureka moments with a very large number of points in cognitive representation. The question is whether these surfaces might be relevant for understanding the nature of mathematical consciousness and how the mathematical notions emerge at space-time level.

11.8.2   Ellipticity

Surfaces with discrete translational symmetries is a natural candidate for a surface with very large cognitive representation. Are their analogs possible? The notions of elliptic function, curve, and surface suggest themselves as a starting point.

1. Elliptic functions (`http://tinyurl.com/gpugcnh`) have 2-D discrete group of translations as symmetries and are therefore doubly periodic and thus identifiable as functions on torus.

   Weierstrass elliptic functions $\mathcal{P}(z; \omega_1, \omega_2)$ (`http://tinyurl.com/ycu8oa4r`) are defined on torus and labelled by the conformal equivalence class $\lambda = \omega_1/\omega_2$ of torus identified as the ratio $\lambda = \omega_1/\omega_2$ of the complex numbers ω_i defining the periodicities of the lattice involved. Functions $\mathcal{P}(z; \omega_1, \omega_2)$ are of special interest as far as elliptic curves are considered and defines an embedding of elliptic curve to CP_2 as will be found.

   If the periods are in extension of rationals then values in the extension appear infinitely many times. Elliptic functions are not polynomials. Although the polynomials giving rise to octonionic polynomials could be replaced by analytic functions it seems that elliptic functions are not the case of primary interest. Note however that the roots r_n could be also complex and could correspond to values of elliptic function forming a lattice.

2. Elliptic curves (`http://tinyurl.com/lovksny`) are defined by the polynomial equation

$$y^2 \quad = \quad P(x) = x^3 + ax + b \ . \tag{11.8.1}$$

   An algebraic curve of genus 1 allowing 2-D discrete translations as symmetries is in question. If a point of elliptic curve has coordinates in extension of rationals then 2-D discrete translation acting in extension give rise to infinite number of points in the cognitive representation. Clearly, the 2-D vectors spanning the lattice defining the group must be in extension of rationals.

One can indeed define commutative sum $P + Q$ for the points of the elliptic curve. The detailed definition of the group law and its geometric illustration can be found in Wikipedia article (`http://tinyurl.com/lovksny`).

1. Consider real case for simplicity so that elliptic curve is planar curve. $y^2 = P(x) = x^3 + ax + b$ must be non-negative to guarantee that y is real. $P(x) \geq 0$ defines a curve in upper (x, y) plane extending from some negative value x_{min} corresponding to $y^2 = P(x_{min}) = 0$ to the right. Given value of y can correspond to 3 real roots or 1 real root of $P_y(x) = y^2 - P(x)$. At the two extrema of $P_y(x)$ 2 real roots co-incide. The graph of $y = \pm\sqrt{P(x)}$ is reflection symmetric having two branches beginning from $(x_{min}, y = 0)$.

2. The negative $-P$ is obtained by reflection with respect to x-axis taking y_P to $-y_P$. Neutral element O is identified as point a infinity (assuming compactification of the plane to a sphere) which goes to itself under reflection $y \to -y$.

3. One assigns to the points P and Q of the elliptic curve a line $y = sx + d$ containing them so that one has $s = (y_p - y_Q)/(x_P - x_Q)$. In the generic case the line intersects the elliptic curve also at third point R since $P_{y=sx+d}(x)$ is third order polynomial having three roots (x_P, x_Q, x_R). It can happen that 2 roots are complex and one has 1 real root. At criticalityfor the transiton from 3 to 1 real roots one has $x_Q = x_R$.

   Geometrically one can distinguish between 4 cases.

     - The roots P, Q, R of $P_{y=sx+d}(x)$ are different and finite: one defines the sum as $P+Q = -R$.

     - $P \neq Q$ and $Q = R$ (roots Q and R are degenerate): $P + Q + Q = O$ giving $R = -P/2$.

     - P and Q are at a line parallel to y-axis and one has $R = O$: $P + Q + O = O$ and $P = -Q$.

     - P is double root of $P_{y=sx+d}(x)$ with tangent parallel to y-axis at the point $(x_{min}, y = 0)$ at which the elliptic curve begins so that one has $R = O$: $P+P+O = O$ gives $P = -P$. This corresponds to torsion.

4. Elliptic surfaces (see `http://tinyurl.com/yc33a6dg`) define a generalization of elliptic curves and are defined for 4-D complex manifolds. Fiber is required to be smooth and has genus 1.

11.8.3   String world sheets and elliptic curves

In twistor lift of TGD space-time surfaces identifiable as minimal surfaces with singularities, which are string world sheets and partonic 2-surfaces. Preferred extremal property means that space-time surfaces are extremals of both Kähler action and volume action except at singularities.

   Are string world sheets with very large number of points in cognitive representation possible? One has right to expect that string world sheets allow special kind of symmetries allowing large, even infinite number of points at the limit of large sheet and related by symmetries acting in the extension of rationals. If one of the points is in the extension, also other symmetry related points are in the extension. For a non-compact group, say translation one would have infinite number of points in the representation but the finite size of CD would pose a limitation to the number of points.

   String world sheets are good candidates for the realization of elliptic curves.

1. The general conjecture is that preferred extremals allow what I call Hamilton-Jacobi structure for M^4 [K88]. The distribution of tangent spaces having decomposition $M^4(x) = M^2(x) \times E^2(x)$ would be integrable giving rise to a family of string world sheets Y^2 and partonic 2-surfaces X^2 more general than those defined above. X^2 and Y^2 are orthogonal to each other at each point of X^4. One can introduce local light-cone coordinates (u, v) for Y^2 and local E^2 complex coordinate w for X^2.

2. Space-time surface itself would be a deformation of M^4 with Hamilton-Jacobi structure in CP_2 direction. w coordinate as function $w(z)$ of CP_2 complex coordinate z or vice versa would define the string world sheet. This would be a transversal deformation of the basic string world sheet Y^2: stringy dynamics is indeed transversal.

3. The idea about maximal cognitive representation suggests that $w \leftrightarrow z$ correspondence defines elliptic curve. One would have $y^2 = P(x) = x^3 + ax + b$ with either $(y = w, x = z)$ or $(y = z, x = w)$. A natural conjecture is that for the space-time surface corresponding to a given extension K of rationals the coefficients a an b belong to K so that the algebraic complexity of string world sheet would increase in number theoretic evolution [L59]. The orbit of a algebraic point at string world sheet would be lattice made finite by the size of CD. Elliptic curves would define very special deformed string world sheets in space-time.

4. It is interesting to consider the pre-image of given point y ($y = w$ or $y = z$) covering point x. One has $y = \pm\sqrt{u}$, $u = P(x)$ corresponding to group element and its negative: there are two points of covering given value of u. $u = P(x)$ covers 3 values of x. The values of x would belong to 6-fold covering of rationals. The number theoretic interpretation for the effective Planck constant $h_{eff} = nh_0$ states that n is the number of sheets for space-time surface as covering.

   There is evidence that $h_{eff} = h$ corresponds to $n = 6$ [L26]. Could 6-fold covering of rationals be fundamental since it gives very large cognitive representation at the level of string world sheets?

   For extensions K of rationals the x coordinates for the points of cognitive representation would belong to 6-D extension of K.

5. Ellipticity condition would apply on the string world sheets themselves. In the number theoretic vision string world sheets would correspond at M^8 level to singularities at which the quaternionic tangent space degenerates to 2-D complex space. Are these conditions consistent with each other? It would seem that the two conditions would select cognitively very special string world sheets and partonic 2-surfaces defining by strong form of holography (SH) space-time surface as a hologram in SH. Consciousness theorist interested in mathematical cognition might ask whether the notion of elliptic surfaces have been discovered just because it is cognitively very special. In the case of partonic 2-surfaces geodesic sphere of CP_2 is similar object.

11.8.4   String like objects and elliptic curves

String like objects - cosmic strings - and their deformations, are fundamental entities in TGD based cosmology and astrophysics and also in TGD inspired quantum biology. One can assign elliptic curves also to string like objects.

1. Quite generally, the products $X^2 \times Y^2 \subset M^4$ of string world sheets X^2 and complex surfaces Y^2 of CP_2 define extremals that I have called cosmic strings [K8].

2. Elliptic curves allow a standard embedding to CP_2 as complex surfaces constructible in terms of Weierstrass elliptic function $\mathcal{P}(z)$ (`http://tinyurl.com/ycu8oa4r`) satisfying the identity

$$[\mathcal{P}'(z)]^2 = [\mathcal{P}(z)]^3 - g_2\mathcal{P}(z) - g_3 \quad . \tag{11.8.2}$$

Here g_2 and g_3 are modular invariants. This identity is of the same form as the condition $y^2 = x^3 + ax + b$ with identifications $y = \mathcal{P}'(z), x = \mathcal{P}(z)$ and ($a = -g_2, b = -g_3$). From the expression

$$y^2 = x(x - 1)(x - \lambda) \tag{11.8.3}$$

in terms of the modular invariant $\lambda = \omega_1/\omega_2$ of torus one obtains

$$g_2 = \frac{4^{1/3}}{3}(\lambda^2 - \lambda + 1) \quad , \quad g_3 = \frac{1}{27}(\lambda + 1)(2\lambda^2 - 5\lambda + 2) \quad . \tag{11.8.4}$$

Note that third root of a appears in the formula. The so called modular discriminant

$$\Delta = g_2^3 - 27g_3^2 = \lambda^2(\lambda - 1)^2 \quad . \tag{11.8.5}$$

vanishes for $\lambda = 0$ and $\lambda = 1$ for which the lattice degenerates.

3. The embedding of the elliptic curve to CP_2 can be expressed in projective coordinates of CP_2 as

$$(z^1, z^2, z^3) = (\xi^1, \xi^2, 1) = (\frac{\mathcal{P}'(w)}{2}, \mathcal{P}(w), 1) \ . \tag{11.8.6}$$

Acknowledgements

Part IV

PARANORMAL PHENOMENA

Chapter 12

Quantum Model of Paranormal Phenomena

12.1 Introduction

The violent encounters with skeptics have demonstrated to me that surprisingly many skeptics refuse to even consider the possibility of taking paranormal phenomena seriously because they take the materialistic-reductionistic world view as the final truth. Usually the discussions reduce to the attempt to give me a label of a pseudoscientist because I do not possess an influential position in the scientific community; because I have not published my work in respectable journals; etc..., and it is very difficult to dig even a single bit of information relating somehow to the actual contents of my work. Regrettably this seems to be the case for most of arguments used by those who appear publicly as skeptics. Needless to say, skepticism in this sense has nothing to do with skepticism in the real sense of the word. Just the opposite, these "skeptics" identify themselves as the mind police of the dominating materialistic-reductionistic science and see as their holy goal the identification and ridicule of the scientific dissidents as pseudo scientists. For instance, I have been blamed for super-naturalism because I have been forced to introduce the notion of quantum jump between quantum histories forcing in turn to give up the notion of observer independent objective reality. The attempts to defend this vision by telling that this is the only possible logically consistent view about quantum jump forced by General Coordinate Invariance alone and solving the basic paradoxes of modern physics have been waste of time.

There are of course notable exceptions to this rule of thumb: Susan Blackmore represents an example of an intellectually honest skeptic who respects also the different world views and takes materialistic dogma only one possible view about world which must be also subjected to testing.

The basic objection against paranormal phenomena by skeptic researchers such as Susan Blackmore, is that there is no theory of paranormal phenomena making possible meaningful experimental tests so that the minimal working hypothesis is that these phenomena do not exist. The absence of a theory certainly makes experimental approach extremely difficult: a good analogy of the situation is provided by the high energy elementary particle physics where the enormous amount of data and noise makes possible only the detection of signatures predicted by various theories by comparing highly detailed Monte Carlo simulations of model world with the data.

Personally I however see this attitude as counter productive: I agree with someone who said that the worst form of ignorance is to regard un-explainable as a synonym of impossible. I find it also very entertaining to play "what if this is true" games with thoughts rather than adopting the somewhat boring role of a serious scientist. These thought games also often lead to ideas which need not be even related to the original question. I however hasten to admit that my attitude does not derive from a mere open-mindedness and mere desire to play thought games but from the simple facts of life: TGD indeed provides a conceptual framework in which paranormal phenomena might be understood and studied; secondly, as an eternally unemployed scientific dissident I really do not have anything to lose anymore.

12.1.1   What One Means With Paranormal?

According to Wikipedia definition [J17] paranormal is a general term that designates experiences that lie outside "the range of normal experience or scientific explanation", or which indicates phenomena understood to be outside of science's current ability to explain or measure. Nothing wrong with this but the text continues: "Paranormal phenomena are distinct from certain hypothetical entities, such as dark matter and dark energy, insofar as paranormal phenomena are inconsistent with the world as already understood through empirical observation coupled with scientific methodology".

The latter sentence contains two intellectually dishonest claims typical for skeptics. First of all, contrary to the claim dark matter and energy are far from being understood within the recent main stream view about physics and very many theoreticians question their existence. Secondly, paranormal phenomena are just something that we do not understand just like dark matter and energy rather than "being inconsistent with empirical observation coupled with scientific methodology". The irony is that in TGD Universe the scientific explanation for dark matter and dark energy supports also the reality of various paranormal phenomena.

The article continues by creating the impression that people taking seriously paranormal phenomena are blind believers and puts the main emphasis on ghosts, haunts, and other spiritual entities and gives only a minor emphasis on phenomena studied systematically in laboratory. To add irony: TGD inspired theory of consciousness predicts an infinite self hierarchy and dark matter is in an essential role in making this hierarchy possible. Depending on one's tastes one can call these higher level entities higher level selves or angels but the possible existence of these entities as such is in no way inconsistent with the scientific methodology.

To make clear my own position: I am anomalistic in the sense that I do not either believe or not-believe. I am just ready to accept also observations which do not conform with the expectation of science as it is five centuries after Newton and try to understand them in a wider conceptual framework rather than trying to ridiculize anomalies by mis-using formal scientific authority.

12.1.2   Development Of Ideas About Paranormal

During years I have developed several ideas about paranormal phenomena and, believing that there must be very few general principles behind these phenomena, I try to combine these ideas into a single coherent conceptual framework in this chapter. For the convenience of the reader it is good to summarize the evolution of the basic concepts briefly.

1. On the experimental side the most important boosts came from the lecture of Cyril Smith about homeopathy in CASYS'2001 conference [I22] and from the contact with Lian Sidorov and from reading her articles related to remote vision and healing [J99]. Also the work of Gariaev's group on wave aspects of DNA [I30] was important for the concretization of the ideas. Of course, without the already existing view about living matter as symbiosis of MEs, of superconducting magnetic flux tubes, and of ordinary biomatter at atomic space-times sheets- a view that was inspired the information about effects of ELF em fields on brain [J115] and by the strange findings challenging the notions of ionic pumps and channels [I40] - these developments would not have been possible.

2. On the theoretical side the realization that p-adic physics provides the physics of cognition was a decisive breakthrough. The realization that number theoretic variant of Shannon entropy can be negative led to the idea of number theoretic entanglement negentropy but it took years to realize the profound implications of the notion, which can be summarized by the statement that living matter is a number theoretically quantum critical phase residing in the intersection of real and p-adic worlds.

3. The lectures of Peter Marcer about quantum holographic brain provided an important stimulus leading to the realization that MEs (massless extremals) serve among other things also as quantum holograms. The ideas about magnetic mirrors (ME-parallel magnetic flux tube pairs) acting as electromagnetic bridges between living subsystems and about liquid crystal blobs representing and amplifying the rotational, vibrational, etc. spectra of molecules, are the most recent newcomers in the zoo of ideas.

4. The resulting concrete view is that living organisms at all levels of the hierarchy are connected by the magnetic mirrors serving as electromagnetic bridges between them and making possible high precision directed communication, remote sensing, sensory representations using magnetic sensory canvas, memory as communication between the geometric past and geometric now, and remote control. Even the claimed communications with deceased can be seen as being based on the same mechanism as long term memory. Besides classical signalling with light velocity quantum entanglement (also time-like) mediated by MEs is key element of model and makes possible sharing of experiences. By fractality the same basic mechanisms are at work in all length scales: water memory and our long term memory are the same phenomenon but in different length scales. Similarly, the miraculous molecular recognition mechanisms and remote healing and vision are also phenomena based on the same basic mechanisms.

5. A further strong support for the idea that biosphere is a fractal organic whole came from the realization that the notion of psychological time leads to paradoxes unless one assumes that psychological time corresponds to the space-time region at which macroscopic volition is concentrated: this front of volition proceeding in the direction of future is where the p-adic-to-real phase transition changing intention to macroscopic action dominantly occurs. The original detailed realization of this view is in conflict with the recent view inspired by zero energy ontology and the notion of causal diamond (CD) and suggesting that the arrow of psychological time at space-time level and the localization of sensory experience in a narrow time interval is an outcome of intentional action and could be understood via a generalization of Negentropy Maximization Principle implying that selves can be regarded as curious entities [K7].

12.1.3 Topics To Be Discussed

The flow diagram for this chapter looks like following.

1. I propose a general vision about the mechanisms behind the paranormal phenomena based on the ideas briefly summarized. This involves the new view about psychological time, p-adic physics as the physics of cognition, the notion of negentropic entanglement, the notion of magnetic mirrors, LC crystal water blobs as mimicking electromagnetically molecules and amplifying signals em signals, field representation of the genetic information based on magnetic mirrors, a general model for remote mental interactions, and the proposal that stochastic resonance serves a universal amplification mechanism.

2. Some paranormal phenomena in biological length scales are considered. A model for healing by time reversal is formulated and Priore's machine is discussed in this framework with an attempt to understand the situation quantitatively. Also a model the delaWarr camera are discussed is proposed.

3. Parapsychological phenomena like extrasensory perception, precognition, psychokinesis, near-death experiences, and communications between living and dead are discussed: remote healing and vision are discussed also in [K42].

4. A TGD based model for the instrumental transcommunication (ITC), in particular electronic voice phenomena (EVP), is developed in more detail (I am grateful for Adrian Klein for informing me about these phenomena).

5. Adaptive robots of Mark Tilden behave very much like living creatures and the possibility that this might actually be the case is considered.

TGD based view about remote mental interactions have developed considerably with the TGD based quantum model of living matter but I have not dicusses these developments to this chapter in detail. Suffice it to say that the mechanisms of TGD inspired quantum biology and model of remote mental interactions are same.

I want to emphasize again to the blood-thirsty skeptics that I am not believer nor non-believer. These phenomena, be they actual or not, are extremely stimulating for a theorist with

a trait to creative thinking and have helped me to understand what in the TGD universe is new and impossible in the reductionistic and materialistic universe of the skeptic. Certainly the ability to explain these not-finally established phenomena does not make TGD pseudo science. In the same way, the ability of TGD based vision to say something nontrivial about religious experience and consciousness after the physical death does not mean that TGD replaces scientific explanation with a religious dogma (also this point I have been forced to explain again and again to some of my very skeptic friends).

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` [L17].

12.2 General View About Paranormal Phenomena

According to Wikipedia definition [J17] paranormal is a general term that designates experiences that lie outside "the range of normal experience or scientific explanation", or which indicates phenomena understood to be outside of science's current ability to explain or measure. Nothing wrong with this but the text continues: "Paranormal phenomena are distinct from certain hypothetical entities, such as dark matter and dark energy, insofar as paranormal phenomena are inconsistent with the world as already understood through empirical observation coupled with scientific methodology".

The latter sentence contains two intellectually dishonest claims typical for skeptics. First of all, contrary to the claim dark matter and energy are far from being understood within the recent main stream view about physics and very many theoreticians question their existence. Secondly, paranormal phenomena are just something that we do not understand just like dark matter and energy rather than "being inconsistent with empirical observation coupled with scientific methodology". The irony is that in TGD Universe the scientific explanation for dark matter and dark energy supports also the reality of various paranormal phenomena.

The article continues by creating the impression that people taking seriously paranormal phenomena are blind believers and puts the main emphasis on ghosts, haunts, and other spiritual entities and gives only a minor emphasis on phenomena studied systematically in laboratory. To add irony: TGD inspired theory of consciousness predicts an infinite self hierarchy and dark matter is in an essential role in making this hierarchy possible. Depending on one's tastes one can call these higher level entities higher level selves or angels but the possible existence of these entities as such is in no manner inconsistent with the scientific methodology.

To make clear my own position: I am anomalistic in the sense that I do not either believe or not-believe. I am just ready to accept also observations which do not conform with the expectation of science as it is five centuries after Newton and try to understand them in a wider conceptual framework rather than trying to ridiculize anomalies by mis-using formal scientific authority.

12.2.1 The Notion Of Magnetic Mirror

Magnetic flux tubes and MEs are basic structures in TGD based model of biosystems based on the symbiosis of MEs, magnetic flux tubes and ordinary biomatter at atomic space-time sheets. Magnetic flux tubes are topological field quanta of magnetic field whereas MEs ("massless extremals") are topological field quanta of radiation field, "light rays".

Magnetic mirrors formed by the magnetic flux tube-ME pairs occur in many different contexts in TGD inspired theory of consciousness. For example, magnetic mirrors of length of order lightlife appear in the model of long term memory. Classically: when I (whose correlate is magnetic body) look at sufficiently distant mirror I see the me of the geometric past as it is represented by the mental images created by brain. Quantum mechanically: time-like quantum entanglement made possible by the magnetic mirror makes it possible for the self of the geometric now to share the experience of the sub-self of the geometric past. Magnetic mirrors can be said to define a fundamental model for sensory-motor loop.

Magnetic mirrors are crucial for the model of the sensory canvas [K48] and there seems to be no sharp difference between different types of memory which suggests that there is an entire hierarchy of memories in various p-adic time scales. Magnetic mirrors play a key role in the

model of frequency imprinting and provide a general molecular recognition mechanism. Magnetic mirrors allow also a generalization of many-sheeted DNA so that magnetic mirrors represent genetic information in electromagnetic form [K42].

In accordance with the fractality of consciousness, the wide applicability of the magnetic mirror notion suggests that various functions associated with the magnetic mirrors are different aspects of the same basic phenomenon. Magnetic mirrors would thus provide sensory canvases, long term memory mirrors and recognition mechanism at all length scales. Even many-sheeted DNA would possess sensory canvas and long term memories, perhaps an entire hierarchy of them. Taken the ideas of fractality and quantum hologram to extreme, one can even consider the possibility that our long term memories are average of those associated with genes associated with various neurons! Nothing precludes the possibility that magnetic mirrors can also serve as electromagnetic bridges between different organisms (even the notion of organism must be generalized if the idea of multi-brained magnetic selves is taken seriously). This could make possible effects similar to observed at DNA level (such as self assembly and translation of RNA to proteins made possible by electromagnetic recognition mechanism based on em bridges).

The latest application of the notion of magnetic mirror is to TGD inspired biology [K81]. Magnetic mirrors in this case appear as pairs of flux sheets assignable to the strands of DNA. The flux tube sheet going through the passive strand mediates sensory information coming from cell and nuclear membranes via magnetic flux tubes to various levels of the magnetic body whereas the flux tube going through the active strand mediates control commands of the magnetic body initiating gene expression with transcription being only one particular kind of gene expression. The intronic parts of DNA are assumed to be involved with topological quantum computation type activities in this model [K2]. One can say that DNA double strand takes the role of brain of cell and the passive and active sections of strands are analogous to sensory and motor areas of brain hemispheres. Also the analog of lateralization of brain functions is suggested to take place at the level of DNA and reflect itself in the character of gene expressions of the two strands (both strands contain sections expressed also in standard sense).

The hierarchy of Planck constants is essential element of the model and leads to a generalization of the notion of genome: magnetic flux sheets integrate sequences of genomes to larger super genome involving genomes of several cells and these in turn can integrate in longer hypergenomes. This could give rise to a collective gene expressions at the level of organelle, organ, organism, and even population. In the case of remote mental interactions applied to living target this model defines a natural starting point since all tools for remote sensory perception and motor action are available in standard form. Also the existence of collective gene expression would bring in new insights: for instance, the notion of species memory proposed by Sheldrake could be realized in this framework.

12.2.2   Summary Of The Model

The general quantum model for bio-systems leads to a model for bio-control which applies to a very wide variety of hard-to-understand bio-chemical phenomena such as molecular recognition mechanisms, water memory, and homeopathy and leads to a generalization of genetic code explaining the mystery of introns. The same model generalizes to a model of paranormal phenomena such as psychokinesis, remote sensing, remote healing, telepathy, communications with deceased, and instrumental transcommunications. The basic difference is that magnetic body receives information and controls "foreign" biological (or even magnetic) body or "dead" matter system.

Key ideas

1. The basic notions of the 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 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 [K83] . The communications between sub-selves would be naturall 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. Cognitions/thoughts 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.

   The original hypothesis was that quantum transitions between surfaces belonging to different number fields are possible: this would mean dispersion between real and p-adic sectors of "world of classical worlds" (WCW). One could say that particle is in one number field at time. This would make possible transformation of intentions to actions and their reversals possible via the intersection of real and p-adic worlds. It has turned out that this hypothesis is not mathematically attractive.

   Rather, the real and p-adic number fields form a book like structure with an algebraic extension of rationals as its back. Any physical system corresponds to pieces at all pages of this Big Book. Same applies at the level of embedding space, space-time surfaces, and WCW. In this framework holography makes it possible to understand real and p-adic space-time surfaces as continuations of string world sheets and partonic 2-surfaces to space-time surfaces, either real or p-adic. The string world sheets themselves are in the intersection of reality and various p-adicities in the sense that the parameters characterizing them belong to an extension of rational numbers. What makes this option so elegant is that one avoids the tension between continuity and symmetries. All symmetries make sense in both real and p-adic sectors and the problem with continuity does not appear at all since one does not try to map reals to p-adics of vice versa.

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. The hierarchy of values of Planck constant would make possible this process in long time and length scales.

A more concrete model

The following would represent the concrete model what happens in remote mental interaction.

1. Magnetic mirrors (ME-magnetic flux tube pairs) 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 magnetic body and active strand receiving control commands leading to various forms of gene expresion. MEs are ideal for the transfer of both classical information and momentum.

2. Real MEs represent the action. Also smaller MEs can be send along the MEs serving as bridges (this is like throwing balls with light velocity!). In this case one can speak about transfer of intent and of action.

3. MEs give rise to remote interaction which can act both endo- and exogenously. Magnetic mirrors as 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 CDs are characterized by fundamental frequencies and MEs and CDs must be in resonance. This makes very strong predictions about resonance bands due to the possibility of Lorentz transforms of CDs. For non-relativistic boosts for CDs the bands have however width of order $\Delta f/f \sim v/c$ and are therefore very narrow.

4. The ME-magnetic flux tube pair connecting sender and receiver can can initiate an arbitrarily complex hologram representing biological program if the wave pattern assignable to ME interferes with a reference wave associated with the receiver. 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 and the challenge of the operator is to learn these control commands. The situation resembles that encountered in neuro feedback.

Remote mental interactions with living *resp.* **"dead" matter**

One can distinguish between psychokinesis applied to living matter and "dead" 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 magnetic body and the receival of sensory input from biological body by magnetic body. Hypnosis would be one example of this kind of interaction.

2. Remote mental interactions in the case "dead" could use simpler variants of the fundamental mechanisms utilized in living matter. For instance, zero energy ontology assigns with the CDs of electron and quarks time scales.1 s and 1 ms defining fundamental biorhythms. The CDs assignable to elementary particles could be involved also with psychokinesis. Negentropic entanglement 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 "dead". Thermodynamical restrictions favor large values of Planck constant.

Who knows how?

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 multibrained and -bodied higher level colletive 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 lelel 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.

Why paranormal phenomena are so rare?

The model should be also able to explain why it is so difficult to show that paranormal phenomena are real.

1. The very fact that experimenters usually do their best to eliminate subjective elements from the experimental arrangements might explain why paranormal phenomena are so poorly reproducible.

2. Field bodies apply naturally to personal biological body basic mechanisms of remote mental interactions and the evolution of a kind of immune system preventing the access of foreign field bodies to personal biological body looks very natural.

3. The basic prediction of zero energy ontology is breaking of second law of thermodynamics in the time scale of CD considered. In sufficiently long scale averaging however destroys the anomaly and statistical argument can be also used to support the claim that the breaking was only a statistical fluctuations. Zero energy states are indeed counterparts of vacuum fluctuations in standard physics. It is also quite possible that in the statistical averaging these phenomena indeed disappear and it might be more reasonable to concentrate on the character of the fluctuations around the average. An interesting analogy is the research of Shnoll related to the fluctuations of radioactive and chemical rates which demonstrated clear periodicities in fluctuations correlating with astrophysical periods [E4] , [E4]. Perhaps this approach might be applied also to the claimed paranormal phenomena.

This model explains a wide variety of observations related to remote healing and vision [J99]: these observations are discussed in [K42]. Since magnetic mirrors can connect also living organisms and "dead" mater, say electronic instruments, the model can be applied to explain also phenomena like micropsychokinesis, causal anomalies related to machine-animal interaction, and so called instrumental transcommunications.

12.3   Paranormal Phenomena In Biological Systems

In this section a TGD inspired model for healing based on time reversal bringing the system back to the healthy state is proposed. Priore's machine is discussed as an application of the model. Also the weird sounding claims about delaWarr camera are discussed in the general conceptual framework.

12.3.1 Healing By Time Reversal

The article of Lian Sidorov [J99] and its references give a thorough view about remote healing and viewing. One particular healing method goes under name Qigong (see the article [J45]). 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.

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.

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 [D6] and is one of the basic notions of holography. MEs act as both quantum holograms and receiving and sending quantum antennae [K68]. 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). Conjugate reference waves would thus provide an incredibly simple and general mechanism of healing by time reversal allowing the living matter to fight against second law. This would be like a general initiating a war by just nodding or shaking his head.

What time reversal for biological programs could mean?

Of course, one can ask what one precisely means when one says that biological program runs backwards.

1. In zero energy ontology the most natural interpretation would be that the arrow of geometric becomes non-standard for some sub-CDs of the CD defining the standard arrow. Time reversal would take place always in some time scale. In the case of healing the reversal would be induced for the population of sub-CDs to be healed. The healing mechanism would require only the reversal of the arrow of time. The details of the biological programs would not matter.

2. The time scales of sub-CDs in question would correspond to the time scales of the biological functions in question and the time scale would be proportional to the value of Planck constant involved. There is direct experimental evidence [D5] that the time direction assigned to the second law changes in time scale of .1 seconds defining the time scale of electronic CD: this

is discussed in detail in [K56]. Miraculous healings in which healing occurs instantaneously could be understood if this interpretation is correct.

The basic question is how to induce the time reversal in a given time scale and here one can make even guesses. The argument for the arrow of geometric time [K7] is based on the generalization of NMP [K56]: sub-selves are curious about what is outside CD and tend to concentrate near either light-like boundary of CD and to induce quantum jumps shifting the quantum superpositions of space-time sheet backwards in geometric time of space-time sheet so that the stationary sub-self is like a stationary object in flowing river and experiences an apparent time flow. Perhaps a powerful enough time reversed signal from the past boundary of CD could stimulate the curiousity of of sub-selves and induce the migration or creation of the sub-self-population to the past boundary. Maybe phase conjugate coherent radiation could define this signal.

Qigong from TGD point of view

The article of Lian Sidorov [J99] and its references give a thorough view about remote healing and viewing. One particular healing method goes under name Qigong (see the article [J45]). Qigong is a general term for a large variety of traditional Chinese energy exercises and therapies. Qigong is generally considered as a self-training method or process through Qi (vital energy) and Yi (consciousness or intention) cultivation to achieve the optimal state of both body and mind. The traditional Chinese medicine postulates the existence of Qi, which could be regarded as a kind of subtle energy circulating around the physical body.

In TGD framework the energy associated with MEs and supercurrents flowing along magnetic circuitry could be a natural counterpart of Qi. The positive metabolic energy assignable to negentropic entanglement or negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/ cat.jpg** or **Fig. ??** in the appendix of this book) 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).

The physiological, chemical and electromagnetic effects of both internal and external Qigong have been studied ([J99] contains large number of related references). Also the effects of Qigong healing on cancer has been studied [J45].

Priore's machine

There is also some empirical support for the idea about healing by time reversal coming already from the period when only Soviet scientists knew about phase conjugation.

1. In 1960's and 1970's French Antoine Priore built and tested electromagnetic healing machines of startling effectiveness [I48]. Tom Bearden has in this website document "The Priore Machine and Phase Conjugation" which I recommend for an interested reader for a more detailed exposition [I19] besides the material that can be found from the homepage of Tom Bearden.

2. In hundreds of rigorous tests with laboratory animals, Priore's machine cured a wide variety of the most difficult kinds of terminal, fatal diseases known today. Many of the experiments and tests were done by prestigious members of the French Academy of Sciences. The operation of the Priore machine was incomprehensible for both the inventor and orthodox French scientists. Into a tube containing a plasma of mercury and neon gas, a pulsed 9.4 GHz wave modulated by a frequency of 17 MHz was introduced. The waves were produced by radio emitters and magnetrons in the presence of a 1200 Gauss magnetic field. Experimental animals were exposed to this magnetic field during irradiation, and the mixture of waves

(about 17 or so) coming from the plasma tube and modulating and riding the magnetic field passed through the animal's bodies.

The following observations suggests that TGD inspired model for bio-control and communication might allow to understand the claimed findings.

1. A combination of magnetic fields and radiation was involved: this conforms with the vision about biosystems as a many-sheeted ionic flow equilibrium controlled by MEs attached to flux tubes and sheets.

2. It is known that phase conjugated waves can be produced in plasmas. The so called four-wave interaction of waves of equal frequency is the simplest manner to amplify weak wave in the effective dynamical diffraction grating defined by the interference of two waves propagating in opposite directions. If a phase conjugate wave with a correct frequency results in this kind of situation, it could act as a reference wave acting with ME and initiate a complex time reversed biological programs at subcellular level.

Metabolism is what drives biological programs and their time reversal could involve the time reversal of the basic metabolic mechanism.

1. According to the quantum model of metabolism [K46], ADP-ATP cycle corresponds to a cyclic flow of protons between some larger space-time sheet (say $k = 169$) and $k = 137$ atomic space-time sheet. The so called $F_0 - F_1$ machine transforming ADP to ATP drives the biological Karma's cycle kicking protons to the atomic space-time sheet, where they dissipate their energy and drop back to the magnetic flux tubes liberating their zero point kinetic energy of about .5 eV. TGD suggest the existence of metabolisms associated with other ions and between other space-time sheet pairs, and the universal energy currencies of these metabolisms are characterized by the zero point kinetic energies of the ion in question. Standard metabolism is a particular example of this general process, and there might exist analogs of $F_0 - F_1$ machines corresponding to other metabolisms. The cycle of ATPase motor is of order 300 Hz, which is the proton cyclotron frequency in the endogenous magnetic field of .2 Gauss.

2. The cyclotron frequency of the ions are assumed to be key frequencies in bio-control. Cyclotron frequency MEs server as space-time correlates of quantum entanglement, and the MEs with frequencies corresponding to zero point kinetic energies propagate along these MEs and induce self-organization at the receiving end. CDs define a further important time and secondary Compton frequency scale related to that for electron by the formula $T_e(k) = 2^{k-127} \times r \times .1$ seconds, $r = \hbar/\hbar_0$. Here corresponds the p-adic prime characterizing the elementary particle. A basic speculation is that light fractally scaled counterparts of elementary particles with Compton lengths corresponding to biologically important Gaussian Mersennes $k = 151, 157, 163, 167$ could be relevant for biology. These Compton time scales vary in the range 1.6×10^6 s -6.4×10^9 s (18.5 days- 205.8 years)

3. Genes are the basic motor instruments of cell and the healing mechanism might affect directly the biological programs at this level. DNA as topological quantum computer paradigm would suggest that these programs are in in reserved time direction and that the size of structures involved is of order of typical unit of genome.

4. Healing process could correspond to the functioning of these machines in a time reversed mode: the generator becomes a motor. Even ordinary metabolism might become time reversed temporarily during healing process. Perhaps the fact that metabolism is minimized during rest, would allow also $F_0 - F_1$ generators to temporarily run in the time reversed mode.

5. Four-wave interaction is believed to be involved with the generation of the phase conjugates of microwaves. The direct irradiation by the phase conjugates of a microwave beam at critical frequency might be a simpler manner to induce the healing process at DNA level.

By its extreme generality this mechanism could apply to almost any disease which is a disease of the highest level quantum biocontrol. This mechanism could be also used to induce de-differentiation of cells. The de-differentiation of cells to stem cells could be controlled by a similar mechanism. One can also wonder whether this kind of mechanism could make possible eternal youth (or rather eternal life) at cell level. An interesting question is whether the phase conjugates of EEG waves or time reversals of nerve pulse patterns could induce time reversals of brain functions.

The most recent iew about healing by reversal relies on NMP. In the first state function reduction to opposite boundary of CD sub-self dies and re-incarnates as time-reversed self, which in statistical sense is more negentropic. Negentropy increase means healing. The next state function reduction to opposite boundary brings back the original healthier subself. Healing is like taking a snap and waking up refreshed. It would be natural to assume that the Becker voltage playing important role in the healing changes its sign in the reduction since time reversal of subself takes place.

One should of course be able to understand whether and why the frequencies used are special. The following represents the guesses inspired by the p-adic length scale hypothesis and cyclotron frequency hypothesis.

1. The effects of ELF em fields on vertebrate brain occur at cyclotron frequencies. Also in this case higher carrier frequency is used but its function is to make possible the penetration of the modulating ELF radiation to the tissue. Let us assume that 9.4 GHz radiation serves for a similar purpose.

2. Electron's cyclotron frequency in a magnetic field of B_{end}, $B_{end} = .2$ Gauss, the difference between $n = 3$ and $n = 0$ cyclotron frequencies of electron is in good approximation 17 MHz. This would suggests that cyclotron phase transition for electrons from $n = 0$ to $n = 3$ level is involved with the mechanism. This would support the assignment of proton cyclotron frequency for $B_{end} = .2$ Gauss with ATPase motor and mean that both electrons and protons are important for the function of the machine.

3. For the standard value of Planck constant the frequencies correspond to energies much below the thermal energy at room temperature. The value of 17 MHz would suggest a value of order $10^7 \hbar_0$ for the Planck constant. Negentropic entanglement might allow to circumvent this constraint.

4. The ratio of $B = .12$ Tesla to B_{end} is $B/B_{end} = 6 \times 10^3 \simeq 3 \simeq 2^{11}$. The magnetic length $L_B \propto \sqrt{\hbar/eB}$ characterizes the thickness of the flux tubes required by the minimum value of magnetic flux. The magnetic field used corresponds to about 10^{-7} meters for the standard value of Planck constant and to a length scale about 10^{-4} m for $\hbar \sim 10^7 \hbar_0$. For the ordinary value of Planck constant the corresponding space-time sheet could be associated with chromomose's basic structure and correspond to $k = 157$ space-time sheet associated with chromosome's coiling. Note that the time size of the CD assignal to $k = 157$ p-adic length scale is $2^{30} \simeq .1$ s $\simeq 10^8$ s. Optimistically one could imagine that correction of the genetic error responsible for the cancer program by time reversal might be in question. In particular, it could induce the time reversal of the "develop-cancer" program controlling the development of the cancer cell population and lead to healing when the standard time direction is re-established.

12.3.2   Delawarr Camera And Field Representation Of Genetic Information

In CASYS'2001 symposium Peter Marcer [I53] told about the British engineer George DelaWarr who built a remote imaging camera in the 1950's (radionics is the term used). Using only a test object provided from the subject such as a small blood, sputum, or hair sample, this device is reported to photographically image the subject's internal conditions at a distance, with a high degree of accuracy. A unique feature of the DelaWarr system is claimed to be that it is able to detect diseases in the pre-clinical stages prior to detection by conventional techniques such as physical examination, X-ray, CT scan, or Magnetic Resonance Imaging. The photographs

taken by DelaWarr camera at fifties were treated by Susan Benford by modern image processing techniques and she claims that these photographs contain the information needed to reconstruct three-dimensional holograms [I53]. The proposed explanation was that the test object (adjunct) contains a hologrammic representation about the patient.

The functioning DelaWarr camera looks highly mysterious even when one takes seriously the idea that DNA generates holograms of the body parts it codes for. Therefore it is better to introduce the ingredients of the model as questions rather than hypothesis.

1. Was the intent of the photographer all that was needed and did other levels levels of the self hierarchy take care of the rest as they do when I make the decision to raise my hand? Could the intent of the photographer have generated a reference wave at some very special frequency acting on the adjunct and activating a hologram giving rise to a photograph about the desired body part or inducing a sequence of events leading eventually to the generation of the photograph?

2. Was the visible light giving rise to the photograph generated in the adjunct? Does the DNA of each cell of body and thus also of the adjunct contain electromagnetic representations for the body parts and are these representations more or less equivalent with holograms? Certainly direct hologrammic images about body parts would provide the simplest manner to realize the field part of the genetic code as proposed.

3. Did the adjunct serve as a relay station (somewhat like thalamus in brain) mediating the information from the patient via magnetic flux tube-ME pairs to the camera projecting it to the camera as a coherent light generating an ordinary photograph? Was the image realized as a coherent light propagating along the MEs connecting adjunct and patient serving as bridges? Could the negentropic entanglement between the adjunct and subject stabilize the connection. Could the radiation correspond to large $\hbar$ radiation at much lower frequencies than that for visible light and transforming to ordinary visible light in the camera?

12.4   Parapsychological Phenomena

In this section various parapsychological phenomena are discussed in the general framework introduced in the previous section.

12.4.1   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. Paraphychic 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 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 would have both real and p-adic parts, which -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 realizing the action as a signal proceeding to geometric past would naturally correspond to 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.

That negative energy MEs would realize intentional actions/volitional acts/motor actions conforms with the recent view about quantum measurement theory in ZEO leading to a detailed view about the notion of self and about how the experience about flow of geometric time emerges.

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 [K84]. The frequency spectrum for the sounds produced by meteors and detected both sensorily and electronically in 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-spesific 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 experiental 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 can be said to have literally infinite size in real sense 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.

12.4.2 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. ??** 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 [K123] 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 [K123] 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 generating 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 space-time sheets ralizing 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 [J99]. 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 critical 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 h_{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 [I28, I29] 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 [K42].

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 retropsychokinesis 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 knows 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 [J36, J37, J34] discussed in the [K116] suggests that the geometric past can change in the time scale of a fraction of second. Both the work done at PEAR [J58] and the work of Helmut Schmidt with retro psychokinesis [J78] 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 [J82] 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 [J79] 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 [J78]. 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) [J58] 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

[J150] [J150, J143, J144, J145] has performed experiments involving intentional imprinting of targets such as water. The model for the findings of Tiller is discussed in [K15]. 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?

Robots, chickens, rabbits and men

The interaction between random number generators and humans or animals is one form of psychokinesis. For a few years ago the issue 62 of "Network", the journal of the Scientific Medical Network [J132] contained a report about the experiments carried out by Dr. Rene Peoch, working at Fondation ODIER at Nantes. In these experiments chickens and rabbits apparently influenced signals composed by a random-number generator for a robot close to them, and human subjects apparently influenced the movements of the robot even though its signals had been generated by a random-number computer program six months earlier.

Chickens stayed close to the robot "imprinted" on it as their mother and followed it about. The robot had a random-number generator inside it controlling its movements, which checks showed to be truly random. The chickens were then removed and one placed so it could see the robot but could not follow it. Under these circumstances the robot spent measurably more time close to the chicken than away from it. The effect was that the chick was influencing the robot's generator. The generator was then removed to a computer away from the experimental area. The same effect occurred. "Non-imprinted" chickens however had no apparent effect on the robot.

In the rabbit experiment, baby rabbits were frightened by the robot and kept away from it. When the rabbit's movement was inhibited, the robot's movements became non-random and it kept away from them. However, when one rabbit was starved and food was placed on the robot, this behavior was reversed and the robot brought the food to the rabbit. It was found that humans likewise could influence the robot.

Also humans were invited to influence the robot as before, but in fact it was being driven by a code generated six months earlier and recorded on a CD, now being played back. The robot was influenced as in the contemporary study. The CD was then examined and it was found that the first half of its code was indeed non-random, but the unused code was truly random. This gave the effect that the computer somehow "knew" six months earlier not only that half the code would be used for such an experiment, but also the general direction of the movements that would be required.

The interpretation of the reported results in terms of psychokinesis and human-animal-machine symbiosis suggests itself. The experiment with humans can also be interpreted as a dramatic verification for the prediction that in quantum jumps between quantum histories also the geometric past changes: the recent experiment suggests that the change occurred in a time scale of six months. If the crucial assumption about the randomness of the random number generator is correct, the effect is also very strong. This could mean that we are changing our geometric past all the subjective time in macro-temporal time scales, as indeed suggested by the paradigm of four-dimensional brain. A further suggestion is that this hypothesis can be indeed tested empirically by developing further these experimental arrangements.

To better comprehend what might be involved, recall that in TGD subjective time and geometric time are not one and the same thing. Accordingly, subjective memories are memories

about conscious experiences and geometric memories are memories with respect to the geometric time for which time is in a precisely same position as space: geometric memories give prediction of the future and past changing quantum jump by quantum jump like weather broadcasts (except that one usually is not interested in the predictions of what weather will subjectively be in geometrically last summer). The crucial point is that the contents of say computer files representing purely geometric memories (such as number sequences) can change in the quantum jumps whereas the possible subjective memories about their contents can remain unchanged. This peculiar contradiction between subjective and geometric memories, which I have christened as "tribar effect", serves as a possible experimental test for the reality of notions of the subjective and geometric time. These experiments are bound to involve human memory as a subjective element: nothing however prevents several human subjects store to their memory the original memory to guarantee objectivity in a statistical sense.

If the randomness of the original random number series produced six months before the experiment involving human-robot interaction has not been checked, it can be argued that random number generators (if genuine) accidentally produced a number series which was not random in the time scale involved. This problem could be circumvented by modifying the experiment by checking already six months earlier whether the number series is really random or not. Humans can indeed remember whether the series is genuinely random or not although they are not able to remember long number series. On the other hand, if the non-randomization effect appears only under special conditions (effect is present for the imprinted chickens only), one has even without the check good reasons to believe that machine-mind interaction has occurred.

An important question of principle is whether the random number generators are genuine or whether the numbers are generated by some algorithm yielding only pseudo random numbers. If genuine randomness is due to quantum phenomena at atomic or molecular level, then intentional action could affect physics at atomic and molecular level. Of course, the success of p-adic mass calculation and interpretation of p-adic physics as physics of cognition forces the same conclusion. If some algorithm produced them and there is no noise affecting the outcome, the only changes which can occur is the modification of the algorithm or of the initial conditions for the algorithm. In the latter case the production of the desired behavior might however be impossible since the algorithm need not even allow the needed regular behavior of the random number sequence. This of course could be checked.

p-Adic space-time sheets representing intentions/memes should be transformed to their real counterparts realized as negative energy signals and able to interact with random number generators. If the p-adic memes are actually chicken's intentions mediated by magnetic mirrors and transformed to real ones when intention is realized, the interaction mechanism is basically ordinary electromagnetic interaction with the machine. The question about the detailed mechanism allowing chicken's volition to affect the geometric past of the robot allows endless variety of answers. The robot could have primitive consciousness, which the chicken can affect by generating negentropic entanglement. The robot could in fact become to some extent part of the chicken, kind of extended body. A signal proceeding to the geometric past and affecting the program coding the robot's behavior could be also involved.

The results of experiments, if replicable, suggest that animal-machine anomalous interactions might be much stronger than human-machine interactions, perhaps because animal is totally confident that the desired interaction happens (Blessed are the meek since they will inherit the kingdom of Heaven!). One could imagine experimental arrangements analogous to the chicken-robot experiments in which the chicken is replaced by a human who genuinely believes that the robot can do what (s)he wishes: this could be achieved by telling the subject person that machine is programmed to deduce her/his wishes, from say EEG. Various modifications of the imprinting mechanism could be applied in more complicated situation. The results might be also used as guidelines in the attempts to generate artificial life. The systematic use of genuine random number generators as control tools of robotic motion suggests itself as a basic principle to guide the attempts to build artificial life. This would optimize the flexibility of the robot behavior so that it could be affected by p-adic intentions.

Adaptive robots as an electronic life form?

The construction of artificial life by building initial value sensitive robots might be a possible breakthrough application of the p-adic cognition. What would be needed is just initial value sensitivity: p-adic memes would take care of the rest.

Mark Tilden is a well-known builder of robots working in the nuclear physics laboratory of Los Alamos. Tilden builds his robots by using pieces of used electronics. The robots do not run any computer program so that the basic philosophy is more or less a diametrical opposite of AI. Rather, the wiring of the robots is such that in a new situation robot tries for different behaviors. For instance, if robot leg gets stuck, the robot changes the orbit of motion of leg. What is remarkable that the robots seem to behave like living organisms in some aspects.

Unfortunately, I do not have any scientific articles about Tilden's work apart from short description in his homepage [J23]. In fact, I encountered completely accidentally Tilden's work by reading an article in the Finnish version of Reader's Digest August 1998 after having seen Stetsoned Tilden and his tiny robots in a popular science program in Finnish TV telling about the recent situation in robotics, AI, and artificial life. The robots of Tilden have surprising abilities to adapt and compete for energy which they get from the sunlight. Robots seem to literally fight for the sunlight. For instance, an electronic fellow called Turbot, kills other robots from his territory and collects them to form a wall against the invasion of other invaders!

The claimed adaptive feats of these robots suggest that a primitive life form might be in question and this is also the belief of Mark Tilden. A general handwaving explanation for the adaptive behavior is that these systems are at the borderline between chaos and order and adaptive behavior "emerges". Of course, what "emergence" means is a complete mystery in the deterministic physics with quantum effects absent in macroscopic length scales.

That primitive life form might be in question, fits nicely with the TGD view. First of all, all forms of self-organization involve quantum jumps and consciousness, and the question is only how important is the role of cognitive consciousness in the behavior of the system. Cognitive consciousness can become important only if the system is sufficiently flexible and initial value sensitive so that the realization of intentional motor actions becomes possible by inducing critical perturbations to the initial-value sensitive behavior.

The in-built flexibility of the robot behavior (a strict opposite of pre-programmed behavior), and initial value sensitivity make in principle possible self-organization by quantum jumps and effective quantum control. For instance, robots could contain modules controlled by genuine random number generators which would be affected by p-adic memes. If p-adic physics is physics of cognition, Nature itself guarantees, that robots form cognitive representations, and by the flexibility of their motor system, they are able to transform cognitive representations to motor actions. If p-adic space-time sheets are indeed memes floating around and waiting for the opportunity to materialize themselves to action, the robots of Tilden could provide an excellent opportunity for a meme to reincarnate!

The extreme generality of the p-adic physics means that one cannot exclude the possibility that electronic systems could quite generally develop p-adic cognitive representations about itself. If so, can one guarantee that the old electronic components recycled by Tilden do not differ cognitively from electronic components coming directly from fabric? If they do, two identical robots built from old and new components might behave differently. Thus a test for whether the robots have mentality and some kind of developing personality is whether two physically identical robots behave differently under similar circumstances.

Quite generally, one can identify p-adic cognitive representations as the mechanism which gives the physical system personality and allowing to distinguish even between two electrons p-adically: of course, Fermi statistics does not allow a state consisting of two electrons in states differing only cognitively. Quite generally, this kind of test could be the counterpart of Turing test allowing to deduce whether physical system has cognitive self or not.

Also now negentropic entanglement and the universality of CD time scales raise the hopes that it might be possible to understand what is involved.

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 buyonancy 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 circument 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 light rays" (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 [H7] provide support for the mechanism. Modanese and Podkletnov studied capacitor at a rather low temperature and at a voltage near the di-eleectric 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 [K34] 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 [K112]. 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 could 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.

12.4.3   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 [J129].

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 phase transitions representing the progress of front of volition to the geometric future and by the reverse phase transitions deconstructing the 4-D body or its parts. 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. Volition can be seen as defining a front of phase transition so that the experience of 4-D body for which deconstruction processes occurs only in the time scales short compared to the duration of lifecycle, would be about entire lifecycle and in this sense "timeless".

Contrary to the original belief, the phase transition associated with volition would not be p-adic-to-real phase transition but a state function reduction to the opposite boundary of CD meaning the death of the mental image representing intention and its re-incarnation about opposite boundary of CD. This reduction would involve a phase trnasition increasing the value of $h_{eff} = n \times h$ and lead to the increase of negentropy in statistical sense. This increase would occur spontaneously since the transition would reduce quantum criticality and the subself representing the mental image about intention would fight to stay at former level criticality and to avoid death. All selves would do this and utilize for this purpose homeostatis and metabolism.

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 concreteness to an entire hierarchy of electromagnetic life forms and electromagnetic bodies whose sizes vary to astronomical length scales [K39, K84]. 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 [K50] 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 [J76] 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, philocybin and mescaline. I have also personal "tunnel experiences" every-daily: when 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 my 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. It has been suggested that the physiology of brain

could explain the properties of near death experiences [J89]. The theory of Cowan [J89] 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 Troschienko have proposed a theory in which also the motion along tunnel could be understood as a visual illusion [J39].

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 [K39] 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 s propagation along this kind of magnetic mirror structure transforming it from p-adic to real: thus the tunnel would be created after the physical death. During lifetime these em bridges would be p-adic and physical death be followed via the transformation of these bridges to real ones.

5. OBE aspect

Blackmore explains OBEs [J136] 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 [K80] [J136], 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 [K38] 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. My own remembrances about the long depressive period after the great experience caused by the extreme dullness of the normal wake-up consciousness suggest at least to me that these kind of memories might make it too painful to continue the daily life.

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 Gauss (Earth's magnetic field has nominal value.5 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" [J134] 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. Interestingly, I often wake-up partially and realize that I hear my own snoring as an outsider. Sometimes I have an experience which might be interpreted by saying that the hearing in the first perspective is superposed with the hearing in the third person perspective. The third person hearing has a time lag so that a kind of double breathing results.

Sensory canvas hypothesis provides a more concrete view about the situation. p-Adic-to-real phase transition of a p-adic magnetic sensory canvas to real one could also be part of the fundamental volitional process. 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 [J99]. 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 [J136]. 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 applaude 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 builder of complex cognitive representations 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.

Note that in adelic vision the cognitive representations and sensory representations are aspects of one and same thing - real and p-adic variants of preferred extremal associated with by the strong form of holography to string world sheets and partonic 2-surfaces in the intersection of reality and p-adicities - and complexity for cognitive representations corresponds very closely to complexity for sensory representations. There are no thoughts in vacuum! One could even say that cognitive representations are determined by matter as materialist believes. Materialist's world view cannot of course include intentional actions.

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 [K89].

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.

12.4.4   Are Communications Between Living And Deceased Possible?

The vision about psychological time suggests that the life after the physical death could be purely electromagnetic so that the memes and memeplexes represented by p-adic cognitive space-time sheets (magnetic mirrors say) associated with the organism continue to transform to their real counterparts after the physical death. Since these magnetic mirrors can connect the 4-D body of the deceased to living physical bodies, communications between deceased and living become possible and the mechanism of communications is same as the mechanism of long term memories. It is also possible that the transformation of the magnetic mirror structures to real form induce generation of biological organisms around them and this would give rise to re-incarnation.

In the language used in the spiritistic circles, 4-D bodies of the deceased together with the magnetic mirror structure associated with them also after the physical death would correspond to "discarnate" or "ethereal" entities belonging to the "etheric level". Perhaps the proper interpretation for p-adic space-time sheets representing thoughts and intentions is as not-yet-born entities.

Since the p-adic copies of all real physical systems are possible, even the most far-fetched claims of psychics about materialization and communication phenomena could in principle make sense. It however seems that what is materialized by is the plan for organism represented by magnetic flux tube structures around which visible matter self-organizes.

Mediums and materializations

In spiritualistic circles mediums have been traditionally seen to mediate communications between deceased and alive. This includes also claimed materializations of physical objects besides the bodies of the deceased. Often direct voices emerging from empty space are claimed to been heard during the sittings: trumpets and accordions flow in the air and produce music. Analogous direct voice phenomena are associated with the claimed poltergeist phenomena. The explanation goes that medium is able to somehow to draw "ectoplasm" from her (quite often her) own body and from the bodies of the participants which then materializes as the bodies of deceased and as material objects.

For a physicist this explanation is empty as long as a physical and mathematical definition of the ectoplasm is lacking. In TGD frame work mediums could be seen as persons able to act as relay stations communicating with both deceased and with the participants of the sitting via magnetic mirror bridges. Perhaps these bridges are generated during sitting and medium helps to transform them to real form so that communications along these bridges become possible. The transformation of the p-adic space-time sheets to real ones is of course the natural candidate for the materialization process.

Zero energy ontology allows also a direct generation of CD in quantum jump is in principle possible and TGD inspired theory of consciousness support this possibility indirectly since the generation of a mental image corresponds to generation of sub-CD and thus creation of zero energy state from vacuum. In this framework ectoplasm would be ordinary biomatter.

My own great experience, which involved several parapsychological elements, was a parade of deep ideas, and one of them was the notion "flogiston" as something new for the existing physics and absolutely essential for the living matter. According to the vision, living organisms were fighting and killing to get "flogiston", and the greatest minds had been able to get it (even steal!) more than the lesser souls. I have considered several identification of this mysterious "flogiston". p-Adic space-time sheets is one possible identification. Second interpretation as negentropic entanglement possible in the intersection of real and p-adic worlds and crucial for TGD inspired view about metabolism.

One cannot exclude the possibility that the transformation of the plan for a material body represented by magnetic mirror structures could induce a self-organization of the ordinary matter around this template to form material objects or at least mimicries of them. This is essentially what biological growth is assumed to be. The intersection of real and p-adic worlds would provide a concrete realization of this mimicry.

The claim is that this kind of materializations take place in spiritistic sittings. To my opinion, what happens is generation of hallucination like experience rather than genuine materialization. Usually the spiritistics sittings have been held in the darkness and this allows excellent opportunities for a fraud. On the other hand, alpha band in EEG begins to dominate in darkness and might make possible the communications. There are several reasons to think that it is fast amplitude modulation of alpha frequencies producing harmonic multiples of the alpha frequency, which could be the communication mechanism between our level and higher levels of self hierarchy. The so called mesoscopic features appearing in EEG correlates and corresponding to 1-2 cm areas of cortex [E2] could be direct physical correlates for these communications [K84]. The model of bicameral mind based on the notion of semitrance relies on the same idea [K91]. Note that the minimization of the sensory input (sittings are arranged in dark room) might be just what is needed for the extrasensory input to dominate.

EMDR method as a mechanism to communicate with deceased

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 [J30, J72] induces what could be interpreted as after-death communications. The experiences of subject persons can be induced by this therapy in highly reliable manner: according to [J30] 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 thythmic 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 could involve communication with the 4-D bodies of the deceased ones located possibly in the geometric recent or past via the magnetic mirrors associated with them. One might think that rapid rhythmic eye movements induce fast modulations of some alpha frequency and generate the above mentioned features which somehow help to get a contact with deceased, perhaps rhythmic eye movements somehow generate the negative energy MEs generating the contact to geometric past. Essentially the same mechanism as involved with long term episodal memories would 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.

12.5 TGD Based Model For Instrumental Transcommunications

12.5.1 Introduction

The so called instrumental transcommunications (ITC) and electronic voice phenomena (EVP) [J127, J92] belong to the borderline of even paranormal phenomena, and skeptically oriented scientists probably find it rather difficult to take the claimed phenomena seriously. Personally I do not have any strong opinions and I am just interested in finding whether TGD view about paranormal phenomena might allow the claimed phenomena. Quite generally, ITC can be defined as messages communicated by some conscious entities other than humans using various kinds of electronic instruments. Electronic voices (EVP) are only a special case of the claimed communications and can be realized as signals appearing in a magnetic tape, as voices heard directly from radio receivers, or even phone calls from dead. Also images appearing in a computer screen are reported. The article of Ralf Determayer in the ITC journal [J127], whose chief editor Anabela Cardoso is also ITC experimenter, helps to get an overview about the ITC phenomena.

   Friedrich Jurgenson is usually mentioned as the pioneer or EVP. In 1959 Jurgenson recorded bird song in the morning to a tape recorder and to his surprise found that the tape contained also something else. He started a systematic research of the voices which he interpreted as messages from deceased. This work materialized in two books, "Voices from Space" and "Radio-link with the Dead". Kostantin Raudive, professor of philosophy and psychology and a student of Carl Jung met Jurgenson in 1965, got interested in the phenomenon, and started an intensive recording and study. He published his results in book "Breakthrough" [J92]. As a matter fact, Jurgenson and Raudive had precedessors, Raymond Bayless, Attila Szalay published 1959 an article about the phenomenon in Journal of the American Society of Psychical Research, few months before Jurgensen made is discovery. Later begun experimenting also with other forms of EVP and ITC [J127]. EVP involves recorded phone calls from deceased, direct radio voices, voices both heard by experimenter and tape recorded, and "paranormal" voices not heard but recorded. ITC involves also also other communication modes such as receival of images via computer screen. If one takes seriously all these reports, it would seem that both analog and digital communications are involved.

EVP and ITC very briefly

My own knowledge abut EVP and ITC is very restricted. According to the articles published in ITC journal, for instance the articles [J127, J121, J120] there seems to be a consensus about the following aspects of ITC.

1. The role of the experimenter is important. The ability to receive messages is learned only gradually. The receiving system which works for one experimenter does not work for another. For instance, if two radios are used simultaneously they usually work at different frequencies. This all suggests that experimenter serves as a kind of medium, relay station, or "radio link".

2. The naïve idea about spirits serving as radio stations is not probably correct [J121, J120]. The voices from radio receivers tend to be located in silent periods containing only the background noise and somehow the sender is able to use the energy of the noise to generate the message. This suggests that stochastic resonance in which a weak signal is amplified using noise to provide the energy might be involved. The transformation of noise to voice raises the question about the possible breaking of the second law of thermodynamics, and TGD indeed allows breaking of second law below p-adic time scales [K46].

3. The spectral analysis of the electronic voices by Paolo Presi [J120] shows that usually the voices have an acoustical structure similar to that of human voices. The temporal sequence of vowels, their duration, the duration of the pauses, and the accent of certain vowels of the voices determine a speech rhythm similar to ours. The transfer of information is based exclusively on the sequence of the vowel formants and the integration, made by listener, of the missing consonants. Consonants are produced by a sudden interruption of the air flow coming from the lugns or by an obstruction of the vocal tract. The spectrograms contain no fundamental frequency [J121, J120] unlike speech for which the fundamental frequency

defines the pitch. In principle this does not mean a loss of information but together with the absence of the consonants would mean that the primary source of the message is probably not speech organs. This makes hoax as an explanation of the voices less plausible.

Questions

There are several questions to be answered. *1. How could one tell whether the ITC messages are real or not?*

Brain tries to generate standard percepts from sensory inputs: by looking at clouds at the sky one realizes that brain almost inevitably tends to see faces or other patterns. Therefore this question is highly non-trivial. One can try to answer the question by analyzing whether (say) the electronic voices have spectra resembling that of human voices, and carry the minimum information to be recognized as a speech. It is relatively easy to distinguish an artefact produced by an intelligent life-form (say quartz clock) from a "dead" matter (say a piece of rock). In the similar manner, the differences between the electronic voices and "dead sounds" provide a criterion for whether they are produced intentionally. The information content of the signal is an obvious criterion for this but it is far from trivial, how to define and measure the information content.

Standard real-number based statistical physics allows only the notion of entropy. Entropy is always non-negative so that the information defined as negentropy would be non-positive always: the best one can achieve would be to know nothing! TGD inspired theory of consciousness strongly encourages a number theoretic modification of the standard notion of information, which is based on Shannon's definition of entropy [K56]. The resulting p-adic entropies (one for each prime p) obey the same axioms as the Shannon's entropy but can have both positive and negative values, and depending on the sign can be interpreted as measures of either dis-information or information. These information measures might apply to the analysis of EVP messages. The conclusion of Paolo Presi [J121, J120] on basis of his analysis is that the voices represent a real attempt to communicate. In the following I will assume the messages are real and look whether TGD based view about remote mental interactions allows to model the phenomenon.

2. What could we speculate about the senders of the messages?

In TGD Universe everything is conscious and consciousness can be only lost by quantum entangling. Thus everything is living, and the question is only about how effectively system can control its own state and the state of its environment and about the time scale of the control.

1. Ordinary humans could send these messages unconsciously: human brain and body act as both receiving and sending electromagnetic antennae and in view of the topological quantization of classical em field, it would not be too surprising if these electromagnetic messages could be received electronically under some conditions.

2. TGD predicts that our electromagnetic bodies will survive so that the conscious experience of a discarnate receives a contribution from the 4-dimensional body of the deceased (life review reported in near death experiences) plus a contribution from electromagnetic body still existing.

3. Also the magnetosphere is predicted to be a conscious entity containing collective multi-brained selves.

4. The model for crop formations [K30, K31] leads to rather detailed ideas about exotic life-forms residing at various boundary layers of the magnetosphere, where energy currents driving self-organization are strong. In particular, the mantle-core and core-inner core boundary layers are good candidates for the seats of lifeforms (intra-terrestrials, ITs) quantum-controlling the liquid and/or liquid-crystal phases of quartz or iron from very cold and super-conducting space-time sheets.

3. What is the communication mechanism? TGD based model of remote mental interactions is based on same mechanism as communications inside biological organisms. The mechanism involves quantum entanglement having low frequency MEs (massless extremals, "topological light

rays") as a space-time correlate, and remotely induced self-organization based on high frequency MEs propagating along low frequency MEs like mass-less particles. If magnetic mirrors act as bridges between the deceased and the experimenter and between the experimenter and the electronic instrument so that the experimenter takes the role of a relay station (or medium), the phenomenon ceases to look totally implausible. Long term memory, telepathy, remote healing, ..., and communications with exotic life-forms and deceased become special cases of the same general phenomenon. For instance, TGD predicts mechanisms for how body and brain seem can act as lasers in wavelength range extending from ELF range to visible and UV wavelengths. This kind of laser action could amplify the incoming signal, say microwaves at GHz region, which could the be detected in turn by the electronic instrument with which the experimenter has quantum entanglement bridges, and then transformed to sounds.

4. How the sender can handle modern information technology to generate the desired messages?

In case of a tape recorder or telephone the electric signal is only em variant of sound wave but in case of radio situation changes. The carrier frequency of the sound changes and amplitude modulation can be replaced with frequency modulation. If signal is to be transformed to visual images, a transformation to binary code is needed. The question is where this technological knowhow comes? There are two possibilities.

1. A feedback from the electronic instrument via the brain of experimenter listening say the magnetotape and thus trial-and-error learning of how to send desired messages becomes possible. The simplest feedback is based on the sharing of the mental images of the experimenter by quantum telepathy. TGD allows also history editing, which means that the message to the instrument in the geometric past is modified again and again so that a repeated listening of the message could make it more comprehensible.

2. The existing knowledge about remote mental interaction suggests that they often involve magnetospheric multi-brained selves acting as kind of relay stations. For instance, remote viewer knows only the coordinates of the target, which as such are completely meaningless numbers to her: it is enough that the person who gave the coordinates of the target to the viewer knows their meaning. If ITC occurs in this manner, the information about how to translate the message to say bit sequences in the computer memory might be available. A direct remote mental interaction with the electronic system might be involved at least in some cases and the question is how the proposed general scenario allows to realize this.

5. How the intention of the sender is realized as action?

Remote mental interactions involve also the transformation of intention to action. In TGD framework this corresponds to p-adic-to-real transformation for some space-time sheets. Natural candidates are systems for which the energy of the resulting real system is small so that external energy feed can provide it. If the primary message comes from the magnetic body of the deceased, p-adic MEs are perhaps the most natural candidates for the representations of intentions. These p-adic MEs must first be transformed to real MEs; the real MEs interact with the magnetospheric self; the real MEs originating from the magnetosphere interact with the brain and/or body of experimenter, which in turn interacts with the receiving instrument.

Detailed models for the transformation of the p-adic ME to a basic signal (represented by light or sound) or directly to an electric signal (say in magnetic tape recorder) are not possible at this stage. The mere occurrence of this transformation involves an active volition, and here the role of the experimenter who believes and wants that the transformation occurs, might be decisive. If this is the case, the phenomenon might be also regarded as a particular form of psychokinesis and disappear if the experimenter has a skeptic attitude. Also feedback via the brain of the experimenter to the sender is required and is strongest when the experimenter listens or sees whether the message is there and possibly recognizes it.

12.5.2   Universe As A Conscious Hologram And A General Mechanism Of Remote Mental Interactions

The idea about brain and perhaps all bio-matter, and even Universe, as a hologram in some sense (see for instance, the articles of Miller and Webb [J114] and of Gariaev *et al* [I31]) has a long history but the question in which precise physical sense this holds true has remained without a satisfactory answer. The notion of conscious hologram provided by TGD approach allows to understand bio-control and remote mental interactions as particular cases of the same basic interaction. The notion of conscious hologram leads also naturally to the notions of magnetic body and magnetospheric sensory representations.

The general model of remote mental interactions

The mechanism of remote mental interaction involves two parts. The entanglement, which made possible by low frequency ME in even astrophysical length scales, means that sender and receiver of the message become effectively a single system. This is enough to explain remote viewing as sharing of mental images implied by the fusion of mental images of viewer and target system. The active remote realization of intention requires high frequency MEs propagating like mass-less particles along the low frequency ME and inducing the leakage of the supra currents from larger to smaller space-time sheets, dissipation and possibly also amplifying laser action. This mechanism works also in ordinary bio-control: remote mental interaction is now between some biostructures such as cells or organs.

The scaling law of homeopathy, stating that high and low frequency MEs accompany each other and the frequencies are in some fixed proportions, plus p-adic length scale hypothesis make the hypothesis highly predictive. There is no need to emphasize that the reduction of both homeostasis and remote mental interaction to the same basic mechanism gives support for the reality of the remote mental interactions.

The notion of conscious hologram

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

In TGD framework topological quantization provides a precise first principle description of coherence. Topological field quanta are the coherence regions of the classical field and classical de-coherence means the splitting of the space-time surface to topological quanta. This process gives rise to the granular structure of matter and space-time sheets in various length scales are excellent candidates for basic units of hologrammic structures at the this level of the p-adic length scale hierarchy. At quantum level bound state quantum entanglement having join along boundaries bonds as a space-time correlate is responsible for the macroscopic and macrotemporal quantum coherence. The notion of conscious hologram combines two dual aspects of consciousness to single concept: macrotemporal quantum coherence due to the generation of bound state entanglement and giving rise to co-operation on one hand, and the dissipative self-organization giving rise to Darwinian selection and competition on the other hand. In nutshell, the notion of conscious hologram follows from the topological field quantization.

1. Classical fields and matter form a Feynman diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by space-time sheets representing matter (elementary particles, atoms, molecules, ...), and virtual bosons are replaced by topological light rays ("mass-less extremals", MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

2. The classical fields associated with MEs interfere only at the nodes, where they meet, and one has a hologram like structure with nodes interpreted as the points of a hologram. Thus one avoids the loss of information caused by the interference of all signals everywhere. This aspect is crucial for understanding the role of em fields in living matter and brain. The MEs corresponding to "real photons" are like laser beams entering the hologram and possibly reflected from it. What is new that the nodes can be connected by "virtual photon" MEs also analogous to laser beams. Hence also "self-holograms" with no laser beam from external world are possible (brain without sensory input). The hologram has a fractal structure: there are space-time sheets at space-time sheets and high frequency MEs propagating effectively as mass-less particles inside low frequency MEs serving as quantum entangling bridges of even astrophysical length.

3. The particle like high frequency MEs induce "bridges" between magnetic flux tubes and atomic space-time sheets at the receiving end. This makes possible the leakage of supra currents from magnetic flux tubes to atomic space-time sheets analogous to the exposure of film producing hologram. The leakage induces dissipation, self-organization, and primitive metabolism as a cyclic flow of ionic currents between the two space-time sheets, and thus a Darwinian selection of the self-organization patterns results. The low frequency MEs are responsible for the bound state entanglement, macroscopic quantum coherence and co-operation whereas high frequency MEs are responsible for self-organization and competition.

4. Also the notion of laser action finds its place: many-sheeted space-time provides natural mechanism of laser interaction: when the system is irradiated with coherent light with a frequency which corresponds to the energy difference for the ions at the space-sheets corresponding to different p-adic primes, induced dropping of the ions to a larger space-time sheet occurs and implies a stimulated emission. Thus the light beam can be amplified.

5. At the level of conscious experience the fusion of sub-selves gives rise to a fusion of mental images. In case of right and left visual fields this fusion gives rise to stereovision analogous to what results in hologram. In the general case kind of stereo consciousness results if the mental images are sufficiently similar.

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.

Magnetic sensory canvas hypothesis

The magnetic sensory canvas hypothesis is perhaps the most radical hypothesis of TGD inspired theory of consciousness. It states that sensory representations are realized outside brain at magnetic flux tube structures associated with brain and have sizes measured perhaps in the size scale of Earth. The realization is based on the same mechanism as remote mental interactions: the simple feeling of existence mental images fuses with the more complex mental images produced in brain.

Possible extra-sensory perceptions induced by atmospheric phenomena might provide support for this hypothesis. Auroras are known to induce sounds not detected by electronic means: could these be extrasensory perceptions induces by auroras on sensory canvas. Also meteors could induce sounds [F3]. If one takes very seriously the model for sensory representations, one can imagine that the meteors could kick electromagnetically the magnetic flux tube-ME pairs of sensory canvas and force them to resonantly oscillate at harmonics of the thalamocortical resonance frequencies in interval 37-44 Hz.

These magnetic mirrors might also mediate the electric perturbations to Earth in a channelled manner so that no attenuation would be involved. The mirrors could mediate un-attenuated or even amplified ELF waves also also to electronic instruments. And what is of special interest now, if electronic instruments couple to the magnetic sensory canvas, machine-man interactions

would become possible. The test is to look whether meteors induce sounds heard without time lag due to finite propagation velocity of sound and whether also electronic instruments detect these sounds.

Amazingly, there is evidence just for this kind of strange effects. For centuries it is known that meteors can generate audible "pop" like sound. Sound is heard instantaneously so that either we hear it as ESP through magnetic sensory canvas or ELF em waves are transformed to sounds at Earth and heard after that. Quite recently also electronic instruments have detected these sound [F3]. Amazingly, the frequencies were 37-44 Hz range contrary to the expectation that they would be in the range 20-20.000 Hz and have much weaker intensity. The generation of sounds with the observed intensity is theoretically possible only if the electric perturbations from ionosphere have propagated to Earth as essentially unattenuated (along magnetic mirrors) or being even selectively amplified (magnetic mirrors as wave cavities).

Thus there is some support, not only for the sensory canvas hypothesis, but also for the machine-mind interactions at thalamocortical resonance frequencies. One could also look whether there are correlations between human EEG and electromagnetic perturbations of electromagnetic instruments in thalamocortical frequency range (and perhaps also at the higher harmonics of it). This interaction might be of fundamental technological important since it might make possible to control electronic instruments directly by thought.

12.5.3   Who Are The Senders?

In TGD Universe everything is conscious and consciousness can be only lost. Therefore it is possible to imagine several kinds of senders.

Deceased and/or living humans?

In some messages the senders tell that they are deceased. There are two possibilities: either the senders live in the geometric now in some other than the usual physical form or they live in the geometric past where their physical body still exists. Both options seem to be possible.

1. The conservation of magnetic flux suggests that the magnetic flux tube structure associated with the electromagnetic body survives the physical death so that both the 4-dimensional physical body of the deceased in the geometric past and also electromagnetic body in geometric present would exist. If the p-adic MES associated with the electromagnetic body continue to transform from p-adic to real form, electromagnetic bridges between the 4-D body of the deceased and physically living creatures or electronic instruments could make possible ITC.

2. Also the entanglement with and signals from the geometric past from the physical bodies of the deceased must be considered (say the communications by Kostantin Raudive). TGD based model of long term memories (all memories, even water memory) is based on the mirror idea: when I remember I look at me at a magnetic mirror located at a huge distance of light years. Therefore I see the me of the geometric past in the mirror [K85]. Magnetic mirrors can however connect me to some other person and this means communications with the persons having 4-D body in the geometric past, receiving their memories. This communication is more probable between persons have had (and still have) a close relationship generating the required magnetic mirror bonds.

3. Also the brains and bodies of living could act as sending antennae and generate unconsciously ITC messages. Thus one cannot expect that all messages would have a deep spiritual tone.

Magnetospheric selves?

The model for the sensory representations realized at magnetic bodies of astrophysical size inspires the hypothesis that also the magnetosphere of Earth acts as sensory magnetic canvas and is a living, conscious system. Magnetosphere could be a seat for multi-brained conscious entities receiving information from human and other brains and bodies serving as neurons of these life-forms. Various EEG frequencies correlate for various parts of the magnetosphere by resonance conditions. Especially interesting seats for em life-forms are various boundary layers of the magnetosphere,

such as the plasma sheet at the night side magnetosphere and magnetopause serving also as a kind of magneto-immune system.

Remote mental interactions such as remote viewing involve aspects which suggests that they proceed via the mediation of multi-brained selves providing information necessary for the localization of the target not possessed by the remote viewer herself. Also ITC might involve these collective levels of consciousness. Empirical support for the notion of multi-brained collective levels of consciousness comes from the experiments of Mark Germine [J105].

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 the multi-brained magnetospheric self.

ETs and/or ITs?

The interior of Earth contains almost empty and cold space-time sheets and the magnetic flux tube structure in the core of Earth serves as a kind of thalamus like relay station. The cavity resonance frequencies associated with core and inner core are in the range 14-15 Hz and 40-50 Hz and correspond to two important frequencies of EEG. Thus also the interior of Earth might be important for consciousness.

The general TGD based view about life implies that various boundary layers containing strong energy currents driving self-organization are optimal for the emergence of life. The mantle-core and core-inner core boundary layers containing possibly liquid-crystal phases of quartz (glass) and iron, are especially interesting seats for life-forms controlling the hot liquid-crystal phase from larger space-time sheets which are very cold and super-conducting. A support for these speculations comes from the strange findings associated with crop circles. In particular, Chilbolton and Crabwood crop formations [H1, H2] can be interpreted as messages providing information about these life forms: even the genetic codes of these life-forms can be deduced and a general model for our genetic code emerges as a by-product [K30, K31]. One cannot exclude a quantum symbiosis between us and these life-forms based on a telepathic sharing of mental images, and this kind of symbiosis conforms with shamanistic and religious mythologies and the Freudian super-ego-ego-id trinity. Therefore one must consider the possibility that the senders of ITCs are ITs (intraterrestrials). Of course, quantum entanglement mechanism allows also ETs as the senders of the messages.

12.5.4   Knowhow Problem

How it is possible to code the information sent by the discarnate entity to say computer picture. It is difficult to imagine that the sender would be able to same as a group of IT specialists and computer engineers. There are two ways to overcome this problem.

Higher level multibrained selves acting as relay stations

Higher level multi-brained magnetospheric selves could act as relay stations entangling the sender of the message with the experimenter in turn entangled with the electronic instrument. The knowhow about how to encode the primary signal to various forms such as AM or FM modulated radio wave

or even signal represented as a binary code could be possessed by some brains of this higher level self.

The role of these selves would be same as in the proposed realization of memes and morphic resonances of Sheldrake in terms of magnetic bodies responsible for collective consciousness [K87]. The possibility of collective gene expression based on hyper genes would make this kind of mechanism possible in the case of biological matter and would provide completely standardized communication and control tools for magnetic bodies.

Feedback and history editing

The proposed model is consistent with the fact that EVP and ITC skills develop only gradually and require patience and that some persons are more gifted than others. The generation of the magnetic mirror bridges between senders and experimenter and experimenter and electronic instrument require time. Also the sender must learn by feedback how to code desired messages to the electronic instrument. The simplest form of feedback is a sharing of the mental images generated by say the listening of the magnetic tape in the experimenter's brain.

History editing provides quite a science fictive sounding manner to make corrections to the message. Each quantum history changes the geometric past so that history editing becomes possible in principle. There is an experiment in which a chicken confined to move in small area became imprinted to a robot [J132]. The motion of the robot was coded to a random number sequence half year before. After the imprinting the motion the robot tended to stay near the chicken which suggests that the bleak chicken was able to alter the random number sequence and thus edit history in a time scale of half year. Our long term memories are unstable and can be altered by suggestions. In TGD framework also this can be regarded as history editing applied to the sensory representations of the brain of the geometric past.

During the listening period the sender of the message could receive the information about the conscious experience of the experimenter by the sharing of the mental images induced by the message. The sender could make a quantum jump to a new history which would imply a modification the message to the electronic instrument located in the geometric past (the geometric past changes in each quantum jump in TGD framework), the experimenter would perceive the improved message, and so on. This iterative loop would lead finally to a message which generates the experience of recognition of message in the receiver. During repeated sessions sender would learn the code and would be able to send messages more easily.

12.5.5 Experimenter As A Medium And Amplifier Of The Signal

Experimenter could act as receiver of the ITC signal, amplify it, and send it further to the receiving instrument. Experimenter might also make possible feedback from the instrument to the sender. Both various experimental findings and TGD based view about bio-systems lend support for this hypothesis.

Magnetic mirror as electromagnetic bridge

The experimenter in ITC seems to play a role similar to that of the medium in spiritistic sittings. The idea about experimenter as a relay station between electronic instrument, making possible both the sending of the classical message to the instrument, and receiving the conscious response of the receiver during the reading/listening session, might indeed help to understand ITC at general level.

Magnetic mirrors are by definition magnetic flux tubes accompanied by MEs parallel to them. The Alfven waves, which represent oscillations of magnetic flux tube analogous to those of violin string, resonate with the classical em wave propagating along ME and amplify the signal. To be precise, one should speak about a mirror pair: the mirrors are the points of magnetic flux tube where ME is attached to the flux tube. The existence of magnetic mirror bridges between experimenter and electronic instrument would not be surprising. MEs and magnetic flux tubes represent topological field quanta of electromagnetic field and it would be more surprising if they would not interact with electronic instruments since these instruments interact already in Maxwell theory with external electromagnetic fields. What is new is that MEs make possible channelled transfer

of energy and information: in Maxwell's theory signals would be transmitted to all directions as "mass communications" and distance would be the limiting factor unlike in case of MEs. The presence of kind of interaction would suggest that humans and electronic instruments are already now in an intense interaction and that the electronic revolution is more like a symbiotic process in which both machines and men are active participants.

The generation of electronic (and also acoustic) signal requires energy. Magnetic mirror quantum entangles the discarnate, experimenter, and the electronic instrument. Only bound state entanglement is preserved in quantum jump and thus binding energy is liberated when bound state entanglement is generated. This energy is usable energy and could provide the energy needed to generate the signal. If stochastic resonance is involved, the noise acts as an amplifier of the signal. In the case of an acoustic signal the body of the experimenter could generate the sound and energy could come from metabolism.

Body and brain as antennae

TGD based view about living systems indeed predicts that brain and body act as receiving and sending quantum antennae in a very wide range of frequencies. For instance, EEG can be regarded as radiation emitted by brain acting as an antenna. TGD predicts that EEG MEs are accompanied by high frequency MEs, most probably at microwave frequencies and induces self-organization at magnetic body and thus give rise to sensory representations. For instance, microwave hearing [I35] lends support for the hypothesis that brain is a receiving microwave antenna. The microwave frequency spectrum relevant for microwave audition is in the range $.2 - 3$ GHz. A receiving antenna can also act as sending antenna and it is known that at the sunset a microwave static of unknown but presumably biological origin emerges and correlates strongly with the so called taos hum [I41]. Taos hum is a humming sound heard during night time, which can become intolerable and has no identified origin. The most plausible explanation of taos hum is as a special case of the microwave hearing.

Are alpha waves in special role?

The general communication mechanism between the sender and experimenter could be based on fast amplitude modulation of alpha waves involving higher harmonics of ~ 10 Hz wave (this is like adding small ripples in long wavelength water wave). This mechanism could in fact be equivalent with the propagation of higher frequency MEs inside 10 Hz ME serving as the quantum entangler.

1. Schumann resonance frequencies correspond to cavity resonances in size scale of Earth and thus might mediate telepathic communications between different selves. The lowest Schumann frequency of about 7.8 Hz is especially interesting in this respect.

2. It seems that the 10 Hz fundamental frequency assignable to electron's CD provides a first principle explanation for this frequency appearing also as fundamental biorhythm. This also explains harmonics of 10 Hz frequency naturally. The hierarchy of Planck constants allows also sub-harmonics and even rational multiples of 10 Hz frequency and one can ask whether 5 Hz theta frequency corresponds to dark electrons.

3. Originally the 10 Hz frequency emerged from the memetic code but zero energy ontology provides a first principle justification for it. One realization of memetic code would be in terms of 7 quark-like CDs of duration 1/1.28 ms with bits represented as states of quark and 7: th bit representing a check bit. Genetic code could be realized in terms of 6 scaled down variants of electronic CD but it is not clear whether this requires that quarks appear with masses coming as half octaves of the basic p-adic mass scale corresponding to 5 MeV mass scale. Memetic code could act as universal code making possible communications also with "dead" matter. One can even consider the possibility that electron possesses primitive intelligence. The success of p-adic mass calculations could be indeed understood if elementary particles reside in the intersection of real and p-adic worlds and are therefore quite generally able to entangle negentropically.

Our speech uses the same mechanism (10 Hz frequency is the basic vibration frequency of speech organs, which is not the fundamental frequency which is above 20 Hz) and so called

features [E2] identified in EEG patterns can be also regarded as a fast amplitude modulation of the alpha wave (low amplitude higher harmonics of the alpha wave appear as ripples of the alpha wave). This suggests that speech is an expression of genetic or perhaps even memetic code (the number of codewords seems to be however enormous and genetic code seems to be quite enough.

The structure of the mesoscopic features of EEG [E2] suggests that the harmonics up to the 8: th harmonic of alpha wave are present in EEG. This amplitude could modulate a carrier wave which should have frequency above 80 Hz: the presence of the carrier wave is however not absolutely necessary (the fundamental frequency defining the pitch of the voice and produced by speech organs indeed tends to be absent in EVP [J120]). Interestingly enough, the frequency interval for so called taos hum is in in the interval 40-80 Hz [K84]. The duration of nerve pulse is consistent with the assumption that entire memetic code is realized at the level of nerve pulse patterns.

These features could communicate information to higher level multibrained selves. It has been found, that healer's alpha wave activity intensifies during healing process and magnetic emissions in ELF range have been observed. Also correlations and synchronization between alpha wave activities of Qigong masters and healees has been reported [J99]. If the brain of the experimenter serves as a relay station, the deceased (identifiable as the electrommagnetic body remaining after the physical death or as the physical body in the geometric past) could use the same code as it has used while controlling its own material body from magnetic sensory canvas during life time to both send and receive mental images. If magnetic sensory canvas is able to produce visual hallucinations and dreams it might be also able to produce visual images by sending similar commands to the brain of the experimenter serving as a relay station and preserving the topological structure of images.

Could the body and brain act as lasers?

According to the experimental findings of Peter Gariaev and his group, the irradiation of DNA by visible laser light induces radio wave emission at frequencies ranging from ELF frequencies to MHz range [I31]. The TGD based model of the phenomenon relies on the hypothesis brain and body could act as a laser in a wide range of frequencies extending from EEG frequencies up to UV. The idea is simple: when an ion drops from a smaller to a larger space-time sheet it liberates the difference for the energies of the initial and final state. For free ions this energy is in the simplest situation essentially the difference of zero point kinetic energies. For magnetic flux tubes it is the difference of magnetic energies, which is very small and can correspond to even ELF frequencies. This leads to a many-sheeted laser mechanism: if the system is irradiated with a radiation, whose frequency is same as for the radiation liberated in the dropping, stimulated emission occurs and incoming coherent radiation can be amplified. The difference with respect to the ordinary laser is that the ions does not drop from a higher to a lower energy state of an atom but from a smaller to a larger space-time sheet. The many-sheeted laser could make possible for a body and/or brains to amplify the incoming ITC signal represented by high frequency MEs propagating along low frequency MEs generating the entanglement.

12.5.6 Could Stochastic Resonance Be Involved With ITC?

EVP research support the view that certain background noise is necessary for receiving messages. Skeptic would of course argue that the noise provides the source from which brain as a builder of familiar patterns constructs the signal. On basis of this observation it has been however proposed that stochastic resonance (the article [D8] is an excellent review about the principles and applications of the stochastic resonance) is the mechanism of EVP. Stochastic resonance requires a bistable system (for instance, double potential well) or an excitable system having metastable states. An essentially nonlinear phenomenon is in question.

Stochastic resonance

Stochastic resonance works if the message to be amplified is represented as an amplitude modulation of a carrier wave with a basic frequency f and serves as a harmonic perturbation of a bistable system which is also subject to white noise. In the resonance, f must be one half of the average

frequency $f(spont)$ for the jumps between two states of the bistable system: $f = f(spont)/2$. This condition has a simple physical interpretation: the height of the potential barrier separating the two potential wells varies periodically with a period which is half of the period defined by f, and the best opportunity to get to another potential well is to hop when the potential barrier is lowest possible. For the mechanical analog system the rate $f(spont) = r_0 A$ is proportional to an "Arrhenius factor" $A = exp(-\Delta V/D)$, where ΔV is the height of the potential barrier and D characterizes the intensity of the white noise. $f(spont)$ is also proportional to a factor $r_0 = \omega \omega_b / \gamma$ where ω is the frequency of small oscillations at either bottom of the symmetric potential well, ω_b is the analogous quantity at the top of barrier, and γ characterizes the linear dissipative force (overcritical damping is assumed).

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

Stochastic resonance and brain

There is a considerable empirical support for the hypothesis that stochastic resonance is responsible for both the so called temporal coding of the sensory inputs to neurons (see the references in [D8, D9]) and for the ability of the brain to extract very weak signals from a noisy background. For instance, crickets seem to detect the signals caused by their predators from a strong background noise using this mechanism. More generally, stochastic resonance is a very attractive candidate for a quantum level neuronal mechanism for amplifying very weak EEG waves to a firing pattern in turn amplifying the original EEG waves amplified again by the stochastic resonance... citeeegII. Amplification of em fields associated with ELF MEs is analogous to physical growth would be basically in question and p-adic MEs (memes) could use any means to achieve this. The development of individual indeed involves the gradual emergence of higher frequency ELF waves above the delta band background.

Stochastic resonance and people seeing elves and auras

It is interesting to apply the stochastic resonance model also to other experiences usually believed to be hallucinatory and purely brain generated. Some of us claim to have the ability to see elves and auras, and an interesting question is whether one could artificially induce this kind of ability by tuning the noise level of the visual perceptive field suitably. My own strange and often frightening OBE type experiences induced by the noise of refrigerator or central heating batteries could be partially understood in terms of stochastic resonance. From the visual hallucinations during my great experience I remember the strange conviction that this what I see is always present in the visual field and that I have in some strange manner only become conscious about its presence, much in the same manner as one suddenly becomes conscious of a well-defined pattern in the autostereogram containing only what looks random points.

A stochastic resonance created by the brain itself and making possible the perception of an already existing weak visual input would conform with this interpretation. The same general explanation might apply as such to the case of EMDR experiences: the EMDR method could optimize the level of the background visual noise making possible to amplify weak signals always present in the visual and other perceptive fields. Finally, the claimed encounters with the deceased induced by the presence of a medium could also be explained by the ability of medium to induce a situation in which an actual weak visual signal is amplified to a conscious perception.

It is easy to guess the reaction of a skeptic to these unconventional interpretations, and it might well be that pattern completion indeed generates information which it is not actually present originally. It is however good to remember that until quite recently the dominating theory about dreams was that cortex does its best to cook up something from a random input coming from the brain stem. For a non-skeptic person with some spiritual traits and taking his/her dreams as an essential part of the personal subjective existence this kind of interpretation seems highly absurd

and even humiliating. The revision of this view has been forced by the accumulating knowledge supporting the view that dreaming is a cognitive ability learned before the age of eight, and also by the observation that dreaming as a virtual world life has an obvious survival value. Continuing in spirit of this section, one might even see the role of brain stem as a producer of the background noise making possible the amplification of the weak signals from the higher levels of the self hierarchy to dreams (at least in some cases).

$1/f$ noise amplifying itself via white noise?

What are the physical correlates of the MEs representing memes and being perhaps amplified by both brain and by the electronic instruments in ITC? Besides white noise there is also $1/f$ noise encountered practically everywhere [D1]. The origin of the $1/f$ noise is poorly understood. In TGD framework $1/f$ noise could be seen as a signature of real mind-like space-time sheets (giving rise to sensory qualia). $1/f$ noise is a good candidate for the physical correlate for the real counterparts of memes realized as MEs with the information represented by an amplitude modulated carrier wave. Also EEG could be seen as resulting from the amplification of $1/f$ noise (delta band for EEG resembles the spectrum of the so called spherics [F1]). The real counterparts of these opportunistic memes would correspond to amplitude modulated ELF waves using all possible means of self expression and using also stochastic resonance mechanism to amplify remote mental interactions (this brings in mind the mysterious sea in the scifi novel "Solaris" of Stanislaw Lem!).

Stochastic resonance and ITC

An important question is how the message is amplified and filtered from the background noise possibly present. A possible answer to this question is stochastic resonance. Stochastic resonance could occur in the receiving instrument and/or in the brain of the receiver. ITC, in particular EVP research indeed supports the view that certain background noise is necessary for receiving messages. On basis of this observation it has been proposed that stochastic resonance (the article [D8] is an excellent review about the principles and applications of the stochastic resonance) is the mechanism of EVP.

Stochastic resonance requires a bistable system (for instance, double potential well) or an excitable system having metastable states. An essentially non-linear phenomenon is in question. Signal is in a role of the harmonic external force: the output of the bistable system is interpreted as a transformed signal. If one takes seriously the claim about the positive effects of the white noise on tape recordings, bistable system must reside either in the electronic system transforming sound signal to an electric signal or in the brain of the experimenter serving as a relay station between the sender and electronic instrument in the proposed model.

TGD Universe is quantum spin glass which means that any system should be characterized by fractal spin glass energy landscape containing valleys (energy minima) inside valleys inside... This of course means that there is plenty of bistable systems. TGD also predicts new kinds of dynamical degrees of freedom not predicted by standard physics, so called zero modes, which typically characterize the shape and size of 3-surface and also so called Kähler field (essentially Maxwell type field) of space-time surface. These new degrees of freedom could provide the required new degrees of freedom possibly making also the relevant parts of electronic instruments bistable systems.

1. Does the brain of the receiver contain the bistable systems?

Skeptic would argue that the noise used to promote the receival of the messages is what cheats the brain of the poor pseudoscientist to recognize a feature which is not actually present in the incoming signal. The skeptic might be quite right although after listening the some of recordings I have a tendency to believe that there are actual messages there. One could however turn around the argument of skeptic. Perhaps it is indeed the brain of the experimenter where the bistable system resides and amplifies the very weak signal from the sender and sends it to the electronic instrument in electronic form. Stochastic resonance in experimenter's brain would be involved also with the receival of the feedback signals from the instrument by the sender of the message. This model has several satisfactory features.

1. The model is consistent with the latest facts about brain science [D8, D9]. The model is also universal in the sense that if does not require discarnate entities to be ingenious electric engineers: they can learn by trial and error how to generate desired messages by affecting the electronic instrument.

2. The model would explain why some experimenters are better than the others in receiving messages. They are like crickets able to distinguish very weak input from the high noise. If feedback from experimenter's brain to the sender is involved this in turn helps the sender to learn to generate desired messages. The model is also consistent with the fact that the highly tuned system which works perfectly for a particular experimenter, does not work for the other experimenters. Note that the magnetic mirror bridges between experimenter and electronic instrument are essential part of the system.

The hypothesis could be tested by purposefully building EVP and ITC instruments for which the background noise can be varied.

2. Do electronic systems contain bistable systems?

The hypothesis that the electronic system contains the bistable system is subject to so strong additional constraints that it does not look too plausible in standard physics framework. If the leakage of ionic currents from the magnetic flux tubes to the wires of the electronic induced by MEs gives rise to the electronic signal, stochastic resonance is perhaps not needed since the background noise is very weak. It must be however emphasized that many-many-sheeted space-time plus spin glass degeneracy might provide new physics mechanisms of transforming the ITC signal to electronic signal.

The very fact that the electronic information transfer systems should not induce large distortions of the signal, requires that the system is effectively linear. Bistable systems are highly non-linear systems unless the signal fed into the system represents sufficiently strong external force in which case system is analogous to a one-dimensional particle in an external harmonic force: archetypal model is the potential well $V(x) = -x^2 + x^4$. In case of magnetic tape the direction of magnetization would naturally represent the two potential wells and hopping of the particle between wells would correspond to the changing direction of magnetization. Thus, if bistable systems are involved, ordinary signals must represent strong external forces for which the system is effectively linear and non-linearity can be important only for very weak signals. In case of EVP this requires that possible messages should be contained by the portions of the magnetic tape, where ordinary signal is reduced to mere noise and the noise is sufficiently weak. Already this requirement might kill the hypothesis.

To test this option, one should find whether the electronic system transforming the sound to electric current contains portions modellable as bistable systems fed by an external signal for sufficiently weak input signals. If this is the case, then model could be tested by varying the intensity of the external noise to see whether this has any effect on the probability of receiving the messages.

12.5.7 How The Signal Is Transformed To A Signal In ElectronicInstrument

One should also understand how the transformation of the ITC signal to the signal appearing in electronic instrument such as tape recorder, telephone, or radio receiver occurs.

Direct radio signal

The simplest situation is direct radio signal. It is known that the voices tend to appear in the silent portions of radio signal containing only noise. This is of course natural since in this manner the masking of the signal can be avoided and might allow also stochastic resonance. If the sender or magnetospheric multi-brained conscious entity has managed to code the signal to AM or FM radio wave, and if the brain or body of the experimenter has managed to amplify it and redirect it to the instrument, then the transformation to an audible signal is not a problem.

"Paranormal" signal to a magnetic tape

The first possibility is that primary messages appear as ME having a Fourier decomposition resembling sufficiently that of the sound wave, and giving rise to the required vibrations of atoms. MEs are the basic candidates for the carriers of these waves and the Fourier spectrum of the voice with respect to frequency could be coded into the Fourier spectrum of em or Z^0 fields associated with ME. Hence ELF frequency range would be in question. Phase information is crucial: anyone can easily verify that a reversed speech usually consists of a gibberish despite the fact that the Fourier spectra are same for speech and reverse speech. This suggests an amplitude modulation of the carrier wave or fast amplitude modulation producing ripples to the carrier wave as a candidate for the representation of the information contained by ME.

The sound frequency range involved with the sounds heard by humans is in the interval $20-20.000$ Hz meaning the lengths of ME would vary between Earth radius and 10 kilometers. This spectrum is also claimed to be important for water memory and the mechanism of homeopathy [I28].

A concrete model for the process might look like following.

1. The signal is first transformed to an electric current, which subsequently induces a shortlasting magnetization of a soft electromagnet which in turn induces a permanent local magnetization of hard ferromagnet (magnetic tape). The strength and sign of the local magnetization depends on the strength of the current which in turn codes the strength of the sound signal. A similar transformation to an electric current occurs also for the signal in case of visual ITC.

2. A concrete manner to generate the electric current inducing the magnetization would be by inducing a leakage of a supra current from magnetic flux tubes to the atomic space-time sheets of the current wire responsible for the magnetization of the soft electro-magnet. This leakage could be induced by microwaves by a mechanism discussed in [K42]. The modulation of the microwave by sound wave would imply the modulation of the current automatically. An analogous mechanism could be at work for the radio receiver.

Transformation of em signal to sound signal before entering the tape recorder

Classical EVP suggests that the basic signal enters to the magnetic tape as an electric signal. On the other hand, the experimental results reported by Alec MacRae [J2] are consistent with the assumption that real sounds generate the signal and that electromagnetic signal does not generate a signal in the microphone. The latter conclusion comes from the observation that Faraday cage around microphone does not affect the communication. In TGD framework this conclusion cannot be made since Faraday cage is not expected to affect MEs. The acoustic insulation of another microphone however weakens the voice so that it seems that a genuine acoustic signalling is in question. This does not of course imply that the generation of real sounds is the only mechanism: in the presence of feedback the best communication mode available could be used.

TGD based model for the real sounds generated by meteors heard both directly and recorded by microphones is based on electromagnetic signals coming along magnetic mirrors associated with the sensory magnetic canvas and acting as wave guides and transformed to ordinary sounds via the coupling with objects at the surface of Earth. Whatever the details of em signal-sound transformation are, it certainly exists, and could be involved also now: the electromagnetic signal could come either from the magnetic sensory canvas of the experimenter, of the sender, or from the magnetosphere containing the multi-brained self serving as a relay station. Higher harmonics of the frequencies 37-43 Hz appearing in case of meteors [F3] would be however required to generate the voices or shorter magnetic mirrors should be involved.

One can imagine several mechanisms for the transformation of the primary signal to sounds.

1. The mechanism transforming electromagnetic signal to sound wave could rely on piezo-electricity and frequency resonance. Quartz crystals are excellent piezo-electrets and used in radio receivers and senders. Also body acts as a piezo-electret and the body of the experimenter could transform the signal to sound. Human body could act also as a Z^0-piezo-electric transforming the Z^0 signal to an ordinary sound. The so called oto-acoustic sounds (audible sounds emanating from ears) could result in the same manner. Also material objects of the acoustic environment could serve the same purpose.

2. The phenomenon of microwave hearing suggests that brain and/or body could also transform microwave signals propagating along ELF ME to ordinary sounds.

12.5.8 Tests For The Model Of ITC

Most tests of the ITC reduce to tests for the general mechanism of remote mental interactions, which should be also at work in length scales below body size (bio-telepathy) and for sensory representations realized at the magnetic body. This is good news in the sense that good models usually explain many apparently unrelated phenomena and bad news in the sense that predictions are not ITC specific.

1. Tests for the motion of electromagnetic bridges.

1. Since the development of the magnetic mirror bridges between experimenter and electronic instrument takes time, the replacement of the magnetic tape in EVP with identical one, might make the performance poorer.

2. One could test the importance of the magnetic flux tubes by varying the strength of the local magnetic field (note that magnetic tape has a natural coupling to the magnetic flux tube structures of Earth's magnetic field) to see whether Earth's magnetic field plays a role in the effect. One could test whether the appearance of ITC messages and perturbations of magnetic field appearing at Schumann frequencies correlate. The correlations of paranormal phenomena with sunspot activity are well-known and could be tested in case of ITC.

3. Maxwell's electrodynamics, which is not equivalent with TGD, would suggest that MEs cannot penetrate Faraday's cage so that ITC would not be possible inside Faraday cage. In many-sheeted space-time this argument is lost because MEs by definition are em bridges outside the atomic space-time sheets where the Faraday cage acts. If MEs cannot penetrate Faraday cage, the TGD based model for sensory representations would fall down since it would predict that person in ideal Faraday cage could not have sensory experiences! Be as it may, one can test this aspect by putting the experimenter and/or the instrument in Faraday cage.

4. One should also test directly whether body and brain act as laser like amplifiers of em radiation at, say, audible frequencies. The work of Gariaev [I31] shows that irradiation of DNA with visible light produces radio waves also at audible frequencies. The work of Blackman and others [J115] shows that the irradiation with ELF waves at EEG frequency range induces biological effects.

2. Tests for the ionic leakage mechanism. For instance, the appearance of ions not originally

in the system by the leakage of the supra currents and the dissipative effects caused by the leakage would be a good signature for the effect. These tests are discussed in [K42]. In the recent case one such system would the current wire inducing the magnetization of the magnetic tape.

3. Tests for the ideas about the communication method.

1. In remote healing the changes of alpha waves in EEG are reported to correlate with the intentions communicated by the healer. alpha waves dominate when sensory input is absent, in particular the closing of eyes stimulates alpha waves. This is consistent with the fact that EVP requires silent and dark room. A possible test would be to record the EEG of the experimenter and look whether there is a clear change in the activity in alpha band both when the tape is on and when the tape is listened to and find whether there are recognizable changes of alpha activity. In particular, one could see whether alpha activity changes at the time when the message appears to the magnetic tape. The lowest Schumann frequency 7.8 Hz is especially interesting in this respect. On basis of the experiments of Mark Germine, also the 11 Hz frequency is interesting [J105] .

2. The sounds detected from meteors [F3] are in the thalamocortical 37-44 Hz frequency band [K84] suggesting that magnetic sensory canvas mediates ELF perturbations to both brains and to electronic instruments at this frequency range. One could in principle test whether thalamocortical resonance band in the EEG of the experimenter contains something correlating with the received message.

3. Are persons able to receive the ITC messages also able to hear microwaves.

4. Are the sounds in EVP are received electronically or acoustically. Both mechanisms might be involved. Alec MacRae has demonstrated and in his experiments signal is received as a sound [J2]. One could also test whether the pitch of the sound correlates with the acoustic environment (big room–small room).

5. One could test the role of the stochastic resonance by varying the level of the acoustic or radio noise. Here explicit formulas for the noise optimal for a signal of given frequency are available [D8].

4. Tests for the notion of magnetospheric selves.

The notion of magnetospheric selves might be crucial for the solution of the knowhow problem and the experiments of Mark Germine [J105] can be seen as a pioneer work in the testing of this hypothesis.

5. Tests for the notion of history editing. History editing is not necessary for understanding of ITC but one could test whether it is involved. Let an outsider, presumably not able to act as a relay station, listen to the magnetic tape first and document whether he/she received any message. Suppose that he/she detects no recognizable message. Next let the experimenter listen the same tape, and report what he/she found: during this session the feedback mechanism could transform the message to a recognizable form by affecting the geometric past at the moment the magnetic tape was on. Suppose that the experimenter indeed recognizes a message. Let an outsider listen the tape again to see whether there is any recognizable message now. If the proposed mechanism is correct, the outsider who did not hear any message in the first trial, should hear now a clear message. Note that one cannot replace external person with a computer since the computer records change in quantum jumps too! Note also that even the geometric memories of the external person might change if they are comparable to mechanical records: genuine subjective memories are required. Also the repeated listening of the tape by the experimenter could improve the quality of the message and the above experimental arrangement could be iterated.

Chapter 13

TGD Based Model for OBEs

13.1 Introduction

Out-of-body experiences (OBEs) [J46, J135, J151] are often understood as experience of seeing oneself from a position outside of the body. According to Susan Blackmore [J135]. OBEs are rather common: from 5 to 35 percent of subjects reports of having had at least one OBE. According to studies persons having OBEs seem to be perfectly healthy. OBEs are poorly understood in the framework of neuro science and pose a challenge for the reductionistic world view.

In TGD framework the notion of magnetic body provides an attractive starting point in attempts to understand what OBEs and related experiences are. The basic idea is that magnetic body serves effectively as a mirror defining a third person view as a cognitive representation also in ordinary wake-up state and that during OBEs this representation becomes sensory representation. Magnetic body need not always be a personal magnetic body but could correspond to a magnetic body receiving information from several brains (collective consciousness), magnetic body of another person, or be even associated with "dead" matter.

The progress in identifying dark matter as a phase of matter with large value of Planck constant making possible macroscopic quantum coherence has led to the vision about dark matter at magnetic flux quanta as quantum controller of ordinary matter in living systems. The Bose-Einstein condensates of dark photons decaying via de-coherence to ordinary photons mediate interactions between ordinary and dark matter and the hypothesis is that dark photon "laser" beams from body and brain reflected at magnetic flux quanta give rise to third person aspect of consciousness which in OBEs and related experiences are realized as sensory representations. The identification of bio-photons as end products of the de-coherence of dark photon beams is natural.

Zero energy ontology and the notion of causal diamond (or CD defined roughly as the intersection of future and past directed light-cones) brings additional quantitative ingredients to the model. Sub-CDs define embedding space ($M^4 \times CP_2$) correlates for selves and by holography the 2-D partonic 2-surfaces at the light-like future and past boundaries of CDs are the ultimate space-time correlates for mental images. The moduli space for CDs makes possible a more detailed view about sensory representations discussed in the chapter "Quantum Model for Sensory Representations" [K83].

A further new element is the vision about life as something in the intersection of real and p-adic worlds. The most important outcome is that the notion of number theoretic entanglement negentropy making sense in this situation is positive so that entanglement carries conscious information. The fusion of selves (in particular mental image) by negentropic entanglement is experienced as expansion of consciousness. It is negentropic entanglement between parts of biological body and corresponding parts of the magnetic body and biological body which makes living system living. This negentropic entanglement between magnetic body and biological body is important also for OBEs.

The model leads also to a model for dreams, hallucinations, sensory feedback from brain to sensory organs, and directed attention. Concrete models for how dark photons can give rise to experiences in various sensory modalities such as vision, hearing, olfaction, and tactile senses, are proposed.

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` [L17].

13.1.1 OBEs, Autoscopy, Heautoscopy, And Other Strange Experiences

Phenomenological characterization

The phenomenological characterization of OBEs [J15] has been discussed in [J151]. A precise definition of OBE is to have sensation of being outside the body. Autoscopic experience involves a 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 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 [J135] . This brings in mind the notion of subtle body of spiritual practices identified as the body experienced during lucid dreaming [J93]. The notions of guardian angle 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 [J64]. Angular gurus 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.

[J151] [J16] 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 [J47] 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 [J134] 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 its 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.

13.2   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).

13.2.1   OBEs, Autoscopy, Heautoscopy, And Other Strange Experiences

Phenomenological characterization

The phenomenological characterization of OBEs [J15] has been discussed in [J151]. A precise definition of OBE is to have sensation of being outside the body. Autoscopic experience involves a 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 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 [J135] . This brings in mind the notion of subtle body of spiritual practices identified as the body experienced during lucid dreaming [J93]. The notions of guardian angle 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 [J64]. Angular gurus 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.

[J151] [J16] 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 [J47] 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 [J134] 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 its 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.

13.2.2   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 objets 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 stimulusandother 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 [J47] 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 [I67] (see the discussion in [K42]) 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 processes 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.

13.2.3 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 [K71] 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 [K15]. Bio-holograms [I67] 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 [J50], the "third eye". This would explain AS as well as the images of internal organs [J134]. 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 [**?**, K15]. 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 [K36] 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 generalize 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 charactering 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 boots to it [K83].

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 [A12] and I have proposed a model for what might be involved [K39].

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 [K116].

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 [K56].

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 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 sate 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.

13.2.4 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 [I67] (for a TGD based model see [K15, K42]). 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 [K46] and the identification as dark photons is discussed in [K32]. The findings of Peter Gariaev about the effects of visible laser light on DNA [I31] and so called phantom DNA effect [I30] provide a further support for the biological importance of bio-photons (see the discussions in [K32, K46]).

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 [K80] [I35] is indeed a well-known but poorly understood phenomenon and the generation of microwaves by plants after sunset correlates also with taos hum [I41] (see the discussion in [K48]) 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 [J85] discussed in TGD framework in [K92] 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 [K19, K84], "third eye", the seat of the soul according to Descartes [J50]. 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 [I62] (see the discussion in [K39]). 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 [J3] 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" [J134] 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.

13.2.5 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. If 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 [J93]) 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 heautoscopic 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 [J30] induces what could be interpreted as after-death communications (see the discussion in [K82]). The experiences of subject persons are claimed to be induced by this therapy in a highly reliable manner: according to [J30] 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 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 [K83] 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 [J126] and I have proposed an explanation based on time mirror mechanism [K83]. 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 [I60] (see

the discussion in [K41]). 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.

13.2.6 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 [J71]. 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. Phychedelics 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

Phychoactive 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 [J71] belong to the third group. Psychedelics (such as psilocin, psicylobin, DMT, LSD) containing aromatic rings and many of them (such as psilocin, psicylobin, 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 phenetylamine which in turn derive from the amino-acids trpandphe.

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/l4h2g2y` 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 there 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/cll2ox7`), 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 [J71], 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 is functions relates to a control of the entire brain in long time scales. Descartes regarded pinearl 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 ti 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 signa 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 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 [L23] [K81] (`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 of 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). Neutral 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 builds a flux tube connection between postsynaptic neutron 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 [L36] [L37] (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 [L20] (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 [L31] (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 neutrons 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 gives 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"?

13.3   The Interpretation Of My Own OBE Type Experiences In Terms Of The Proposed Model

My own personal experiences have served as a test bed for the basic ideas of TGD inspired theory of consciousness. I find it practical to divide these experiences into two classes. The first class of experiences have repeated relatively often during years after the great experiences. The Great Experiences in turn involved a rich spectrum of experiences which I group into the second class. There is some overlap between these categories.

13.3.1   Visual Experiences And Kinesthetic Sensations

The first class of strange experiences involves several kinds of visual experiences and kinesthetic sensations.

1. When I lightly close my eyes during ordinary wake-up consciousness and in calm state of mind, I see dimly a complex flow in the visual field. This flow brings in mind time dependent magnetic field or incompressible flow of fluid. The direction of flow can be either inwards or outwards and can change. The flow can be also colored. The straightforward interpretation would be as a visual stimulus from the magnetic body which does not give rise to concrete images.

2. I have had many AS experiences in which I have seen my body in strangely deformed state and have had a sensation of floating. This experience is often followed by the experience of raising to the roof and I have made attempts to test whether the levitation is real or not. The experiences have ended to a wake-up to ordinary state of consciousness. Quite concrete sensations of what I have identified as "electrical storms in temporal lobes" have often accompanied these experiences.

3. I have had also flying experiences: typically there is some critical height which I cannot exceed. I have had also experiences about being in completely dissipation free spinning or translational motion, which bring strongly in mind what purely quantal motions of this kind feel like. The translational motion has been possible only in a finite volume defined typically by the walls of the room. I have also experienced my children to bring me back when I have tried to go too far. A possible interpretation is that my magnetic body is bound to that of room so that it is not possible to leave it.

4. I have often experienced quite concretely a return to my own body during wake-up as a kind of contraction somewhat like djinn returning to a bottle. After a visit to Holland where I was subject to a treatment by a healer, I waked up to a rather long-lasting experience in which I felt that the entire room was part of my body. The world around me was strangely peaceful and calm, somewhat like the world in the pictures I saw in fairy tales in my childhood.

5. Two illusions analogous to train illusion but involving a 2- or 3-dimensional wave motion instead of linear motion deserve also to be mentioned. I sat in a calm state of mind on cliff on beach and enjoyed looking the waves. Suddenly I got a long lasting sensation that the cliff is in a wave like motion as if I had seen the cliff from the perspective of the moving surface of sea and thus in a wave like movement with respect to it. The explanation would be magnetic body began to mimic the wave motion somewhat like a person listening very attentively begins to mimic the facial expressions of the speaker. Since magnetic body also serves also the dual role of a sensory canvas to which sensory mental images are projected [K48], the situation would be like projecting sensory mental images to a deformable screen along which deformation waves propagate. The projected sensory images such as the visual image about cliff would inherit the wavy character.

   Anyone who has enjoyed free floating in a windy sea for a sufficiently long time has probably experienced a sensation about a wave like motion inside the body after the return to the shore. The sensation continues surprisingly long time. As far as I can remember, this experience is absent during free floating. Also this experience might relate to the fixation of bodily attention to the

wavy sea inducing a mimicry of wave motion by a relevant magnetic body as in the previous case and continuing for a considerable time after the return to the shore. During free floating in sea this sensation is weak since the relative motion is minimal but at the shore the situation changes since the body is in a relative 3-D motion with respect to the magnetic body.

13.3.2 OBE Type Auditory Sensations

Also OBE type auditory sensations have often occurred.

1. The AS experience have often started usually by a gradual amplification of sounds such as the sound of refrigerator and have involved the rather frightening sensation that the refrigerator attracts me towards it and wants to fuse my self with its own (for this reason I have been forced to minimize this sound). A possible explanation is that magnetic body in this kind of situation contributes to the auditory stimulus the secondary sound representing the sensory stimulus that it has received from the body and a positive feedback loop is generated. Representation as microwaves is perhaps the most plausible option.

2. When I wake up during night-time, I can sometimes hear a kind of wind blowing and often I realize that ordinary wind is not in question when I see that there is completely calm outside. This wind has preceded sometimes a loss of consciousness. A microwave stimulus arriving from magnetic body along magnetic flux tubes and transformed to auditory sensation could be in question. Obviously this sensation would be direct auditory counterpart for the flow in visual field experienced during wake-up.

3. To listen one's own snoring during sleep or just before wake-up as an outsider is a rather bizarre experience and often it takes time to realize that it is really me. The interpretation in terms of microwave dark photon beams modulated by the snoring and reflected back from the magnetic body would be the simplest one.

4. Sometimes I also hear my own breathing as double with a time laps of a fraction of second between the copies. This gives some idea about size of the magnetic body possibly involved. For microwave hearing the size of magnetic body would correspond to a wavelength of typical EEG wave and would be of the order of Earth circumference for 7.8 Hz. If ordinary sound waves are in question the size of magnetic body involve would be of order 10 meters.

Chapter i

Appendix

A-1 Introduction

Originally this appendix was meant to be a purely technical summary of basic facts but in its recent form it tries to briefly summarize those basic visions about TGD which I dare to regarded stabilized. I have added illustrations making it easier to build mental images about what is involved and represented briefly the key arguments. This chapter is hoped to help the reader to get fast grasp about the concepts of TGD.

The basic properties of embedding space and related spaces are discussed and the relationship of CP_2 to the standard model is summarized. The basic vision is simple: the geometry of the embedding space $H = M^4 \times CP_2$ geometrizes standard model symmetries and quantum numbers. The assumption that space-time surfaces are basic objects, brings in dynamics as dynamics of 3-D surfaces based on the induced geometry. Second quantization of free spinor fields of H induces quantization at the level of H, which means a dramatic simplification.

The notions of induction of metric and spinor connection, and of spinor structure are discussed. Many-sheeted space-time and related notions such as topological field quantization and the relationship many-sheeted space-time to that of GRT space-time are discussed as well as the recent view about induced spinor fields and the emergence of fermionic strings. Also the relationship to string models is discussed briefly.

Various topics related to p-adic numbers are summarized with a brief definition of p-adic manifold and the idea about generalization of the number concept by gluing real and p-adic number fields to a larger book like structure analogous to adele [L36, L37]. In the recent view of quantum TGD [L80], both notions reduce to physics as number theory vision, which relies on $M^8 - H$ duality [L63, L64] and is complementary to the physics as geometry vision.

Zero energy ontology (ZEO) [L58] [K124] 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) [L58, L73] [K124] 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 [A29] so that $H = M^4 \times CP_2$ is twistorially unique.

One can loosely say that quantum states in a given sector of "world of classical worlds" (WCW) are superpositions of space-time surfaces inside CDs and that positive and negative energy parts of zero energy states are localized and past and future boundaries of CDs. CDs form a hierarchy. One can have CDs within CDs and CDs can also overlap. The size of CD is characterized by the proper time distance between its two tips. One can perform both translations and also Lorentz boosts of CD leaving either boundary invariant. Therefore one can assign to CDs a moduli space and speak about wave function in this moduli space.

In number theoretic approach it is natural to restrict the allowed Lorentz boosts to some discrete subgroup of Lorentz group and also the distances between the tips of CDs to multiples of CP_2 radius defined by the length of its geodesic. Therefore the moduli space of CDs discretizes. The quantization of cosmic recession velocities for which there are indications, could relate to this quantization.

A-2.1 Basic facts about CP_2

CP_2 as a four-manifold is very special. The following arguments demonstrate that it codes for the symmetries of standard models via its isometries and holonomies.

CP_2 as a manifold

CP_2, the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space C^3 under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \ . \tag{A-2.1}$$

Here λ is any non-zero complex number. Note that CP_2 can be also regarded as the coset space $SU(3)/U(2)$. The pair z^i/z^j for fixed j and $z^i \neq 0$ defines a complex coordinate chart for CP_2. As j runs from 1 to 3 one obtains an atlas of three coordinate charts covering CP_2, the charts being holomorphically related to each other (e.g. CP_2 is a complex manifold). The points $z^3 \neq 0$ form a subset of CP_2 homoeomorphic to R^4 and the points with $z^3 = 0$ a set homeomorphic to S^2. Therefore CP_2 is obtained by "adding the 2-sphere at infinity to R^4".

Besides the standard complex coordinates $\xi^i = z^i/z^3$, $i = 1, 2$ the coordinates of Eguchi and Freund [A22] will be used and their relation to the complex coordinates is given by

$$
\begin{aligned}
\xi^1 &= z + it \ , \\
\xi^2 &= x + iy \ .
\end{aligned}
\tag{A-2.2}
$$

These are related to the "spherical coordinates" via the equations

$$
\begin{aligned}
\xi^1 &= r \exp(i\frac{(\Psi + \Phi)}{2})\cos(\frac{\Theta}{2}) \ , \\
\xi^2 &= r \exp(i\frac{(\Psi - \Phi)}{2})\sin(\frac{\Theta}{2}) \ .
\end{aligned}
\tag{A-2.3}
$$

The ranges of the variables r, Θ, Φ, Ψ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold CP_2 is compact and simply connected, with Euler number Euler number 3, Pontryagin number 3 and second $b = 1$.

Fig. 4. CP_2 as manifold. `http://tgdtheory.fi/appfigures/cp2.jpg`

Metric and Kähler structure of CP_2

In order to obtain a natural metric for CP_2, observe that CP_2 can be thought of as a set of the orbits of the isometries $z^i \rightarrow exp(i\alpha)z^i$ on the sphere S^5: $\sum z^i \bar{z}^i = R^2$. The metric of CP_2 is obtained by projecting the metric of S^5 orthogonally to the orbits of the isometries. Therefore the distance between the points of CP_2 is that between the representative orbits on S^5.

The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}}d\xi^a d\bar{\xi}^b \ , \tag{A-2.4}$$

where the Hermitian, in fact Kähler metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K \ , \tag{A-2.5}$$

where the function K, Kähler function, is defined as

$$\begin{aligned} K &= log(F) \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-2.6}$$

The Kähler function for S^2 has the same form. It gives the S^2 metric $dzd\bar{z}/(1+r^2)^2$ related to its standard form in spherical coordinates by the coordinate transformation $(r, \phi) = (tan(\theta/2), \phi)$.

The representation of the CP_2 metric is deducible from S^5 metric is obtained by putting the angle coordinate of a geodesic sphere constant in it and is given

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2 \sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \ , \tag{A-2.7}$$

where the quantities σ_i are defined as

$$\begin{aligned} r^2 \sigma_1 &= Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2 \sigma_2 &= -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2 \sigma_3 &= -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \ . \end{aligned} \tag{A-2.8}$$

R denotes the radius of the geodesic circle of CP_2. The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A \ , \tag{A-2.9}$$

are given by

$$\begin{aligned} e^0 &= \frac{dr}{F} \ , & e^1 &= \frac{r\sigma_1}{\sqrt{F}} \ , \\ e^2 &= \frac{r\sigma_2}{\sqrt{F}} \ , & e^3 &= \frac{r\sigma_3}{F} \ . \end{aligned} \tag{A-2.10}$$

The explicit representations of vierbein vectors are given by

$$
\begin{aligned}
e^0 &= \frac{dr}{F} \;, & e^1 &= \frac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \;, \\
e^2 &= \frac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \;, & e^3 &= \frac{r(d\Psi + cos\Theta d\Phi)}{2F} \;.
\end{aligned}
$$

(A-2.11)

The explicit representation of the line element is given by the expression

$$
ds^2/R^2 = \frac{dr^2}{F^2} + \frac{r^2}{4F^2}(d\Psi + cos\Theta d\Phi)^2 + \frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2) \;.
$$

(A-2.12)

From this expression one finds that at coordinate infinity $r = \infty$ line element reduces to $\frac{r^2}{4F}(d\Theta^2 + sin^2\Theta d\Phi^2)$ of S^2 meaning that 3-sphere degenerates metrically to 2-sphere and one can say that CP_2 is obtained by adding to R^4 a 2-sphere at infinity.

The vierbein connection satisfying the defining relation

$$
de^A = -V^A_B \wedge e^B \;,
$$

(A-2.13)

is given by

$$
\begin{aligned}
V_{01} &= -\frac{e^1}{r} \;, & V_{23} &= \frac{e^1}{r} \;, \\
V_{02} &= -\frac{e^2}{r} \;, & V_{31} &= \frac{e^2}{r} \;, \\
V_{03} &= (r - \frac{1}{r})e^3 \;, & V_{12} &= (2r + \frac{1}{r})e^3 \;.
\end{aligned}
$$

(A-2.14)

The representation of the covariantly constant curvature tensor is given by

$$
\begin{aligned}
R_{01} &= e^0 \wedge e^1 - e^2 \wedge e^3 \;, & R_{23} &= e^0 \wedge e^1 - e^2 \wedge e^3 \;, \\
R_{02} &= e^0 \wedge e^2 - e^3 \wedge e^1 \;, & R_{31} &= -e^0 \wedge e^2 + e^3 \wedge e^1 \;, \\
R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \;, & R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \;.
\end{aligned}
$$

(A-2.15)

Metric defines a real, covariantly constant, and therefore closed 2-form J

$$
J = -is_{a\bar{b}}d\xi^a d\bar{\xi}^b \;,
$$

(A-2.16)

the so called Kähler form. Kähler form J defines in CP_2 a symplectic structure because it satisfies the condition

$$
J^k_{\;r}J^{rl} = -s^{kl} \;.
$$

(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

$$
J = dB \;,
$$

(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

$$
\begin{aligned}
B &= 2re^3 ~, \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) = \frac{r}{F^2} dr \wedge (d\Psi + cos\Theta d\Phi) + \frac{r^2}{2F} sin\Theta d\Theta \wedge d\Phi ~.
\end{aligned}
\tag{A-2.19}
$$

The vierbein curvature form and Kähler form are covariantly constant and have in the complex coordinates only components of type $(1, 1)$.

Useful coordinates for CP_2 are the so called canonical (or symplectic or Darboux) coordinates in which the Kähler potential and Kähler form have very simple expressions

$$
\begin{aligned}
B &= \sum_{k=1,2} P_k dQ_k ~, \\
J &= \sum_{k=1,2} dP_k \wedge dQ_k ~.
\end{aligned}
\tag{A-2.20}
$$

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$
\begin{aligned}
P_1 &= -\frac{1}{1+r^2} ~, \\
P_2 &= -\frac{r^2 cos\Theta}{2(1+r^2)} ~, \\
Q_1 &= \Psi ~, \\
Q_2 &= \Phi ~.
\end{aligned}
\tag{A-2.21}
$$

Spinors In CP_2

CP_2 doesn't allow spinor structure in the conventional sense [A18]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of CP_2 play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space M. The parallel propagation around a closed curve with a base point x leads to a rotated vierbein at x: $e^A = R^A_B e^B$ and one can associate to each closed path an element of $SO(4)$.

Consider now a one-parameter family of closed curves $\gamma(v) : v \in (0, 1)$ with the same base point x and $\gamma(0)$ and $\gamma(1)$ trivial paths. Clearly these paths define a sphere S^2 in M and the element $R^A_B(v)$ defines a closed path in $SO(4)$. When the sphere S^2 is contractible to a point e.g., homologically trivial, the path in $SO(4)$ is also contractible to a point and therefore represents a trivial element of the homotopy group $\Pi_1(SO(4)) = Z_2$.

For a homologically nontrivial 2-surface S^2 the associated path in $SO(4)$ can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group Spin(4) (leading from the matrix 1 to -1 in the matrix representation). Assume this is the case.

Assume now that the space allows spinor structure. Then one can parallel propagate also spinors and by the above construction associate a closed path of Spin(4) to the surface S^2. Now, however this path corresponds to a lift of the corresponding $SO(4)$ path and cannot be closed. Thus one ends up with a contradiction.

From the preceding argument it is clear that one could compensate the non-allowed -1-factor associated with the parallel transport of the spinor around the sphere S^2 by coupling it to a gauge potential in such a way that in the parallel transport the gauge potential introduces a compensating -1-factor. For a $U(1)$ gauge potential this factor is given by the exponential

$exp(i2\Phi)$, where Φ is the magnetic flux through the surface. This factor has the value -1 provided the $U(1)$ potential carries half odd multiple of Dirac charge $1/2g$. In case of CP_2 the required gauge potential is half odd multiple of the Kähler potential B defined previously. In the case of $M^4 \times CP_2$ one can in addition couple the spinor components with different chiralities independently to an odd multiple of $B/2$.

Geodesic sub-manifolds of CP_2

Geodesic sub-manifolds are defined as sub-manifolds having common geodesic lines with the embedding space. As a consequence the second fundamental form of the geodesic manifold vanishes, which means that the tangent vectors h_α^k (understood as vectors of H) are covariantly constant quantities with respect to the covariant derivative taking into account that the tangent vectors are vectors both with respect to H and X^4.

In [A36] a general characterization of the geodesic sub-manifolds for an arbitrary symmetric space G/H is given. Geodesic sub-manifolds are in 1-1-correspondence with the so called Lie triple systems of the Lie-algebra g of the group G. The Lie triple system t is defined as a subspace of g characterized by the closedness property with respect to double commutation

$$[X, [Y, Z]] \in t \ \text{ for } \ X, Y, Z \in t \ . \tag{A-2.22}$$

$SU(3)$ allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that $SU(3)$ allows two nonequivalent $SU(2)$ algebras corresponding to subgroups $SO(3)$ (orthogonal 3×3 matrices) and the usual isospin group $SU(2)$. By taking any subset of two generators from these algebras, one obtains a Lie triple system and by exponentiating this system, one obtains a 2-dimensional geodesic sub-manifold of CP_2.

Standard representatives for the geodesic spheres of CP_2 are given by the equations

$$S_I^2 \ : \ \xi^1 = \bar{\xi}^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Psi = 0) \ ,$$

$$S_{II}^2 \ : \ \xi^1 = \xi^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Phi = 0) \ .$$

The non-equivalence of these sub-manifolds is clear from the fact that isometries act as holomorphic transformations in CP_2. The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for S_I^2. S_{II}^2 is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

A-2.2 CP_2 geometry and Standard Model symmetries

Identification of the electro-weak couplings

The delicacies of the spinor structure of CP_2 make it a unique candidate for space S. First, the coupling of the spinors to the $U(1)$ gauge potential defined by the Kähler structure provides the missing $U(1)$ factor in the gauge group. Secondly, it is possible to couple different H-chiralities independently to a half odd multiple of the Kähler potential. Thus the hopes of obtaining a correct spectrum for the electromagnetic charge are considerable. In the following it will be demonstrated that the couplings of the induced spinor connection are indeed those of the GWS model [B18] and in particular that the right handed neutrinos decouple completely from the electro-weak interactions.

To begin with, recall that the space H allows to define three different chiralities for spinors. Spinors with fixed H-chirality $e = \pm 1$, CP_2-chirality l, r and M^4-chirality L, R are defined by the condition

$$
\begin{aligned}
\Gamma \Psi &= e\Psi \ , \\
e &= \pm 1 \ ,
\end{aligned}
\tag{A-2.23}
$$

where Γ denotes the matrix $\Gamma_9 = \gamma_5 \otimes \gamma_5$, $1 \otimes \gamma_5$ and $\gamma_5 \otimes 1$ respectively. Clearly, for a fixed H-chirality CP_2- and M^4-chiralities are correlated.

The spinors with H-chirality $e = \pm 1$ can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite H-chirality one can identify the vielbein group of CP_2 as the electro-weak group: $SO(4)$ having as its covering group $SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A \quad = \quad V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) \ . \tag{A-2.24}$$

Here V and B denote the projections of the vielbein and Kähler gauge potentials respectively and $1_{+(-)}$ projects to the spinor H-chirality $+(-)$. The integers $n_\pm$ are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection V and of B are given by the equations

$$
\begin{array}{llll}
V_{01} & = & -\frac{e^1}{r} \ , & V_{23} & = & \frac{e^1}{r} \ , \\
V_{02} & = & -\frac{e^2}{r} \ , & V_{31} & = & \frac{e^2}{r} \ , \\
V_{03} & = & (r - \frac{1}{r})e^3 \ , & V_{12} & = & (2r + \frac{1}{r})e^3 \ ,
\end{array}
\tag{A-2.25}
$$

and

$$B \quad = \quad 2re^3 \ , \tag{A-2.26}$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying Σ_3^0 and Σ_2^1 as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} \quad = \quad 2V_{23}I_L^1 + 2V_{13}I_L^2 \ , \tag{A-2.27}$$

where one have defined

$$
\begin{aligned}
I_L^1 & = & \frac{(\Sigma_{01} - \Sigma_{23})}{2} \ , \\
I_L^2 & = & \frac{(\Sigma_{02} - \Sigma_{13})}{2} \ .
\end{aligned}
\tag{A-2.28}
$$

A_{ch} is clearly left handed so that one can perform the identification of the gauge potential as

$$W^\pm \quad = \quad \frac{2(e^1 \pm ie^2)}{r} \ , \tag{A-2.29}$$

where $W^\pm$ denotes the charged intermediate vector boson.

The covariantly constant curvature tensor is given by

$$
\begin{aligned}
R_{01} &= -R_{23} = e^0 \wedge e^1 - e^2 \wedge e^3 \ , \\
R_{02} &= -R_{31} = e^0 \wedge e^2 - e^3 \wedge e^1 \ , \\
R_{03} &= 4e^0 \wedge e^3 + 2e^1 \wedge e^2 \ , \\
R_{12} &= 2e^0 \wedge e^3 + 4e^1 \wedge e^2 \ .
\end{aligned}
\tag{A-2.30}
$$

The charged part of the curvature tensor is left handed.

This is to be compared with the Weyl tensor, which defines a representation of quaternionic imaginary units.

$$W_{03} = W_{12} \equiv 2I_3 = 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ ,$$
$$W_{01} = W_{23} \equiv I_1 = -e^0 \wedge e^1 - e^2 \wedge e^3 \ , \qquad \text{(A-2.31)}$$
$$W_{02} = W_{31} \equiv I_2 = -e^0 \wedge e^2 - e^3 \wedge e^1 \ .$$

The charged part of the Weyl tensor is right-handed and that the relative sign of the two terms in the curvature tensor and Weyl tensor are opposite.

Consider next the identification of the neutral gauge bosons γ and Z^0 as appropriate linear combinations of the two functionally independent quantities

$$X = re^3 \ ,$$
$$Y = \frac{e^3}{r} \ , \qquad \text{(A-2.32)}$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$\bar{\gamma} = aX + bY \ ,$$
$$\bar{Z}^0 = cX + dY \ , \qquad \text{(A-2.33)}$$

where the normalization condition

$$ad - bc = 1 \ ,$$

is satisfied. The physical fields γ and Z^0 are related to $\bar{\gamma}$ and $\bar{Z}^0$ by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$A_{nc} = [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma}$$
$$+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 \ .$$
$$\text{(A-2.34)}$$

Identifying Σ_{12} and $\Sigma_{03} = 1 \times \gamma_5\Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that γ couples vectorially leads to the condition

$$c = -d \ . \qquad \text{(A-2.35)}$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \qquad \text{(A-2.36)}$$

Here the electromagnetic charge Q_{em} and the weak isospin are defined by

$$Q_{em} = \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} \ ,$$
$$I_L^3 = \frac{(\Sigma^{12} - \Sigma^{03})}{2} \ . \qquad \text{(A-2.37)}$$

The fields γ and Z^0 are defined via the relations

$$\gamma = 6d\bar{\gamma} = \frac{6}{(a+b)}(aX + bY) \ ,$$
$$Z^0 = 4(a+b)\bar{Z}^0 = 4(X - Y) \ . \qquad \text{(A-2.38)}$$

The value of the Weinberg angle is given by

$$sin^2\theta_W \quad = \quad \frac{3b}{2(a+b)} \quad , \tag{A-2.39}$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electro-weak interactions.

The determination of the value of the Weinberg angle is a dynamical problem. The original approach was based on the assumption that it makes sense to talk about electroweak action defined at fundamental level and introduce a symmetry breaking by adding an additional term proportional to Kähler action. The recent view is that Kähler action plus volume term defines the fundamental action.

The Weinberg angle is completely fixed if one requires that the electroweak action contains no cross term of type γZ^0. This leads to a definite value for the Weinberg angle.

One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle. As a matter fact, color gauge action identifying color gauge field as proportional to $H^A J_{\alpha\beta}$ is proportional to Kähler action. A possible interpretation would be as a sum of electroweak and color gauge interactions.

To evaluate the value of the Weinberg angle one can express the neutral part F_{nc} of the induced gauge field as

$$F_{nc} \quad = \quad 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) \quad , \tag{A-2.40}$$

where one has

$$\begin{aligned}
R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) \quad , \\
R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) \quad , \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \quad ,
\end{aligned} \tag{A-2.41}$$

in terms of the fields γ and Z^0 (photon and Z- boson)

$$F_{nc} \quad = \quad \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \quad . \tag{A-2.42}$$

Evaluating the expressions above, one obtains for γ and Z^0 the expressions

$$\begin{aligned}
\gamma &= 3J - sin^2\theta_W R_{12} \quad , \\
Z^0 &= 2R_{03} \quad .
\end{aligned} \tag{A-2.43}$$

For the Kähler field one obtains

$$J \quad = \quad \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \quad . \tag{A-2.44}$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned}
L_{ew} &= L_{sym} + fJ^{\alpha\beta}J_{\alpha\beta} \quad , \\
L_{sym} &= \frac{1}{4g^2}Tr(F^{\alpha\beta}F_{\alpha\beta}) \quad ,
\end{aligned} \tag{A-2.45}$$

where the trace is taken in spinor representation, in terms of γ and Z^0 one obtains for the coefficient X of the γZ^0 cross term (this coefficient must vanish) the expression

$$
\begin{aligned}
X &= -\frac{K}{2g^2} + \frac{fp}{18} \ , \\
K &= Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ ,
\end{aligned}
\tag{A-2.46}
$$

This parameter can be calculated by substituting the values of quark and lepton charges and weak isospins.

In the general case the value of the coefficient K is given by

$$
K = \sum_i \left[-\frac{(18 + 2n_i^2)sin^2\theta_W}{9} \right] \ ,
\tag{A-2.47}
$$

where the sum is over the spinor chiralities, which appear as elementary fermions and n_i is the integer describing the coupling of the spinor field to the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$
sin^2\theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i(18 + n_i^2))} \ .
\tag{A-2.48}
$$

In the scenario where both leptons and quarks are elementary fermions the value of the Weinberg angle is given by

$$
sin^2\theta_W = \frac{9}{\left(\frac{fg^2}{2} + 28\right)} \ .
\tag{A-2.49}
$$

The bare value of the Weinberg angle is $9/28$ in this scenario, which is not far from the typical value $9/24$ of GUTs at high energies [B5]. The experimental value at the scale length scale of the electron can be deduced from the ratio of W and Z boson masses as $sin^2\theta_W = 1 - (m_W/m_Z)^2 \simeq .22290$. This ratio and also the weak boson masses depend on the length scale.

If one interprets the additional term proportional to J as color action, one could perhaps interpret the value of Weinberg angle as expressing a connection between strong and weak coupling constant evolution. The limit $f \to 0$ should correspond to an infinite value of color coupling strength and at this limit one would have $sin^2\theta_W = \frac{9}{28}$ for $f/g^2 \to 0$. This does not make sense since the Weinberg angle is in the standard model much smaller in QCD scale Λ corresponding roughly to pion mass scale. The Weinberg angle is in principle predicted by the p-adic coupling constant evolution fixed by the number theoretical vision of TGD.

One could however have a sum of electroweak action, correction terms changing the value of Weinberg angle, and color action and coupling constant evolution could be understood in terms of the coupling parameters involved.

Electroweak symmetry breaking

One of the hardest challenges in the development of the TGD based view of weak symmetry breaking was the fact that classical field equations allow space-time surfaces with finite but arbitrarily large size. For a fixed space-time surface, the induced gauge fields, including classical weak fields, are long ranged. On the other hand, the large mass for weak bosons would require a short correlation length. How can one understand this together with the fact that a photon has a long correlation length?

In zero energy ontology quantum states are superpositions of space-time surfaces as analogs of almost unique Bohr orbits of particles identified as 3-D surfaces. For some reason the superposition should be such that the quantum averages of weak gauge boson fields vanish below the weak scale whereas the quantum average of electromagnetic fields is non-vanishing.

This is indeed the case.

1. The supersymplectic symmetries form isometries of the world of classical worlds (WCW) and they act in CP_2 degrees of freedom as symplectic transformations leaving the CP_2 symplectic form J invariant and therefore also its contribution to the electromagnetic field since this part is the same for all space-time surfaces in the superposition of space-time surfaces as a representation of supersymplectic isometry group (as a special case a representation of color group).

2. In TGD, color and electroweak symmetries acting as holonomies are not independent and for the $SU(2)_L$ part of induced spinor connection the symplectic transformations induces $SU(2)_L \times U(1)_R$ gauge transformation. This suggests that the quantum expectations of the induced weak fields over the space-time surfaces vanish above the quantum coherence scale. The averages of W and of the left handed part of Z^0 should therefore vanish.

3. $\langle Z^0 \rangle$ should vanish. For $U(1)_R$ part of Z^0, the action of gauge transformation is trivial in gauge theory. Now however the space-time surface changes under symplectic transformations and this could make the average of the right-handed part of Z^0 vanishing. The vanishing of the average of the axial part of the Z^0 is suggested by the partially conserved axial current hypothesis.

   One can formulate this picture quantitatively.

1. The electromagnetic field [L85] contains, besides the induced Kähler form, also the induced curvature form R_{12}, which couples vectorially. Conserved vector current hypothesis suggests that the average of R_{12} is non-vanishing. One can express the neutral part of the induced gauge field in terms of induced spinor curvature and Kähler form J as

$$
\begin{aligned}
R_{03} &= 2(2e^0 \wedge e^3 + e^1 \wedge e^2) = J + 2e^0 \wedge e^3 ~, \\
J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) ~, \\
R_{12} &= 2(e^0 \wedge e^3 + 2e^1 \wedge e^2) = 3J - 2e^0 \wedge e^3 ~,
\end{aligned}
\tag{A-2.50}
$$

2. The induced fields γ and Z^0 (photon and Z- boson) can be expressed as

$$
\begin{aligned}
\gamma &= 3J - sin^2\theta_W R_{12} ~, \\
Z^0 &= 2R_{03} = 2(J + 2e^0 \wedge e^3)
\end{aligned}
\tag{A-2.51}
$$
$$
per.
\tag{A-2.52}
$$

The condition $\langle Z^0 \rangle = 0$ gives $2\langle e^0 \wedge e^3 \rangle = -2J$ and this in turn gives $\langle R_{12} \rangle = 4J$. The average over γ would be

$$
\langle \gamma \rangle = (3 - 4sin^2\theta_W)J ~.
$$

For $sin^2\theta_W = 3/4$ $langle\gamma\rangle$ would vanish.

   The quantum averages of classical weak fields quite generally vanish. What about correlation functions?

1. One expects that the correlators of classical weak fields as color invariants, and perhaps even symplectic invariants, are non-vanishing below the Compton length since in this kind of situation the points in the correlation function belong to the same 3-surface representing particle, such as hadron.

2. The intuitive picture is that in longer length scales one has disjoint 3-surfaces with a size scale of Compton length. If the states associated with two disjoint 3-surfaces are separately color invariant there are no correlations in color degrees of freedom and correlators reduce to the products of expectations of classical weak fields and vanish. This could also hold when the 3-surfaces are connected by flux tube bonds.

Below the Compton length weak bosons would thus behave as correlated massless fields. The Compton lengths of weak bosons are proportional to the value of effective Planck constant h_{eff} and in living systems the Compton lengths are proposed to be even of the order of cell size. This would explain the mysterious chiral selection in living systems requiring large parity violation.

3. What about the averages and correlators of color gauge fields? Classical color gauge fields are proportional to the products of Hamiltonians of color isometries induced Kähler form and the expectations of color Hamiltonians give vanishing average above Compton length and therefore vanishing average. Correlators are non-vanishing below the hadron scale. Gluons do not propagate in long scales for the same reason as weak bosons. This is implied by color confinement, which has also classical description in the sense that 3-surfaces have necessarily a finite size.

A large value of h_{eff} allows colored states even in biological scales below the Compton length since in this kind of situation the points in the correlation function belong to the same 3-surface representing particle, such as dark hadron.

Discrete symmetries

The treatment of discrete symmetries C, P, and T is based on the following requirements:

1. Symmetries must be realized as purely geometric transformations.

2. Transformation properties of the field variables should be essentially the same as in the conventional quantum field theories [B6] .

The action of the reflection P on spinors of is given by

$$\Psi \quad \to \quad P\Psi = \gamma^0 \otimes \gamma^0 \Psi \ . \tag{A-2.53}$$

in the representation of the gamma matrices for which γ^0 is diagonal. It should be noticed that W and Z^0 bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P.

The guess that a complex conjugation in CP_2 is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$
\begin{aligned}
m^k &\to T(M^k) \ , \\
\xi^k &\to \bar{\xi}^k \ , \\
\Psi &\to \gamma^1 \gamma^3 \otimes 1 \Psi \ .
\end{aligned}
\tag{A-2.54}
$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in CP_2:

$$
\begin{aligned}
\xi^k &\to \bar{\xi}^k \ , \\
\Psi &\to \Psi^\dagger \gamma^2 \gamma^0 \otimes 1 \ .
\end{aligned}
\tag{A-2.55}
$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

A-3 Induction procedure and many-sheeted space-time

Since the classical gauge fields are closely related in TGD framework, it is not possible to have space-time sheets carrying only single kind of gauge field. For instance, em fields are accompanied by Z^0 fields for extremals of Kähler action.

Classical em fields are always accompanied by Z^0 field and some components of color gauge field. For extremals having homologically non-trivial sphere as a CP_2 projection em and Z^0 fields are the only non-vanishing electroweak gauge fields. For homologically trivial sphere only W fields are non-vanishing. Color rotations does not affect the situation.

For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has U(1) holonomy by 2-dimensionality of the CP_2 projection. Color gauge field has $U(1)$ holonomy for all space-time surfaces and quantum classical correspondence suggest a weak form of color confinement meaning that physical states correspond to color neutral members of color multiplets.

A-3.1 Induction procedure for gauge fields and spinor connection

Induction procedure for gauge potentials and spinor structure is a standard procedure of bundle theory. If one has embedding of some manifold to the base space of a bundle, the bundle structure can be induced so that it has as a base space the imbedded manifold, whose points have as fiber the fiber if embedding space at their image points. In the recent case the embedding of space-time surface to embedding space defines the induction procedure. The induced gauge potentials and gauge fields are projections of the spinor connection of the embedding space to the space-time surface (see `http://tgdtheory.fi/appfigures/induct.jpg`).

Induction procedure makes sense also for the spinor fields of embedding space and one obtains geometrization of both electroweak gauge potentials and of spinors. The new element is induction of gamma matrices which gives their projections at space-time surface.

As a matter fact, the induced gamma matrices cannot appear in the counterpart of massless Dirac equation. To achieve super-symmetry, Dirac action must be replaced with Kähler-Dirac action for which gamma matrices are contractions of the canonical momentum currents of Kähler action with embedding space gamma matrices. Induced gamma matrices in Dirac action would correspond to 4-volume as action.

Fig. 9. Induction of spinor connection and metric as projection to the space-time surface. `http://tgdtheory.fi/appfigures/induct.jpg`.

A-3.2 Induced gauge fields for space-times for which CP_2 projection is a geodesic sphere

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional CP_2 projection, only vacuum extremals and space-time surfaces for which CP_2 projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing W fields and homologically non-trivial sphere to non-vanishing W fields but vanishing γ and Z^0. This can be verified by explicit examples.

$r = \infty$ surface gives rise to a homologically non-trivial geodesic sphere for which e_0 and e_3 vanish imply the vanishing of W field. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \ .$$

The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

$Im(\xi^1) = Im(\xi^2) = 0$ corresponds to homologically trivial geodesic sphere. A more general representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case e^1 and e^3 vanish so that the induced em, Z^0, and Kähler fields vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

A-3.3 Many-sheeted space-time

TGD space-time is many-sheeted: in other words, there are in general several space-sheets which have projection to the same M^4 region. Second manner to say this is that CP_2 coordinates are many-valued functions of M^4 coordinates. The original physical interpretation of many-sheeted space-time time was not correct: it was assumed that single sheet corresponds to GRT space-time and this obviously leads to difficulties since the induced gauge fields are expressible in terms of only four embedding space coordinates.

Fig. 10. Illustration of many-sheeted space-time of TGD. `http://tgdtheory.fi/appfigures/manysheeted.jpg`

Superposition of effects instead of superposition of fields

The first objection against TGD is that superposition is not possible for induced gauge fields and induced metric. The resolution of the problem is that it is effects which need to superpose, not the fields.

Test particle topologically condenses simultaneously to all space-time sheets having a projection to same region of M^4 (that is touches them). The superposition of effects of fields at various space-time sheets replaces the superposition of fields. This is crucial for the understanding also how GRT space-time relates to TGD space-time, which is also in the appendix of this book).

Wormhole contacts

Wormhole contacts are key element of many-sheeted space-time. One does not expect them to be stable unless there is non-trivial Kähler magnetic flux flowing through then so that the throats look like Kähler magnetic monopoles.

Fig. 11. Wormhole contact. `http://tgdtheory.fi/appfigures/wormholecontact.jpg`

Since the flow lines of Kähler magnetic field must be closed this requires the presence of another wormhole contact so that one obtains closed monopole flux tube decomposing to two Minkowskian pieces at the two space-time sheets involved and two wormhole contacts with Euclidian signature of the induced metric. These objects are identified as space-time correlates of elementary particles and are clearly analogous to string like objects.

The relationship between the many-sheeted space-time of TGD and of GRT space-time

The space-time of general relativity is single-sheeted and there is no need to regard it as surface in H although the assumption about representability as vacuum extremal gives very powerful constraints in cosmology and astrophysics and might make sense in simple situations.

The space-time of GRT can be regarded as a long length scale approximation obtained by lumping together the sheets of the many-sheeted space-time to a region of M^4 and providing it with an effective metric obtained as sum of M^4 metric and deviations of the induced metrics of various space-time sheets from M^4 metric. Also induced gauge potentials sum up in the similar manner so that also the gauge fields of gauge theories would not be fundamental fields.

Fig. 12. The superposition of fields is replaced with the superposition of their effects in many-sheeted space-time. `http://tgdtheory.fi/appfigures/fieldsuperpose.jpg`

Space-time surfaces of TGD are considerably simpler objects that the space-times of general relativity and relate to GRT space-time like elementary particles to systems of condensed matter physics. Same can be said about fields since all fields are expressible in terms of embedding space coordinates and their gradients, and general coordinate invariance means that the number of bosonic field degrees is reduced locally to 4. TGD space-time can be said to be a microscopic description whereas GRT space-time a macroscopic description. In TGD complexity of space-time topology replaces the complexity due to large number of fields in quantum field theory.

Topological field quantization and the notion of magnetic body

Topological field quantization also TGD from Maxwell's theory. TGD predicts topological light rays ("massless extremals (MEs)") as space-time sheets carrying waves or arbitrary shape propagating

with maximal signal velocity in single direction only and analogous to laser beams and carrying light-like gauge currents in the generi case. There are also magnetic flux quanta and electric flux quanta. The deformations of cosmic strings with 2-D string orbit as M^4 projection gives rise to magnetic flux tubes carrying monopole flux made possible by CP_2 topology allowing homological Kähler magnetic monopoles.

Fig. 13. Topological quantization for magnetic fields replaces magnetic fields with bundles of them defining flux tubes as topological field quanta. `http://tgdtheory.fi/appfigures/field.jpg`

The imbeddability condition for say magnetic field means that the region containing constant magnetic field splits into flux quanta, say tubes and sheets carrying constant magnetic field. Unless one assumes a separate boundary term in Kähler action, boundaries in the usual sense are forbidden except as ends of space-time surfaces at the boundaries of causal diamonds. One obtains typically pairs of sheets glued together along their boundaries giving rise to flux tubes with closed cross section possibly carrying monopole flux.

These kind of flux tubes might make possible magnetic fields in cosmic scales already during primordial period of cosmology since no currents are needed to generate these magnetic fields: cosmic string would be indeed this kind of objects and would dominated during the primordial period. Even superconductors and maybe even ferromagnets could involve this kind of monopole flux tubes.

A-3.4   Embedding space spinors and induced spinors

One can geometrize also fermionic degrees of freedom by inducing the spinor structure of $M^4 \times CP_2$.

CP_2 does not allow spinor structure in the ordinary sense but one can couple the opposite H-chiralities of H-spinors to an $n = 1$ ($n = 3$) integer multiple of Kähler gauge potential to obtain a respectable modified spinor structure. The em charges of resulting spinors are fractional (integer valued) and the interpretation as quarks (leptons) makes sense since the couplings to the induced spinor connection having interpretation in terms electro-weak gauge potential are identical to those assumed in standard model.

The notion of quark color differs from that of standard model.

1. Spinors do not couple to color gauge potential although the identification of color gauge potential as projection of $SU(3)$ Killing vector fields is possible. This coupling must emerge only at the effective gauge theory limit of TGD.

2. Spinor harmonics of embedding space correspond to triality $t = 1$ ($t = 0$) partial waves. The detailed correspondence between color and electroweak quantum numbers is however not correct as such and the interpretation of spinor harmonics of embedding space is as representations for ground states of super-conformal representations. The wormhole pairs associated with physical quarks and leptons must carry also neutrino pair to neutralize weak quantum numbers above the length scale of flux tube (weak scale or Compton length). The total color quantum numbers or these states must be those of standard model. For instance, the color quantum numbers of fundamental left-hand neutrino and lepton can compensate each other for the physical lepton. For fundamental quark-lepton pair they could sum up to those of physical quark.

The well-definedness of em charge is crucial condition.

1. Although the embedding space spinor connection carries W gauge potentials one can say that the embedding space spinor modes have well-defined em charge. One expects that this is true for induced spinor fields inside wormhole contacts with 4-D CP_2 projection and Euclidian signature of the induced metric.

2. The situation is not the same for the modes of induced spinor fields inside Minkowskian region and one must require that the CP_2 projection of the regions carrying induced spinor field is such that the induced W fields and above weak scale also the induced Z^0 fields vanish in order to avoid large parity breaking effects. This condition forces the CP_2 projection to be 2-dimensional. For a generic Minkowskian space-time region this is achieved only if the

spinor modes are localized at 2-D surfaces of space-time surface - string world sheets and possibly also partonic 2-surfaces.

3. Also the Kähler-Dirac gamma matrices appearing in the modified Dirac equation must vanish in the directions normal to the 2-D surface in order that Kähler-Dirac equation can be satisfied. This does not seem plausible for space-time regions with 4-D CP_2 projection.

4. One can thus say that strings emerge from TGD in Minkowskian space-time regions. In particular, elementary particles are accompanied by a pair of fermionic strings at the opposite space-time sheets and connecting wormhole contacts. Quite generally, fundamental fermions would propagate at the boundaries of string world sheets as massless particles and wormhole contacts would define the stringy vertices of generalized Feynman diagrams. One obtains geometrized diagrammatics, which brings looks like a combination of stringy and Feynman diagrammatics.

5. This is what happens in the the generic situation. Cosmic strings could serve as examples about surfaces with 2-D CP_2 projection and carrying only em fields and allowing delocalization of spinor modes to the entire space-time surfaces.

A-3.5   About induced gauge fields

In the following the induced gauge fields are studied for general space-time surface without assuming the preferred extremal property (Bohr orbit property). Therefore the following arguments are somewhat obsolete in their generality.

Space-times with vanishing em, Z^0, or Kähler fields

The following considerations apply to a more general situation in which the homologically trivial geodesic sphere and extremal property are not assumed. It must be emphasized that this case is possible in TGD framework only for a vanishing Kähler field.

Using spherical coordinates (r, Θ, Ψ, Φ) for CP_2, the expression of Kähler form reads as

$$
\begin{aligned}
J &= \frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta)d\Phi) + \frac{r^2}{2F} sin(\Theta)d\Theta \wedge d\Phi \ , \\
F &= 1 + r^2 \ .
\end{aligned}
\tag{A-3.1}
$$

The general expression of electromagnetic field reads as

$$
\begin{aligned}
F_{em} &= (3+2p)\frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta)d\Phi) + (3+p)\frac{r^2}{2F} sin(\Theta)d\Theta \wedge d\Phi \ , \\
p &= sin^2(\Theta_W) \ ,
\end{aligned}
\tag{A-3.2}
$$

where Θ_W denotes Weinberg angle.

1. The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$
\begin{aligned}
\Psi &= k\Phi \ , \\
(3+2p)\frac{1}{r^2 F}(d(r^2)/d\Theta)(k + cos(\Theta)) &+ (3+p)sin(\Theta) = 0 \ ,
\end{aligned}
\tag{A-3.3}
$$

hold true. The conditions imply that CP_2 projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$r = \sqrt{\frac{X}{1-X}} \ ,$$

$$X = D\left[\left|\frac{k+u}{C}\right|\right]^{\epsilon} \ ,$$

$$u \equiv cos(\Theta) \ , \ \ C = k + cos(\Theta_0) \ , \ \ D = \frac{r_0^2}{1+r_0^2} \ , \ \ \epsilon = \frac{3+p}{3+2p} \ , \tag{A-3.4}$$

where C and D are integration constants. $0 \leq X \leq 1$ is required by the reality of r. $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u + k| = [(1 + r_0^2)/r_0^2]^{(3+2p)/(3+p)}$ achieved only for

$$sign(u+k) \times [\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}} \leq k+1 \ ,$$

where $sign(x)$ denotes the sign of x.

The expressions for Kähler form and Z^0 field are given by

$$J = -\frac{p}{3+2p}X du \wedge d\Phi \ ,$$

$$Z^0 = -\frac{6}{p}J \ . \tag{A-3.5}$$

The components of the electromagnetic field generated by varying vacuum parameters are proportional to the components of the Kähler field: in particular, the magnetic field is parallel to the Kähler magnetic field. The generation of a long range Z^0 vacuum field is a purely TGD based feature not encountered in the standard gauge theories.

2. The vanishing of Z^0 fields is achieved by the replacement of the parameter ϵ with $\epsilon = 1/2$ as becomes clear by considering the condition stating that Z^0 field vanishes identically. Also the relationship $F_{em} = 3J = -\frac{3}{4}\frac{r^2}{F}du \wedge d\Phi$ is useful.

3. The vanishing Kähler field corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and Z^0 fields are proportional to each other:

$$Z^0 = 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u)\frac{\partial r}{\partial u}du \wedge d\Phi = (k+u)du \wedge d\Phi \ ,$$

$$r = \sqrt{\frac{X}{1-X}} \ , \ \ X = D|k+u| \ ,$$

$$\gamma = -\frac{p}{2}Z^0 \ . \tag{A-3.6}$$

For a vanishing value of Weinberg angle ($p = 0$) em field vanishes and only Z^0 field remains as a long range gauge field. Vacuum extremals for which long range Z^0 field vanishes but em field is non-vanishing are not possible.

The effective form of CP_2 metric for surfaces with 2-dimensional CP_2 projection

The effective form of the CP_2 metric for a space-time having vanishing em,Z^0, or Kähler field is of practical value in the case of vacuum extremals and is given by

$$
\begin{aligned}
ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta}d\Theta^2 + s^{eff}_{\Phi\Phi}d\Phi^2] \;, \\
s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \;, \\
s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \;,
\end{aligned}
\tag{A-3.7}
$$

and is useful in the construction of vacuum embedding of, say Schwartchild metric.

Topological quantum numbers

Space-times for which either em, Z^0, or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers (ω_1 and ω_2) are frequency type parameters, two (k_1 and k_2) are wave vector like quantum numbers, two of the quantum numbers (n_1 and n_2) are integers. The parameters ω_i and n_i will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

   The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of CP_2 coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

   Under rather general conditions the coordinates Ψ and Φ can be written in the form

$$
\begin{aligned}
\Psi &= \omega_2 m^0 + k_2 m^3 + n_2\phi + \text{Fourier expansion} \;, \\
\Phi &= \omega_1 m^0 + k_1 m^3 + n_1\phi + \text{Fourier expansion} \;.
\end{aligned}
\tag{A-3.8}
$$

m^0, m^3 and ϕ denote the coordinate variables of the cylindrical M^4 coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters ω_i, k_i and n_i and m and C are bounded by the surfaces at which space-time surface becomes ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

   The space-time surface decomposes into regions characterized by different values of the vacuum parameters r_0 and Θ_0. At $r = \infty$ surfaces n_2, ω_2 and m can change since all values of Ψ correspond to the same point of CP_2: at $r = 0$ surfaces also n_1 and ω_1 can change since all values of Φ correspond to same point of CP_2, too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

   This implies what might be called topological quantization since in general it is not possible to find a smooth global embedding for, say a constant magnetic field. Although global embedding exists it decomposes into regions with different values of the vacuum parameters and the coordinate u in general possesses discontinuous derivative at $r = 0$ and $r = \infty$ surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteeing the absence of edges are satisfied.

   For instance, the vanishing of the electromagnetic fields implies that the condition

$$
\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \;,
\tag{A-3.9}
$$

is satisfied. In particular, the ratio ω_2/ω_1 is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter n_1 and n_2 (ω_1 and ω_2) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

A-4 The relationship of TGD to QFT and string models

The recent view of the relationship of TGD to QFT and string models has developed slowly during years and it seems that in a certain sense TGD means a return to roots: instead of QFT like description involving path integral one would have wave mechanics for 3-surfaces.

A-4.1 TGD as a generalization of wave mechanism obtained by replacing point-like particles with 3-surfaces

The first vision of TGD was as a generalization of quantum field theory (string models) obtained by replacing pointlike particles (strings) as fundamental objects with 3-surfaces.

The later work has revealed that TGD could be seen as a generalization of the wave mechanism based on the replacement of a point-like particle with 3-D surface. This is due to holography implied by general coordinate invariance. The definition of the metric of the "world of classical worlds" (WCW) must assign a unique or at least almost unique space-time surface to a given 3-surface. This 4-surface is analogous to Bohr orbit so that also Bohr orbitology becomes an exact part of quantum physics. The failure of strict determinism forces to replace 3-surfaces with 4-surfaces and this leads to zero energy ontology (ZEO) in which quantum states are superpositions of space-time surfaces [K44, K26, K88] [L74, L80].

Fig. 5. TGD replaces point-like particles with 3-surfaces. `http://tgdtheory.fi/appfigures/particletgd.jpg`

A-4.2 Extension of superconformal invariance

The fact that light-like 3-surfaces are effectively metrically 2-dimensional and thus possess generalization of 2-dimensional conformal symmetries with light-like radial coordinate defining the analog of second complex coordinate suggests that this generalization could work and extend the super-conformal symmetries to their 4-D analogs.

The boundary $\delta M_+^4 = S^2 \times R_+$- of 4-D light-cone M_+^4 is also metrically 2-dimensional and allows extended conformal invariance. Also the group of isometries of light-cone boundary and of light-like 3-surfaces is infinite-dimensional since the conformal scalings of S^2 can be compensated by S^2-local scaling of the light-like radial coordinate of R_+. These simple facts mean that 4-dimensional Minkowski space and 4-dimensional space-time surfaces are in a completely unique position as far as symmetries are considered.

In fact, this leads to a generalization of the Kac-Moody type symmetries of string models. $\delta M_+^4 \times CP_2$ allows huge supersymplectic symmetries for which the radial light-like coordinate of δM_+^4 plays the role of complex string coordinate in string models. These symmetries are assumed to act as isometries of WCW.

A-4.3 String-like objects and strings

String like objects obtained as deformations of cosmic strings $X^2 \times Y^2$, where X^2 is minimal surface in M^4 and Y^2 a holomorphic surface of CP_2 are fundamental extremals of Kähler action having string world sheet as M^4 projections. Cosmic strings dominate the primordial cosmology of the TGD Universe and the inflationary period corresponds to the transition to radiation dominated cosmology for which space-time sheets with 4-D M^4 projection dominate.

Also genuine string-like objects emerge from TGD. The conditions that the em charge of modes of induces spinor fields is well-defined requires in the generic case the localization of the modes at 2-D surfaces -string world sheets and possibly also partonic 2-surfaces. This in Minkowskian space-time regions.

Fig. 6. Well-definedness of em charge forces the localization of induced spinor modes to 2-D surfaces in generic situations in Minkowskian regions of space-time surface. `http://tgdtheory.fi/appfigures/fermistring.jpg`

A-4.4 TGD view of elementary particles

The TGD based view about elementary particles has two key aspects.

1. The space-time correlates of elementary particles are identified as pairs of wormhole contacts with Euclidean signature of metric and having 4-D CP_2 projection. Their throats behave effectively as Kähler magnetic monopoles so that wormhole throats must be connected by Kähler magnetic flux tubes with monopole flux so that closed flux tubes are obtained.

2. At the level of H Fermion number is carried by the modes of the induced spinor field. In space-time regions with Minkowski signature the modes are localized at string world sheets connecting the wormhole contacts.

   Fig. 7. TGD view about elementary particles. a) Particle orbit corresponds to a 4-D generalization of a world line or b) with its light-like 3-D boundary (holography). c) Particle world lines have Euclidean signature of the induced metric. d) They can be identified as wormhole contacts. e) The throats of wormhole contacts carry effective Kähler magnetic charges so that wormhole contacts must appear as pairs in order to obtain closed flux tubes. f) Wormhole contacts are accompanied by fermionic strings connecting the throats at the same sheet: the strings do not extend inside the wormhole contacts. `http://tgdtheory.fi/appfigures/elparticletgd.jpg`

   Particle interactions involve both stringy and QFT aspects.

1. The boundaries of string world sheets correspond to fundamental fermions. This gives rise to massless propagator lines in generalized Feynman diagrammatics. One can speak of "long" string connecting wormhole contacts and having a hadronic string as a physical counterpart. Long strings should be distinguished from wormhole contacts which due to their super-conformal invariance behave like "short" strings with length scale given by CP_2 size, which is 10^4 times longer than Planck scale characterizing strings in string models.

2. Wormhole contact defines basic stringy interaction vertex for fermion-fermion scattering. The propagator is essentially the inverse of the superconformal scaling generator L_0. Wormhole contacts containing fermion and antifermion at its opposite throats behave like virtual bosons so that one has BFF type vertices typically.

3. In topological sense one has 3-vertices serving as generalizations of 3-vertices of Feynman diagrams. In these vertices 4-D "lines" of generalized Feynman diagrams meet along their 3-D ends. One obtains also the analogs of stringy diagrams but stringy vertices do not have the usual interpretation in terms of particle decays but in terms of propagation of particles along two different routes.

   Fig. 8. a) TGD analogs of Feynman and string diagrammatics at the level of space-time topology. b) The 4-D analogs of both string diagrams and QFT diagrams appear but the interpretation of the analogs stringy diagrams is different. `http://tgdtheory.fi/appfigures/tgdgraphs.jpg`

A-5 About the selection of the action defining the Kähler function of the "world of classical worlds" (WCW)

The proposal is that space-time surfaces correspond to preferred extremals of some action principle, being analogous to Bohr orbits, so that they are almost deterministic. The action for the preferred extremal would define the Kähler function of WCW [K44, K88].

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 [L38] [L74, L75, L76] 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 [A29] so that TGD would be unique. Dimensional reduction is forced by the condition that the 6-surface has S^2-bundle structure characterizing twistor spaces and the base space would be the space-time surface.

1. Dimensional reduction of 6-D Kähler action implies that at the space-time level the fundamental action can be identified as the sum of Kähler action and volume term (cosmological constant). Other choices of the action do not look natural in this picture although they would have the same preferred extremals.

2. Preferred extremals are proposed to correspond to minimal surfaces with singularities such that they are also extremals of 4-D Kähler action outside the singularities. The physical analogue are soap films spanned by frames and one can localize the violation of the strict determinism and of strict holography to the frames.

3. The preferred extremal property is realized as the holomorphicity characterizing string world sheets, which generalizes to the 4-D situation. This in turn implies that the preferred extremals are the same for any general coordinate invariant action defined on the induced gauge fields and induced metric apart from possible extremals with vanishing CP_2 Kähler action.

   For instance, 4-D Kähler action and Weyl action as the sum of the tensor squares of the components of the Weyl tensor of CP_2 representing quaternionic imaginary units constructed from the Weyl tensor of CP_2 as an analog of gauge field would have the same preferred extremals and only the definition of Kähler function and therefore Kähler metric of WCW would change. One can even consider the possibility that the volume term in the 4-D action could be assigned to the tensor square of the induced metric representing a quaternionic or octonionic real unit.

   Action principle does not seem to be unique. On the other hand, the WCW Kähler form and metric should be unique since its existence requires maximal isometries.

   Unique action is not the only way to achieve this. One cannot exclude the possibility that the Kähler gauge potential of WCW in the complex coordinates of WCW differs only by a complex gradient of a holomorphic function for different actions so that they would give the same Kähler form for WCW. This gradient is induced by a symplectic transformation of WCW inducing a U(1) gauge transformation. The Kähler metric is the same if the symplectic transformation is an isometry.

   Symplectic transformations of WCW could give rise to inequivalent representations of the theory in terms of action at space-time level. Maybe the length scale dependent coupling parameters of an effective action could be interpreted in terms of a choice of WCW Kähler function, which maximally simplifies the computations at a given scale.

1. The 6-D analogues of electroweak action and color action reducing to Kähler action in 4-D case exist. The 6-D analog of Weyl action based on the tensor representation of quaternionic imaginary units does not however exist. One could however consider the possibility that only the base space of twistor space $T(M^4)$ and $T(CP_2)$ have quaternionic structure.

2. Kähler action has a huge vacuum degeneracy, which clearly distinguishes it from other actions. The presence of the volume term removes this degeneracy. However, for minimal surfaces having CP_2 projections, which are Lagrangian manifolds and therefore have a vanishing induced Kähler form, would be preferred extremals according to the proposed definition. For these 4-surfaces, the existence of the generalized complex structure is dubious.

   For the electroweak action, the terms corresponding to charged weak bosons eliminate these extremals and one could argue that electroweak action or its sum with the analogue of color action, also proportional Kähler action, defines the more plausible choice. Interestingly, also the neutral part of electroweak action is proportional to Kähler action.

   Twistor lift strongly suggests that also M^4 has the analog of Kähler structure. M^8 must be complexified by adding a commuting imaginary unit i. In the E^8 subspace, the Kähler structure of E^4 is defined in the standard sense and it is proposed that this generalizes to M^4 allowing also

generalization of the quaternionic structure. M^4 Kähler structure violates Lorentz invariance but could be realized at the level of moduli space of these structures.

The minimal possibility is that the M^4 Kähler form vanishes: one can have a different representation of the Kähler gauge potential for it obtained as generalization of symplectic transformations acting non-trivially in M^4. The recent picture about the second quantization of spinors of $M^4 \times CP_2$ assumes however non-trivial Kähler structure in M^4.

A-5.2 Two paradoxes

TGD view leads to two apparent paradoxes.

1. If the preferred extremals satisfy 4-D generalization of holomorphicity, a very large set of actions gives rise to the same preferred extremals unless there are some additional conditions restricting the number of preferred extremals for a given action.

2. WCW metric has an infinite number of zero modes, which appear as parameters of the metric but do not contribute to the line element. The induced Kähler form depends on these degrees of freedom. The existence of the Kähler metric requires maximal isometries, which suggests that the Kähler metric is uniquely fixed apart from a conformal scaling factor Ω depending on zero modes. This cannot be true: galaxy and elementary particle cannot correspond to the same Kähler metric.

Number theoretical vision and the hierarchy of inclusions of HFFs associated with supersymplectic algebra actings as isometries of WcW provide equivalent realizations of the measurement resolution. This solves these paradoxes and predicts that WCW decomposes into sectors for which Kähler metrics of WCW differ in a natural way.

The hierarchy subalgebras of supersymplectic algebra implies the decomposition of WCW into sectors with different actions

Supersymplectic algebra of $\delta M_+^4 \times CP_2$ is assumed to act as isometries of WCW [L80]. 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 [L80] 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 [L80] 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 [L80] 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 [L77] 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 [K57, K58]). Each of them would be characterized by a confinement phase transition in which n_S and therefore also the action changes.

2. Coupling constant evolutions with respect to ramified primes for a given value of $n(P)$

For a given value of $n(P)$, one could have coupling constant sub-evolutions with respect to the set of ramified primes of P and dimensions $n = h_{eff}/h_0$ of algebraic extensions. The action would only change by U(1) gauge transformation induced by a symplectic isometry of WCW. Coupling parameters could change but the actions would be equivalent.

The choice of the action in an optimal manner in a given scale could be seen as a choice of the most appropriate effective field theory in which radiative corrections would be taken into account. One can interpret the possibility to use a single choice of coupling parameters in terms of quantum criticality.

The range of the p-adic length scales labelled by ramified primes and effective Planck constants h_{eff}/h_0 is finite for a given value of $n(SS)$.

The first coupling constant evolution of this kind corresponds to ramified primes defining p-adic length scales for given $n(SS)$.

1. Ramified primes are factors of the discriminant $D(P)$ of P, which is expressible as a product of non-vanishing root differents and reduces to a polynomial of the n coefficients of P. Ramified primes define p-adic length scales assignable to the particles in the amplitudes scattering amplitudes defined by zero energy states.

   P would represent the space-time surface defining an interaction region in $N-$particle scattering. The N ramified primes dividing $D(P)$ would characterize the p-adic length scales assignable to these particles. If $D(P)$ reduces to a single ramified prime, one has elementary particle [L77], 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 [L77], 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 [L77].

3. p-Adic length scale hypothesis [L81] 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 [L80] 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 $\delta M_+^4 \times CP_2$ [K44, K26]. 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 [L79].
     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 [K62, K52, K23]. The fusion of the various p-adic physics leads to what I call adelic physics [L36, L37]. Later the hypothesis about hierarchy of Planck constants labelling phases of ordinary matter behaving like dark matter emerged [K27, K28, K29, K29].

     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 [L63, L64] 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 [L77, L79]. 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 [L38] 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 [A15]. p-Adic numbers are representable as power expansion of the prime number p of form

$$ x \;=\; \sum_{k \geq k_0} x(k)p^k, \; x(k) = 0, ..., p - 1 \;\; . \tag{A-6.1}$$

The norm of a p-adic number is given by

$$|x| \quad = \quad p^{-k_0(x)} \quad . \tag{A-6.2}$$

Here $k_0(x)$ is the lowest power in the expansion of the p-adic number. The norm differs drastically from the norm of the ordinary real numbers since it depends on the lowest pinary digit of the p-adic number only. Arbitrarily high powers in the expansion are possible since the norm of the p-adic number is finite also for numbers, which are infinite with respect to the ordinary norm. A convenient representation for p-adic numbers is in the form

$$x \quad = \quad p^{k_0} \varepsilon(x) \quad , \tag{A-6.3}$$

where $\varepsilon(x) = k + ...$ with $0 < k < p$, is p-adic number with unit norm and analogous to the phase factor $exp(i\phi)$ of a complex number.

The distance function $d(x, y) = |x - y|_p$ defined by the p-adic norm possesses a very general property called ultra-metricity:

$$d(x, z) \quad \leq \quad max\{d(x, y), d(y, z)\} \quad . \tag{A-6.4}$$

The properties of the distance function make it possible to decompose R_p into a union of disjoint sets using the criterion that x and y belong to same class if the distance between x and y satisfies the condition

$$d(x, y) \quad \leq \quad D \quad . \tag{A-6.5}$$

This division of the metric space into classes has following properties:

1. Distances between the members of two different classes X and Y do not depend on the choice of points x and y inside classes. One can therefore speak about distance function between classes.

2. Distances of points x and y inside single class are smaller than distances between different classes.

3. Classes form a hierarchical tree.

Notice that the concept of the ultra-metricity emerged in physics from the models for spin glasses and is believed to have also applications in biology [B15]. The emergence of p-adic topology as the topology of the effective space-time would make ultra-metricity property basic feature of physics.

Canonical correspondence between p-adic and real numbers

The basic challenge encountered by p-adic physicist is how to map the predictions of the p-adic physics to real numbers. p-Adic probabilities provide a basic example in this respect. Identification via common rationals and canonical identification and its variants have turned out to play a key role in this respect.

1. Basic form of the canonical identification

There exists a natural continuous map $I : R_p \to R_+$ from p-adic numbers to non-negative real numbers given by the "pinary" expansion of the real number for $x \in R$ and $y \in R_p$ this correspondence reads

$$
\begin{aligned}
y \quad &= \quad \sum_{k>N} y_k p^k \to x = \sum_{k<N} y_k p^{-k} \quad , \\
y_k \quad &\in \quad \{0, 1, .., p-1\} \quad .
\end{aligned}
\tag{A-6.6}
$$

This map is continuous as one easily finds out. There is however a little difficulty associated with the definition of the inverse map since the pinary expansion like also decimal expansion is not unique ($1 = 0.999...$) for the real numbers x, which allow pinary expansion with finite number of pinary digits

$$
x = \sum_{k=N_0}^{N} x_k p^{-k} \ ,
$$

$$
x = \sum_{k=N_0}^{N-1} x_k p^{-k} + (x_N - 1)p^{-N} + (p-1)p^{-N-1} \sum_{k=0,..} p^{-k} \ .
$$

$$(A\text{-}6.7)$$

The p-adic images associated with these expansions are different

$$
y_1 = \sum_{k=N_0}^{N} x_k p^{k} \ ,
$$

$$
y_2 = \sum_{k=N_0}^{N-1} x_k p^{k} + (x_N - 1)p^{N} + (p-1)p^{N+1} \sum_{k=0,..} p^{k}
$$

$$
= y_1 + (x_N - 1)p^{N} - p^{N+1} \ ,
$$

$$(A\text{-}6.8)$$

so that the inverse map is either two-valued for p-adic numbers having expansion with finite pinary digits or single valued and discontinuous and non-surjective if one makes pinary expansion unique by choosing the one with finite pinary digits. The finite pinary digit expansion is a natural choice since in the numerical work one always must use a pinary cutoff on the real axis.

2. The topology induced by canonical identification

The topology induced by the canonical identification in the set of positive real numbers differs from the ordinary topology. The difference is easily understood by interpreting the p-adic norm as a norm in the set of the real numbers. The norm is constant in each interval $[p^k, p^{k+1})$ (see **Fig. A-6.1**) and is equal to the usual real norm at the points $x = p^k$: the usual linear norm is replaced with a piecewise constant norm. This means that p-adic topology is coarser than the usual real topology and the higher the value of p is, the coarser the resulting topology is above a given length scale. This hierarchical ordering of the p-adic topologies will be a central feature as far as the proposed applications of the p-adic numbers are considered.

Ordinary continuity implies p-adic continuity since the norm induced from the p-adic topology is rougher than the ordinary norm. p-Adic continuity implies ordinary continuity from right as is clear already from the properties of the p-adic norm (the graph of the norm is indeed continuous from right). This feature is one clear signature of the p-adic topology.

Fig. 14. The real norm induced by canonical identification from 2-adic norm. `http://tgdtheory.fi/appfigures/norm.png`

The linear structure of the p-adic numbers induces a corresponding structure in the set of the non-negative real numbers and p-adic linearity in general differs from the ordinary concept of linearity. For example, p-adic sum is equal to real sum only provided the summands have no common pinary digits. Furthermore, the condition $x +_p y < max\{x, y\}$ holds in general for the p-adic sum of the real numbers. p-Adic multiplication is equivalent with the ordinary multiplication only provided that either of the members of the product is power of p. Moreover one has $x \times_p y < x \times y$ in general. The p-Adic negative -1_p associated with p-adic unit 1 is given by $(-1)_p = \sum_k (p-1)p^k$ and defines p-adic negative for each real number x. An interesting possibility is that p-adic linearity might replace the ordinary linearity in some strongly nonlinear systems so these systems would look simple in the p-adic topology.

These results suggest that canonical identification is involved with some deeper mathematical structure. The following inequalities hold true:

$$
\begin{aligned}
(x+y)_R &\leq x_R + y_R ~, \\
|x|_p |y|_R \leq (xy)_R &\leq x_R y_R ~,
\end{aligned}
\tag{A-6.9}
$$

where $|x|_p$ denotes p-adic norm. These inequalities can be generalized to the case of $(R_p)^n$ (a linear vector space over the p-adic numbers).

$$
\begin{aligned}
(x+y)_R &\leq x_R + y_R ~, \\
|\lambda|_p |y|_R \leq (\lambda y)_R &\leq \lambda_R y_R ~,
\end{aligned}
\tag{A-6.10}
$$

where the norm of the vector $x \in T_p^n$ is defined in some manner. The case of Euclidian space suggests the definition

$$
(x_R)^2 ~=~ (\sum_n x_n^2)_R ~.
\tag{A-6.11}
$$

These inequalities resemble those satisfied by the vector norm. The only difference is the failure of linearity in the sense that the norm of a scaled vector is not obtained by scaling the norm of the original vector. Ordinary situation prevails only if the scaling corresponds to a power of p.

These observations suggests that the concept of a normed space or Banach space might have a generalization and physically the generalization might apply to the description of some non-linear systems. The nonlinearity would be concentrated in the nonlinear behavior of the norm under scaling.

3. Modified form of the canonical identification

The original form of the canonical identification is continuous but does not respect symmetries even approximately. This led to a search of variants which would do better in this respect. The modification of the canonical identification applying to rationals only and given by

$$
I_Q(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)}
\tag{A-6.12}
$$

is uniquely defined for rationals, maps rationals to rationals, has also a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$. It has turned out that it is this map which most naturally appears in the applications. The map is obviously continuous locally since p-adically small modifications of r and s mean small modifications of the real counterparts.

Canonical identification is in a key role in the successful predictions of the elementary particle masses. The predictions for the light elementary particle masses are within extreme accuracy same for I and I_Q but I_Q is theoretically preferred since the real probabilities obtained from p-adic ones by I_Q sum up to one in p-adic thermodynamics.

4. Generalization of number concept and notion of embedding space

TGD forces an extension of number concept: roughly a fusion of reals and various p-adic number fields along common rationals is in question. This induces a similar fusion of real and p-adic embedding spaces. Since finite p-adic numbers correspond always to non-negative reals n-dimensional space R^n must be covered by 2^n copies of the p-adic variant R_p^n of R^n each of which projects to a copy of R_+^n (four quadrants in the case of plane). The common points of p-adic and real embedding spaces are rational points and most p-adic points are at real infinity.

Real numbers and various algebraic extensions of p-adic number fields are thus glued together along common rationals and also numbers in algebraic extension of rationals whose number belong to the algebraic extension of p-adic numbers. This gives rise to a book like structure with rationals and various algebraic extensions of rationals taking the role of the back of the book. Note that Neper number is exceptional in the sense that it is algebraic number in p-adic number field Q_p satisfying $e^p \bmod p = 1$.

Fig. 15. Various number fields combine to form a book like structure. `http://tgdtheory.fi/appfigures/book.jpg`

For a given p-adic space-time sheet most points are literally infinite as real points and the projection to the real embedding space consists of a discrete set of rational points: the interpretation in terms of the unavoidable discreteness of the physical representations of cognition is natural. Purely local p-adic physics implies real p-adic fractality and thus long range correlations for the real space-time surfaces having enough common points with this projection.

p-Adic fractality means that M^4 projections for the rational points of space-time surface X^4 are related by a direct identification whereas CP_2 coordinates of X^4 at these points are related by I, I_Q or some of its variants implying long range correlates for CP_2 coordinates. Since only a discrete set of points are related in this manner, both real and p-adic field equations can be satisfied and there are no problems with symmetries. p-Adic effective topology is expected to be a good approximation only within some length scale range which means infrared and UV cutoffs. Also multi-p-fractality is possible.

The notion of p-adic manifold

The notion of p-adic manifold is needed in order to fuse real physics and various p-adic physics to a larger structure which suggests that real and p-adic number fields should be glued together along common rationals bringing in mind adeles. The notion is problematic because p-adic topology is totally disconnected implying that p-adic balls are either disjoint or nested so that ordinary definition of manifold using p-adic chart maps fails. A cure is suggested to be based on chart maps from p-adics to reals rather than to p-adics (see the appendix of the book)

The chart maps are interpreted as cognitive maps, "thought bubbles".

Fig. 16. The basic idea between p-adic manifold. `http://tgdtheory.fi/appfigures/padmanifold.jpg`

There are some problems.

1. Canonical identification does not respect symmetries since it does not commute with second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map arithmetic operations which requires pinary cutoff below which chart map takes rationals to rationals so that commutativity with arithmetics and symmetries is achieved in finite resolution: above the cutoff canonical identification is used

2. Canonical identification is continuous but does not map smooth p-adic surfaces to smooth real surfaces requiring second pinary cutoff so that only a discrete set of rational points is mapped to their real counterparts by chart map requiring completion of the image to smooth preferred extremal of Kähler action so that chart map is not unique in accordance with finite measurement resolution

3. Canonical identification violates general coordinate invariance of chart map: (cognition-induced symmetry breaking) minimized if p-adic manifold structure is induced from that for p-adic embedding space with chart maps to real embedding space and assuming preferred coordinates made possible by isometries of embedding space: one however obtains several inequivalent p-adic manifold structures depending on the choice of coordinates: these cognitive representations are not equivalent.

A-6.2 Hierarchy of Planck constants and dark matter hierarchy

Hierarchy of Planck constants was motivated by the "impossible" quantal effects of ELF em fields on vertebrate cyclotron energies $E = hf = \hbar \times eB/m$ are above thermal energy is possible only if $\hbar$ has value much larger than its standard value. Also Nottale's finding that planetary orbits migh be understood as Bohr orbits for a gigantic gravitational Planck constant.

Hierachy of Planck constant would mean that the values of Planck constant come as integer multiples of ordinary Planck constant: $h_{eff} = n \times h$. The particles at magnetic flux tubes characterized by h_{eff} would correspond to dark matter which would be invisible in the sense that only particle with same value of h_{eff} appear in the same vertex of Feynman diagram.

Hierarchy of Planck constants would be due to the non-determism of the Kähler action predicting huge vacuum degeneracy allowing all space-time surfaces which are sub-manfolds of any $M^4 \times Y^2$, where Y^2 is Lagrangian sub-manifold of CP_2. For agiven Y^2 one obtains new manifolds Y^2 by applying symplectic transformations of CP_2.

Non-determinism would mean that the 3-surface at the ends of causal diamond (CD) can be connected by several space-time surfaces carrying same conserved Kähler charges and having same values of Kähler action. Conformal symmetries defined by Kac-Moody algebra associated with the embedding space isometries could act as gauge transformations and respect the light-likeness property of partonic orbits at which the signature of the induced metric changes from Minkowskian to Euclidian (Minkowskianb space-time region transforms to wormhole contact say). The number of conformal equivalence classes of these surfaces could be finite number n and define discrete physical degree of freedom and one would have $h_{eff} = n \times h$. This degeneracy would mean "second quantization" for the sheets of n-furcation: not only one but several sheets can be realized.

This relates also to quantum criticality postulated to be the basic characteristics of the dynamics of quantum TGD. Quantum criticalities would correspond to an infinite fractal hierarchy of broken conformal symmetries defined by sub-algebras of conformal algebra with conformal weights coming as integer multiples of n. This leads also to connections with quantum criticality and hierarchy of broken conformal symmetries, p-adicity, and negentropic entanglement which by consistency with standard quantum measurement theory would be described in terms of density matrix proportional $n \times n$ identity matrix and being due to unitary entanglement coefficients (typical for quantum computing systems).

Formally the situation could be described by regarding space-time surfaces as surfaces in singular n-fold singular coverings of embedding space. A stronger assumption would be that they are expressible as as products of n_1 -fold covering of M^4 and n_2-fold covering of CP_2 meaning analogy with multi-sheeted Riemann surfaces and that M^4 coordinates are n_1-valued functions and CP_2 coordinates n_2 -valued functions of space-time coordinates for $n = n_1 \times n_2$. These singular coverings of embedding space form a book like structure with singularities of the coverings localizable at the boundaries of causal diamonds defining the back of the book like structure.

Fig. 17. Hierarchy of Planck constants. `http://tgdtheory.fi/appfigures/planckhierarchy.jpg`

A-6.3 $M^8 - H$ duality as it is towards the end of 2021

The view of M^8-H duality (see Appendix **??**) has changed considerably towards the end 2021 [L74] after the realization that this duality is the TGD counterpart of momentum position duality of wave mechanics, which is lost in QFTs. Therefore M^8 and also space-time surface is analogous to momentum space. This forced us to give up the original simple identification of the points $M^4 \subset M^4 \times E^4 = M^8$ and of $M^4 \times CP_2$ so that it respects Uncertainty Principle (UP).

The first improved guess for the duality map was the replacement with the inversion $p^k \to m^k = \hbar_{eff} p^k/p^2$ conforming in spirit with UP but turned out to be too naive.

The improved form [L74] 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 [L74] 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 [L63, L64]. 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 $X^4 \subset M^8$ [L53]. 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 [L74]. 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 [L70] 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 [L74]. 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 [L58] [K124].

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 [L58].

2. To avoid getting totally confused it is good to emphasize some aspects of ZEO.

    (a) ZEO does not mean that physical states in the usual 3-D sense as snapshots of time evolution would have zero energy state pairs defining zero energy states as initial and final states have same conserved quantities such as energy. Conservation implies that one can adopt the conventions that the values of conserved quantities are opposite for these states so that their sum vanishes: one can think that incoming and outgoing particles come from geometric past and future is the picture used in quantum field theories.

    (b) ZEO means two times: subjective time as sequence of quantum jumps and geometric time as space-time coordinate. These times are identifiable but are strongly correlated.

3. In BSFRs the arrow of time is changed and the time evolution in the final state occurs backwards with respect to the time of the external observer. BSFRs can occur in all scales since TGD predicts a hierarchy of effective Planck constants with arbitrarily large values. There is empirical support for BSFRs.

    (a) The findings of Minev et al [L51] in atomic scale can be explained by the same mechanism [L51]. 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 [J34] 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 [L52]. 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 [L56, L92].

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 [L56, L92]. ZEO could also allow understanding of what planned actions - like realizing the experiment under consideration - could be.

1. Second law in the standard sense does not favor - perhaps even not allow - realization of planned actions. ZEO forces a generalization of thermodynamics: dissipation with a non-standard arrow of time for a subsystem would look like self-organization and planned action and its realization.

   Could most if not all planned action be like this - induced by BSFR in the geometric future and only apparently planned? There would be however the experience of planning and realizing induced by the signals from geometric future by a higher level in the hierarchy of conscious entities predicted by TGD! In long time scales we would be realizing our fates or wishes of higher level conscious entities rather than agents with completely free will.

2. The notion of magnetic body (MB) serving as a boss of ordinary matter would be central. MB carries dark matter as $h_{eff} = nh_0$ phases of ordinary matter with n serving as a measure for algebraic complexity of extension of rationals as its dimension and defining a kind of universal IQ. There is a hierarchy of these phases and MBs labelled by extension of rationals and the value of n.

   MBs would form a hierarchy of bosses - a realization for master slave hierarchy. Ordinary matter would be at the bottom and its coherent behavior would be induced from quantum coherence at higher levels. BSFR for higher level MB would give rise to what looks like planned actions and experienced as planned action at the lower levels of hierarchy. One could speak of planned actions inducing a cascade of planned actions in shorter time scales and eventually proceeding to atomic level.

A-8 Some notions relevant to TGD inspired consciousness and quantum biology

Below some notions relevant to TGD inspired theory of consciousness and quantum biology.

A-8.1 The notion of magnetic body

Topological field quantization inspires the notion of field body about which magnetic body is especially important example and plays key role in TGD inspired quantum biology and consciousness theory. This is a crucial departure fromt the Maxwellian view. Magnetic body brings in third level to the description of living system as a system interacting strongly with environment. Magnetic body would serve as an intentional agent using biological body as a motor instrument and sensory receptor. EEG would communicated the information from biological body to magnetic body and Libet's findings from time delays of consciousness support this view.

The following pictures illustrate the notion of magnetic body and its dynamics relevant for quantum biology in TGD Universe.

Fig. 18. Magnetic body associated with dipole field. `http://tgdtheory.fi/appfigures/fluxquant.jpg`

Fig. 19. Illustration of the reconnection by magnetic flux loops. `http://tgdtheory.fi/appfigures/reconnect1.jpg`

Fig. 20. Illustration of the reconnection by flux tubes connecting pairs of molecules. `http://tgdtheory.fi/appfigures/reconect2.jpg`

Fig. 21. Flux tube dynamics. a) Reconnection making possible magnetic body to "recognize" the presence of another magnetic body, b) braiding, knotting and linking of flux tubes making possible topological quantum computation, c) contraction of flux tube in phase transition reducing the value of h_{eff} allowing two molecules to find each other in dense molecular soup. `http://tgdtheory.fi/appfigures/fluxtubedynamics.jpg`

A-8.2 Number theoretic entropy and negentropic entanglement

TGD inspired theory of consciousness relies heavily p-Adic norm allows an to define the notion of Shannon entropy for rational probabilities (and even those in algebraic extension of rationals) by replacing the argument of logarithm of probability with its p-adic norm. The resulting entropy can be negative and the interpretation is that number theoretic entanglement entropy defined by this formula for the p-adic prime minimizing its value serves as a measure for conscious information. This negentropy characterizes two-particle system and has nothing to do with the formal negative negentropy assignable to thermodynamic entropy characterizing single particle. Negentropy Maximization Principle (NMP) implies that number theoretic negentropy increases during evolution by quantum jumps. The condition that NMP is consistent with the standard quantum measurement theory requires that negentropic entanglement has a density matrix proportional to unit matrix so that in 2-particle case the entanglement matrix is unitary.

Fig. 22. Schrödinger cat is neither dead or alive. For negentropic entanglement this state would be stable. `http://tgdtheory.fi/appfigures/cat.jpg`

A-8.3 Life as something residing in the intersection of reality and p-adicities

In TGD inspired theory of consciousness p-adic space-time sheets correspond to space-time correlates for thoughts and intentions. The intersections of real and p-adic preferred extremals consist of points whose coordinates are rational or belong to some extension of rational numbers in preferred embedding space coordinates. They would correspond to the intersection of reality and various p-adicities representing the "mind stuff" of Descartes. There is temptation to assign life to the intersection of realities and p-adicities. The discretization of the chart map assigning to real space-time surface its p-adic counterpart would reflect finite cognitive resolution.

At the level of "world of classical worlds" (WCW) the intersection of reality and various p-adicities would correspond to space-time surfaces (or possibly partonic 2-surfaces) representable in terms of rational functions with polynomial coefficients with are rational or belong to algebraic extension of rationals.

The quantum jump replacing real space-time sheet with p-adic one (vice versa) would correspond to a buildup of cognitive representation (realization of intentional action).

Fig. 23. The quantum jump replacing real space-time surface with corresponding p-adic manifold can be interpreted as formation of though, cognitive representation. Its reversal would correspond to a transformation of intention to action. `http://tgdtheory.fi/appfigures/padictoreal.jpg`

A-8.4   Sharing of mental images

The 3-surfaces serving as correlates for sub-selves can topologically condense to disjoint large space-time sheets representing selves. These 3-surfaces can also have flux tube connections and this makes possible entanglement of sub-selves, which unentangled in the resolution defined by the size of sub-selves. The interpretation for this negentropic entanglement would be in terms of sharing of mental images. This would mean that contents of consciousness are not completely private as assumed in neuroscience.

Fig. 24. Sharing of mental images by entanglement of subselves made possible by flux tube connections between topologically condensed space-time sheets associated with mental images. `http://tgdtheory.fi/appfigures/sharing.jpg`

A-8.5   Time mirror mechanism

Zero energy ontology (ZEO) is crucial part of both TGD and TGD inspired consciousness and leads to the understanding of the relationship between geometric time and experience time and how the arrow of psychological time emerges. One of the basic predictions is the possibiity of negative energy signals propagating backwards in geometric time and having the property that entropy basically associated with subjective time grows in reversed direction of geometric time. Negative energy signals inspire time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig.** 24 in the appendix of this book) providing mechanisms of both memory recall, realization of intentational action initiating action already in geometric past, and remote metabolism. What happens that negative energy signal travels to past and is reflected as positive energy signal and returns to the sender. This process works also in the reverse time direction.

Fig. 25. Zero energy ontology allows time mirror mechanism as a mechanism of memory recall. Essentially "seeing" in time direction is in question. `http://tgdtheory.fi/appfigures/timemirror.jpg`

REFERENCES

Mathematics

[A1] Catastrophe Theory. Available at: `https://en.wikipedia.org/wiki/Catastrophe_theory#Cusp_catastrophe`.

[A2] Classification of finite simple groups. Available at: `https://en.wikipedia.org/wiki/Classification_of_finite_simple_groups`.

[A3] Icosahedral graph. Wolfram MathWorld. Available at: `https://mathworld.wolfram.com/IcosahedralGraph.html`.

[A4] Pythagorean triangles. Available at: `https://en.wikipedia.org/wiki/Pythagorean_triangle`.

[A5] Super Virasoro algebra. Available at: `https://en.wikipedia.org/wiki/Super_Virasoro_algebra`.

[A6] Why are there 1024 Hamiltonian cycles on an icosahedron? Available at: `https://tinyurl.com/pmghcwd`.

[A7] Yangian symmetry. Available at: `https://en.wikipedia.org/wiki/Yangian`.

[A8] Khrennikov A. *p-Adic Valued Distributions in Mathematical Physics*. Kluwer, Dordrecht, 1994.

[A9] Stern A. *Matrix Logic*. North-Holland, 1988.

[A10] Khrennikov AYu. p-Adic Probability and Statistics. *Dokl Akad Nauk*, (6), 1992.

[A11] Kostant B. The Graph of the Truncated Icosahedron and the Last Letter of Galois. *Notices AMS*, (9):959–, 1995.

[A12] Shipman B. The geometry of momentum mappings on generalized flag manifolds, connections with a dynamical system, quantum mechanics and the dance of honeybee, 1998. Available at: `https://math.cornell.edu/~oliver/Shipman.gif`.

[A13] Shipman B. On the geometry of certain isospectral sets in the full Kostant-Toda lattice., 1998. Available at: `https://nyjm.albany.edu:8000/PacJ/1997/Shipman.html`.

[A14] Shipman B. A symmetry of order two in the full Kostant-Toda lattice., 1998. Available at: `https://www.math.rochester.edu:8080/u/shipman/symmetrypaper/`.

[A15] Shafarevich IR Borevich ZI. *Number Theory*. Academic Press, 1966.

[A16] Freund PG Brekke L. p-Adic Numbers in Physics. *Phys Rep*, 233(1), 1993.

[A17] Kassel C. *Quantum Groups*. Springer Verlag, 1995.

[A18] Pope CN. Eigenfunctions and $Spin^c$ Structures on CP_2, 1980.

[A19] Freed DS. The Geometry of Loop Groups, 1985.

[A20] Witten E. Quantum field theory and the Jones polynomial. *Comm Math Phys*, 121:351–399, 1989.

[A21] Zeeman EC. *Catastrophe Theory*. Addison-Wessley Publishing Company, 1977.

[A22] Hanson J Eguchi T, Gilkey B. *Phys Rep*, 66, 1980.

[A23] Hanson J Eguchi T, Gilkey B. *Phys Rep*, 66, 1980.

[A24] Eisenhart. *Riemannian Geometry*. Princeton University Press, 1964.

[A25] Bastin T et al. 7:445–, 1979.

[A26] Jones FR. *Braid groups, Hecke algebras and type II_1 factors*. 1983.

[A27] Pope CN Gibbons GW. CP_2 as gravitational instanton. *Comm Math Phys*, 55, 1977.

[A28] Pope CN Hawking SW. Generalized Spin Structures in Quantum Gravity. *Phys Lett*, (1), 1978.

[A29] N. Hitchin. Kählerian twistor spaces. *Proc London Math Soc*, 8(43):133–151, 1981.. Available at: `https://tinyurl.com/pb8zpqo`.

[A30] Zuber J-B Iztykson C. *Quantum Field Theory*, volume 549. Mc Graw-Hill, New York, 1980.

[A31] Dixmier J. *Von Neumann Algebras*. North-Holland, Amsterdam, 1981. First published in French in 1957: Les Algebres d'Operateurs dans l'Espace Hilbertien, Paris: Gauthier-Villars.

[A32] Milnor J. *Topology form Differential Point of View*. The University Press of Virginia, Virginia, 1965.

[A33] Spivak M. *Differential Geometry I,II,III,IV*. Publish or Perish, Boston, 1970.

[A34] Sneyd J McKenzie A. *On the Formation and Breakup of Spiral Waves of Calcium*, volume 8. World Scientific, 1999.

[A35] Thom R. *Comm Math Helvet*, 28, 1954.

[A36] Helgason S. *Differential Geometry and Symmetric Spaces*. Academic Press, New York, 1962.

[A37] Sawin S. Links, Quantum Groups, and TQFT's, 1995.Available at: `https://arxiv.org/abs/q-alg/9506002`.

[A38] Lin S-K. Correlation of entropy with similarity and symmetry. *J Chem Inf Comput Sci*, 36367, 1996.

[A39] Negadi T. "On the structural entropy of the genetic code" and "The genetic code by its own numbers". Private correspondence.

[A40] Jones V. In and around the origin of quantum groups, 2003. Available at: `https://arxiv.org/abs/math/0309199`.

[A41] Wallace. *Differential Topology*. W. A. Benjamin, New York, 1968.

[A42] Ge ML Yang CN. *Braid Group, Knot Theory, and Statistical Mechanics*. World Scientific, 1989.

Theoretical Physics

[B1] Elitzur–Vaidman bomb-testing problem. Available at: `https://en.wikipedia.org/wiki/Elitzur\OT1\textendashVaidman_bomb-testing_problem`.

[B2] Global Scaling. Available at: `https://www.dr-nawrocki.de/globalscalingengl2.html`.

[B3] No-cloning theorem. Available at: `https://en.wikipedia.org/wiki/No_cloning_theorem`.

[B4] Verlinde A. On the Origin of Gravity and the Laws of Newton, 2010. Available at: `https://arxiv.org/abs/1001.0785`.

[B5] Zee A. *The Unity of Forces in the Universe*. World Sci Press, Singapore, 1982.

[B6] Drell S Björken J. *Relativistic Quantum Fields*. Mc Graw-Hill, New York, 1965.

[B7] Rapoport D. Stochastic processes in conformal Riemann-Cartan-Weyl gravitation, 1991. Available at: `https://link.springer.com/article/10.1007/BF00675614`.

[B8] Olle Haro de S. Quantum Gravity and the Holographic Principle, 2001. Available at: `https://arxiv.org/abs/hep-th/0107032`.

[B9] Witten E Dolan L, Nappi CR. Yangian Symmetry in $D = 4$ superconformal Yang-Mills theory, 2004. Available at: `https://arxiv.org/abs/hep-th/0401243`.

[B10] Plefka J Drummond J, Henn J. Yangian symmetry of scattering amplitudes in $\mathcal{N} = 4$ super Yang-Mills theory, 2009. Available at: `https://cdsweb.cern.ch/record/1162372/files/jhep052009046.pdf`.

[B11] Arkani-Hamed N et al. The All-Loop Integrand For Scattering Amplitudes in Planar N=4 SYM, 2010. Available at: `https://arxiv.org/abs/1008.2958`.

[B12] Minev ZK et al. To catch and reverse a quantum jump mid-flight, 2019. Available at: `https://arxiv.org/abs/1803.00545`.

[B13] Sokolov IV et al. Quantum holographic teleportation of light fields, 2001. Available at: `https://arxiv.org/abs/quant-ph/0007026v1`.

[B14] Wang Z Freedman M, Larsen H. A modular functor which is universal for quantum computation. *Comm Math Phys*, 1(2):605–622, 2002. Available at: `https://arxiv.org/abs/quant-ph/0001108`.

[B15] Parisi G. *Field Theory, Disorder and Simulations*. World Scientific, 1992.

[B16] Haken H. *Information and Self-Organization*. Springer Verlag, Berlin, 1988.

[B17] Zuber J-B Itzykson C. *Quantum Field Theory*. Mc Graw-Hill, New York, 1980.

[B18] Huang K. *Quarks,Leptons & Gauge Fields*. World Scientific, 1982.

[B19] Lomonaco SJ Jr Kauffmann LH. Braiding operations are universal quantum gates, 2004. Available at: `https://arxiv.org/abs/quant-ph/0401090`.

[B20] Arkani-Hamed N and Maldacena J. Cosmological Collider Physics, 2015.Available at:`https://arxiv.org/pdf/1503.08043v1`.

[B21] Frieden R. *Physics from Fisher Information*. Cambridge University Press, Cambridge, 1999.

[B22] Mathews R. I is the law. *New Scientist*, 30, January 1999.

[B23] Adamo T and Newman ET. The Kerr-Newman metric: A Review. *Scholarpedia*, 9(10), 2014. Available at:`https://arxiv.org/abs/1410.6626`.

Particle and Nuclear Physics

[C1] Shnoll SE et al. Realization of discrete states during fluctuations in macroscopic processes. *Usp Fis Nauk*, 41(10):1025–1035, 1998.

[C2] Egede U. A theoretical limit on Higgs mass, 1998. Available at: `https://www.hep.lu.se/atlas//thesis/egede/thesis-node20.html`.

Condensed Matter Physics

[D1] A Bibliography of $1/f$ noise. Available at: `https://linkage.rockefeller.edu/wli/1fnoise`.

[D2] Burning salt water. Available at: `https://www.youtube.com/watch?v=aGg0ATfoBgo`.

[D3] Fractional quantum Hall Effect. Available at: `https://en.wikipedia.org/wiki/Fractional_quantum_Hall_effect`.

[D4] Liquid crystals on line. Available at: `https://www.lcionline.net/`.

[D5] Whitehouse D. Beads of doubt, 2002. Available at: `https://news.bbc.co.uk/hi/english/sci/tech/newsid_2135000/2135779.stm`.

[D6] Pepper DM. Nonlinear Optical Phase Conjugation. *Opt Eng*, 21(2), March 1982.

[D7] Evans DJ et al. Experimental Demonstration of Violations of the Second Law of Thermodynamics for Small Systems and Short Time Scales. *Phys Rev*, 89, 2002.

[D8] Gammaitoni L et al. Stochastic Resonance. *Rev Mod Phys* ., 70, 1998.Available at: `https://www.umbrars.com/sr/`.

[D9] Winterer G et al. Cortical activation, signal-to-noise ratio and stochastic resonance during information processing in man. *Clin Neurophysiol J*, 110(7):1193–203, 1999.

[D10] Chown M. Quantum Rebel. *New Scientist*, (2457), 2004.

[D11] Ho M-W. Can Water burn, 2009. Available at: `https://www.i-sis.org.uk/canWaterBurn.php`.

[D12] Anderson PW. *Rev Mod Phys*, 38, 1966.

[D13] Zeldowich BYa Shkunov VV. Optical Phase Conjugation. *Sci Am*, 1985.

[D14] Tilley K Tilley DR. *Super Fluidity and Super Conductivity*. Adam Hilger Ltd, 1986.

Cosmology and Astro-Physics

[E1] Nottale L Da Rocha D. Gravitational Structure Formation in Scale Relativity, 2003. Available at: `https://arxiv.org/abs/astro-ph/0310036`.

[E2] Freeman PE et al. Examining the Effect of the Map-making Algorithm on Observed Power Asymmetry in WMAP Data. *Astrophys J*, 638, 2006. Available at: `https://arxiv.org/abs/astro-ph/0510406`.

[E3] Neugebauer M et al. The solar magnetic field and the solar wind: Existence of preferred longitudes. *J Geophys Res*, 105:2315–2324, 2000. Available at: `https://spacephysics.jpl.nasa.gov/pr/longitude.htm`.

[E4] Shnoll SE et al. Realization of discrete fluctuations in macroscopic processes. *Physics-Uspekhi*, 41(10):1025–1035.

Physics of Earth

[F1] Saleh A. Capturing the Earth's songs. *ABC Science Online*, 2001. Available at: `https://www.abc.net.au/science/news/stories/s237849.htm`.

[F2] Sentman DD. *Schumann Resonances*, volume 1, pages 267–295. Boca Raton: CRC Press, 1995.

[F3] Zgrablic G et al. Instrumental recording of electrophonic sounds from Leonid fireballs. *J. Geophys Res*, 2001. Available at: `https://fizika.org/ilwcro/results/`.

[F4] Hecht J. The Giant Crystal at the Heart of the Earth. *New Scientist*, page 17, 1994.

Fringe Physics

[H1] Chilbolton crop formation. Available at: `https://www.cropcircleresearch.com/articles/arecibo.html`.

[H2] P. Vigay's homeopage about Crop Circle Research. Available at: `https://www.cropcircleresearch.com/articles/alienface.html`.

[H3] Selvam AM. Quantum-like Chaos in Prime Number Distribution and in Turbulent Fluid Flows, 2000. Available at: `https://arxiv.org/abs/physics/0005067`.

[H4] Akimov et al. Predvaritelnyye rezultaty astronomicheskikh nabludenii po metodike N. A. Kozyreva. Preliminary results of astronomical observations using N. A. Kozyrev's method, 1992.

[H5] Kozyrev NA. *Izbrannyye trudy*. Leningrad State University, 1991.

[H6] Sokolov AN Nachalov YuV. Experimental investigation of new long-range interactions, 1999. Available at: `https://www.amasci.com/freenrg/tors/doc17.html`.

[H7] Modanese G Podkletnov E. Investigation of high voltage discharges in low pressure gases through large ceramic super-conducting electrodes, 2002. Available at: `https://xxx.lanl.gov/abs/physics/0209051`.

[H8] Nieminen R Podkletnov E. Weak gravitational shielding properties of composite bulk YBa2Cu3O7-x super-conductor below 70 K under electro-magnetic field, 1992. Available at: `https://arxiv.org/abs/cond-mat/9701074`. Report MSU-chem 95, improved version at `https://arxiv.org/abs/cond-mat/9701074`.

[H9] Godin SM Roshchin VV. An Experimental Investigation of the Physical Effects in a Dynamic Magnetic System. *New Energy Technologies*, 1, 2001.

[H10] Flandern van T. *Phys Lett A*, 250(1-3):1–11.

[H11] Nachalov YuV. Theoretical basis of experimental phenomena, 1999. Available at: `https://www.amasci.com/freenrg/tors/tors3.html`.

Biology

[I1] Acetyl group. Available at: `https://en.wikipedia.org/wiki/Acetyl_group`.

[I2] Acetylation. Available at: `https://en.wikipedia.org/wiki/Acetylation`.

[I3] Brief introduction into WaveGenetics. Its scope and opporturnities. Available at: `https://www.wavegenetics.jino-net.ru`.

[I4] Chirality (chemistry). Available at: `https://en.wikipedia.org/wiki/Chirality_(chemistry)`.

[I5] CpG-island. Available at: `https://en.wikipedia.org/wiki/CpG-island`.

[I6] Cytochrome P450. Available at: `https://en.wikipedia.org/wiki/Cytochrome_P450`.

[I7] Deacetylation. Available at: `https://en.wikipedia.org/wiki/Deacetylation`.

[I8] Demethylase. Available at: `https://en.wikipedia.org/wiki/Demethylase`.

[I9] Demethylation. Available at: `https://en.wikipedia.org/wiki/Demethylation`.

[I10] High energy phosphate. Available at: `https://en.wikipedia.org/wiki/High-energy_phosphate`.

[I11] Homeopathy. Available at: `https://en.wikipedia.org/wiki/Homeopathy`.

[I12] Housekeeping gene. Available at: `https://en.wikipedia.org/wiki/Housekeeping_gene`.

[I13] Methyl group. Available at: `https://en.wikipedia.org/wiki/Methyl_group`.

[I14] Methylation. Available at: `https://en.wikipedia.org/wiki/Methylation`.

[I15] Methyltransferase. Available at: `https://en.wikipedia.org/wiki/Methyltransferase`.

[I16] Protein folding. Available at: `https://en.wikipedia.org/wiki/Protein_folding`.

[I17] Quantum Mechanics Boosts Photosynthesis. Available at: `https://physicsworld.com/cws/article/news/41632`.

[I18] Sirtuin. Available at: `https://en.wikipedia.org/wiki/Sirtuin`.

[I19] *Aids: Biological Warfare*, volume 1649, P. O.Box 1649, Greenville, TX 75401, 1988. Tesla Book Company.

[I20] Mitchell A. Liquid Genius. *New Scientist*, 1999. Available at: `https://www.newscientist.com/ns/19990313/liquidgeni.html`.

[I21] Kane AE and Sinclair DA. Epigenetic changes during aging and their reprogramming potential. *Crit Rev Biochem Mol Biol.*, 54(1):61–83, 2019. Available at: `https://www.tandfonline.com/doi/abs/10.1080/10409238.2019.1570075`.

[I22] Smith C. *Learning From Water , A Possible Quantum Computing Medium*. CHAOS, 2001.

[I23] Testa U Castelli G, Pelosi E. Targeting histone methyltransferase and demethylase in acute myeloid leukemia therapy. *Onco Targets Ther*, 11:131–155, 2018. Available at: `https://doi.org/10.2147/OTT.S145971`.

[I24] Koruga D. Micro-tubule screw symmetry: packing of spheres as a latent bioinformation code. *Ann Ny Acad Sci*, 466, 1974.

[I25] Sinclair DA and Laplante MD. *Lifespan: Why we age - and we don't have to*. Thorsons, 2019.

[I26] Wang C Deber CM, Liu LP. Perspective: peptides as mimics of transmembrane segments in proteins. *J Pept Res*, 54(3), 1999.

[I27] Woodbury DJ. Pure lipid vesicles can induce channel-like conductances in planar bilayers., 1989.

[I28] Benveniste J et al. Human basophil degranulation triggered by very dilute antiserum against IgE. *Nature*, 333:816–818, 1988.

[I29] Benveniste J et al. Transatlantic transfer of digitized antigen signal by telephone link. *J Allergy and Clinical Immunology*, 99:175, 1989. Available at: `https://www.digibio-.com/`.

[I30] Gariaev P et al. *The DNA-wave biocomputer*, volume 10. CHAOS, 2001.

[I31] Gariaev PP et al. The spectroscopy of bio-photons in non-local genetic regulation. *J Non-Locality and Remote Mental Interactions*, (3), 2002. Available at: `https://www.emergentmind.org/gariaevI3.htm`.

[I32] H Han et al. DNA methylation directly silences genes with non-CpG island promoters and establishes a nucleosome occupied promoter. *Hum Mol Genet*, 20(22):4299–4310, 2011. Available at: `https://pubmed.ncbi.nlm.nih.gov/21835883/`.

[I33] Johnson A et al. The Role of DNA Methylation in Aging, Rejuvenation, and Age-Related Disease. *Rejuvenation Res*, 15(5):483–494, 20129.Available at: `https://www.liebertpub.com/doi/abs/10.1089/rej.2012.1324`.

[I34] Lev AA et al. Rapid switching of ion current in narrow pores: implications for biological ion channels. *Proc R Soc London. Series B: Biological Sci s*, pages 187–192, 1993.

[I35] Lin JC et al. The Micro-wave Auditive phenomenon. *Proceedings of the IEEE*, 68, 1980.

[I36] Parbin S et al. Histone Deacetylases: A Saga of Perturbed Acetylation Homeostasis in Cancer. *J Histochem Cytochem*, 62(1):11–33, 2014. Available at: `https://doi.org/10.1369/0022155413506582`.

[I37] Popp F-A et al. Emission of Visible and Ultraviolet Radiation by Active Biological Systems. *Collective Phenomena*, 3, 1981.

[I38] Sen P et al. Epigenetic mechanisms regulating longevity and aging. *Cell*, 166(4):822–839, 2016. Available at:https://pubmed.ncbi.nlm.nih.gov/27518561/.

[I39] Albrecht-Buehler G. Surface extensions of 3T3 cells towards distant infrared sources. *J Cell Biology*, 114:493–502, 1991.

[I40] Pollack G. *Cells, Gels and the Engines of Life*. Ebner and Sons, 2000. Available at: `https://www.cellsandgels.com/`.

[I41] Vassilatos G. Nocturnal Disturbances and the Infrasonic "HUM", 2001. Available at: `https://www.borderlands.com/journal/nux.htm`.

[I42] Tovmash AV Gariaev PP, Tertishni GG. Experimental investigation in vitro of holographic mapping and holographic transposition of DNA in conjuction with the information pool encircling DNA. *New Medical Technologies*, 9:42–53, 2007.

[I43] Ling GN. *A physical theory of the living state: the association-induction hypothesis; with considerations of the mechanics involved in ionic specificity*. Blaisdell Pub. Co., New York, 1962.

[I44] Turberfield J A Green SJ, Lubrich D. DNA Hairpins: Fuel for Autonomous DNA Devices. *Biophys J*, 2006. Available at: `https://findarticles.com/p/articles/mi_qa3938/is_200610/ai_n16779588/pg_1`.

[I45] Fröhlich H. The extraordinary dielectric properties of biological materials and the action of enzymes. *Nature*, 72(1968):641–649, 1975.

[I46] Saunders PT Ho M-W. *Liquid Crystalline Mesophase in living organisms*. World Scientific, Singapore, 1994.

[I47] Wright J and Schneider BL. Cell size control is sirtuin(ly) exciting. *Mol Syst Biol*, 9(706), 2013.

[I48] Bateman JB. A Biologically Active Combination of Modulated Magnetic and Microwave Fields: the Priore Machine,, 1978. Office of Naval Research. London Report R-5-78. August 1978.

[I49] Fiaxat JD. A hypothesis on the rhythm of becoming. *World Futures*, 36:31–36, 1993.

[I50] Fiaxat JD. The hidden rhythm of evolution, 2014. Available at: `https://byebyedarwin.blogspot.fi/p/english-version_01.html`.

[I51] Matter-Walstra K. Unasked questions, 1999. Available at: `https://www.datacomm.ch/kmatter/unaskq.htm`.

[I52] Levin M. Morphogenetic fields in embryogenesis, regeneration, and cancer: Non-local control of complex patterning. *Biosystems*, 109(3):243–261, 2012. Available at: `https://www.ncbi.nlm.nih.gov/pubmed/22542702`.

[I53] Schempp W Marcer P. A Mathematically Specified Template For DNA and the Genetic Code in Terms of Physical Process of Quantum Holography. pages 45–62, 1996.

[I54] Bannister AJ Dawson MA Michalak EM, Burr ML. The roles of DNA, RNA and histone methylation in ageing and cancer. *Nat Rev Mol Cell Biol*, 20(10):573–589, 2019.Available at: `https://doi.org/10.1038/s41580-019-0143-1`.

[I55] Willcox BJ Morris BJ and Donlon TA. Genetic and epigenetic regulation of human aging and longevity. *Biochim Biophys Acta Mol Basis Dis.*, 1865(7):1718–1744, 2019. Available at: `https://www.sciencedirect.com/science/article/pii/S0925443918303326`.

[I56] Benford MS. Probable Axion Detection via Consistent Radiographic Findings after Exposure to a Shpilman Axion Generator. *J Theoretics*, 4, 1999.

[I57] Volkenstein MV. *Biophysics*. Mir Publishers, Moscow, 1983.

[I58] Ho MW. *The Rainbow and the Worm*. World Scientific, Singapore, 1993.

[I59] Rattemayer M Nagl W, Popp F-A. Evidence of Photon Emission from DNA in Living Systems. *Naturwissenschaften*, 68(5):577, 1981.

[I60] Callahan P. *Insect behavior*. 1971. Available at: `https://www.nexusmagazine.com`. See also the interview *Dr. Phil Callahan on Power of Paramagnetism*. Nexus, February-March 2003 at: `https://www.nexusmagazine.com`. p. 37.

[I61] England J Perunov N, Marsland R. Statistical Physics of Adaptation, 2014. Available at: `https://arxiv.org/pdf/1412.1875v1.pdf`.

[I62] Callahan PS. Moth and Candle: the Candle Flame as a Sexual Mimic of the Coded Infrared Wavelengths from a Moth Sex Scent. *Appl Opt*, 16(12), 1977.

[I63] Sheldrake R. *A New Science of Life: The Hypothesis of Formative Causation*. Inner Traditions Intl Ltd., 1995.

[I64] Sheldrake R. *The Presence of Past: Morphic Resonance and the Habits of Nature* . Icon Books Ltd, 2011.

[I65] Qin F Sachs F. Gated, ion-selective channels observed with patch pipettes in the absence of membranes: novel properties of a gigaseal. *Biophys J*, pages 1101–1107, 1993.

[I66] Bejaoui Y Salameen Y and El Hajj N. DNA Methylation Biomarkers in Aging and Age-Related Diseases, 2020. Available at:`https://doi.org/10.3389/fgene.2020.00171`.

[I67] Tshitshinadze G Shaduri M. On the problem of application of Bioenergography in medicine. *Georgian Eng News*, 2, 1999.

[I68] Creighton TE. *Proteins: Structures and Molecular Properties*. Freeman, New York, 1993.

[I69] Poponin V. DNA PHANTOM EFFECT: Direct Measurement of a New Field in the Vacuum Substructure, 1996. Available at: `https://www.webcom/~hrtmath/IHM/ResearchPapers/DNAPhantom/DNAPhantom.html`.

[I70] Xie L Wang Y, Yuan Q. Histone Modifications in Aging: The Underlying Mechanisms and Implications. *Curr Stem Cell Res Ther*, 13(2), 2018. Available at: `https://doi.org/10.2174/1574888X12666170817141921`.

[I71] Li Y and Heroux P. *Electromagnetic Biology ad Mecicine*, 33(4), 2014. Available at: `https://tinyurl.com/y9lv47qp`.

[I72] Merali Z. Water gave live on Earth a guiding hand. *New Scientist*, (2540), 2006.

Neuroscience and Consciousness

[J1] Available at: `https://www.hia.com/pcr`. See also `https://listserv.arizona.edu/lsv/www/quantum-mind.html`.

[J2] Available at: `https://aspsite.tripod.com/expt11.htm`. Homepage of Alexander MacRae containing information about experiments supporting the view that EVP is ASP (real sounds generate the signal).

[J3] A Secret Sense in The Human Nose? Available at: `https://www.hhmi.org/senses/`.

[J4] AMPA receptor. Available at: `https://en.wikipedia.org/wiki/AMPA_receptor`.

[J5] Binocular rivalry. Available at: `https://en.wikipedia.org/wiki/Binocular_rivalry`.

[J6] Breaking the Code of Color. Available at: `https://www.hhmi.org/senses/b/b120.htm`.

[J7] Bulerias. Available at: `https://en.wikipedia.org/wiki/Bulerias`.

[J8] CaMKII. Available at: `https://en.wikipedia.org/wiki/CaMKII`.

[J9] Chemical synapse. Available at: `https://en.wikipedia.org/wiki/Chemical_synapse`.

[J10] Hebbian theory. Available at: `https://en.wikipedia.org/wiki/Hebbian_theory`.

[J11] Hippocampus . Available at: `https://en.wikipedia.org/wiki/Hippocampus`.

[J12] Long term depression. Available at: `https://en.wikipedia.org/wiki/Long-term_depression`.

[J13] Long term potentiation. Available at: `https://en.wikipedia.org/wiki/Long-term_potentiation`.

[J14] Microtubules. Available at: `https://en.wikipedia.org/wiki/Microtubules`.

[J15] Out-of-body experiences. Available at: `https://en.wikipedia.org/wiki/Out_Of_Body_Experiences`.

[J16] Out-of-Body Experiences (OBEs) and Brain Localisation. A Perspective . Editorial Commentary available at: `https://www.pni.org/esp/medicine/obe/obeangular.htm`.

[J17] Paranormal.

[J18] Pythagorean tuning. Available at: `https://en.wikipedia.org/wiki/Pythagorean_tuning`.

[J19] Split-brain. Available at: `https://en.wikipedia.org/wiki/Split-brain`.

[J20] Synaptic plasticity. Available at: `https://en.wikipedia.org/wiki/Synaptic_plasticity`.

[J21] Synaptic Plasticity. Available at: `https://en.wikipedia.org/wiki/Synaptic_plasticity`.

[J22] Synaptic transmission. Available at: `https://en.wikipedia.org/wiki/Synaptic_transmission`.

[J23] The homepage of Mark Tilden. Available at: `https://sst.lanl.gov/robot`.

[J24] The Plants Respond: An Interview with Cleve Backster. Available at: `https://www.derrickjensen.org/backster.html`. Published in "The Sun" July 1997 and in "Free Spirit".

[J25] Words of truth. Available at: `https://www.reversespeech.com/words.shtml`.

[J26] The zombie within. *New Scientist*, 159(2150), 1998.

[J27] Neuroscience of free will, 2018. Available at: `https://en.wikipedia.org/wiki/Neuroscience_of_free_will`.

[J28] Revonsuo A. Is synchronization the direct neural correlate of visual consciousness?, 1998. Available at: `https://www.phil.vt.edu/ASSC/engel/revonsuo1.html`.

[J29] Vannini A. Advanced Waves, Retrocausality, and Consciousness. 2007. textnormalAvailable at: `https://www.scientificexploration.org/`.

[J30] Botkin AL. The Induction of After-Dearth Communications Utilizing Eye-Movement Desensitization and Reprocessing: A New Discovery. *J Near-Death Studies*, (3):181, 2000.

[J31] Sackett AM Armor DA. Accuracy, error, and bias in predictions for real versus hypothetical events. *J Pers Soc Psychol*, 91(4):583–600, 2006.

[J32] Khrennikov AY. Classical and quantum mechanics on information spaces with applications to cognitive, psychological, social, and anomalous phenomena. *Found Phys*, 29:1065–2098, 1999.

[J33] Haisch B. *The God Theory*. Weiser Books, 2006.

[J34] Libet B. Readiness potentials preceding unrestricted spontaneous and preplanned voluntary acts, 1982. Available at: `https://tinyurl.com/jqp1`. See also the article *Libet's Research on Timing of Conscious Intention to Act: A Commentary* of Stanley Klein at `https://tinyurl.com/jqp1`.

[J35] Selden G Becker RO. *The Body Electric: Electromagnetism and the Foundation of Life*. William Morrow & Company, Inc., New York, 1990.

[J36] Radin DI Bierman DJ. Anomalous Anticipatory Response on Randomized Future Conditions. *Percept & Mot Skills*, 84:689–690, 1997.

[J37] Radin DI Bierman J D. Anomalous unconscious emotional responses: Evidence for a reversal of the arrow of time, 1998. Available at: `https://www-psy.uva.nl/resedu/pn/PUBS/BIERMAN/1998/tucson/tucson3.html`.

[J38] Baars BJ. Understanding Subjectivity: Global Workspace Theory and the Resurrection of the Observing Self. *J Conscious Stud*, 3(3):211–16, 1996.

[J39] Troscianko TS Blackmore SJ. The physiology of the tunnel. *J Near-Death Studies*, 8:15–28, 1989.

[J40] Blackman CF Blanchard JP. A model of magnetic field effects on biological system with conforming data from a cell culture preparation. *On the Nature of Electromagnetic Field Interactions with Biological Systems*, 1994.

[J41] Backster C. Evidence of a Primary Perception in Plant Life. *Int J Parapsych*, 10(4):329–348, 1968.

[J42] Rifat C. Conscious dreaming and controlled hallucinations, 1999. Available at: `https://www.dog.net.uk/claude/dreams.html`.

[J43] Pert CB. *Molecules of Emotion*. Simon & Schuster Inc., 1997.

[J44] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.

[J45] He G Chen K. Preliminary Studies of the Effect of Qigong Therapy on Cancer. 2001. Available at: `https://www.emergentmind.org/chen.htm`.

[J46] Tart CT. Psychophysiological Study of Out-of-the-Body Experiences in a Selected Subject. *J Am Soc Psych Res*, 62:3–27, 1968.

[J47] Tart CT. Six Studies of Out-of-the-Body Experience. *J Near Death Stud*, 1997.

[J48] Chalmers D. *The conscious mind: in search of a fundamental theory*. Oxford University Press, New York, 1996.

[J49] Eagleman D, 2011. Available at: `https://tinyurl.com/p9pvefz`. Talk about the neuroscientist's view about time in fQXI conference "Setting time aright: investigating the nature of time. Bergen-Copehagen. 27.8.1.1, 2011".

[J50] McMillin D. *The Pineal*. A.R.E. Press, Virginia, 1991. textnormalAvailable at: `https://www.meridianinstitute.com/mh/pineal.html`.

[J51] Pouzzner D. The symphonic architecture of mind: the circulating wavetrain of consciousness., 1999. Available at: `https://www-douzzer.ai.mit.edu:8080/wavetrain.html`.

[J52] Pouzzner D. The symphonic architecture of mind: the circulating wavetrain of consciousness, 1999. Available at: `https://www-douzzer.ai.mit.edu:8080/wavetrain.html`.

[J53] Yarrow D. Spin the tale of the dragon, 1990. Available at: `https://www.ratical.org/reatvlle/RofD2.html`.

[J54] Treffert DA. The idiot savant: a review of the syndrome. *Am J Psychiatry*, 145(5):563–572, 1988. Available at:`https://psycnet.apa.org/record/1988-26936-001`.

[J55] DelaWarr G Day L. *New Worlds Beyond the Atom*. Vincent Stuart Publishers Ltd., London, 1956.

[J56] Radin DI. Unconscious perception of future emotions: An experiment in presentiment. *J Sci Expl*, 11(2), 1997.

[J57] Benor DJ. *Spiritual Healing: scientific validation of a healing revolution Vol. I*. Vision publications, Southfield MI, 2001.

[J58] Jahn RG Dunne BJ. Consciousness and Anomalous Physical Phenomena. Available at: `https://www.princeton.edu/~pear/finalcap.pdf`, 1995. Available at: `https://www.princeton.edu/~pear/finalcap.pdf`.

[J59] Nanopoulos DV. Theory of Brain function, Quantum Mechanics, and Superstrings, 1995. Available at: `https://arxiv.org/abs/hep-ph/9505374`.

[J60] Ackerman E. *Biophysical Science*. Prentice Hall, 1962. Available at: `https://en.wikipedia.org/wiki/Electroencephalography`.

[J61] Laszlo E. Psi, Grof, Jung and the Quantum Vacuum, 1996. Available at: `https://godel.psy.uwa.edu.au/dynapsych/1996/subtle.html`.

[J62] Manousakis E. Quantum theory, consciousness and temporal perception: Binocular rivalry, 2007. Available at: `https://arxiv.org/abs/0709.4516`.

[J63] Blackman CF et al. Multiple power density windows and their possible origin. *Bioelectromagn*, 10(2):115–128, 1989.

[J64] Blanke O et al. Stimulating illusory own-body perceptions. *Brain*, 127(2):243–258, 2002.

[J65] Cacciola A et al. Coalescent embedding in the hyperbolic space unsupervisedly discloses the hidden geometry of the brain, 2017. Available at:`https://arxiv.org/pdf/1705.04192.pdf`.

[J66] Gelbard-Sagiv et al. Human single neuron activity precedes emergence of conscious perception. *Nature communications.* Available at: `https://www.nature.com/articles/s41467-018-03749-0`, 9(2057), 2018. Available at:`https://www.eneuro.org/content/early/2018/05/14/ENEURO.0038-18.2018`.

[J67] Giuditta A et al. The sequential hypothesis of the function of sleep. *Behavioural Brain Res*, 69, 1995.

[J68] Grinberg-Zylverbaum J et al. Human communication and the electrophysiological activity of the brain. *Subtle Energies*, 3.

[J69] Kiviniemi V et al. Comparison of methods for determining non-deterministic BOLD fluctuation in fMRI. *Magn Reson Imaging*, 22, 2004.

[J70] Libet B et al. Subjective referral of the timing for a conscious sensory experience. *Brain*, 102, 1979.

[J71] Strassman R et al. *Inner paths to Outer Space.* Available at: `https://www.amazon.com/Inner-Paths-Outer-Space-Psychedelics/dp/159477224X`. Park Street Press, Rochester Vermont, 2008.

[J72] Shapiro F. *Eye moment densensitization and reprocessing: Principles, processes and procedures.* Guilford, New York, 1995.

[J73] Raichle ME Fox MD. Spontaneous fluctuations in brain activity observed with functional magnetic resonance imaging. *Nature Reviews/Neuroscience*, 8:700, 2007. Available at: `https://www.nature.com/reviews/neuro`.

[J74] Collins GP. Magnetic revelations: Functional MRI Highlights Neuron s Receiving Signals. *Sci Am*, 21, 2001.

[J75] Hameroff S Graddock T, Tuszynksi A. Cytoskeletal Signaling: Is Memory Encoded in Microtubule Lattices by CaMKII Phosphorylation? *PLoS Comput Biol*, 8(3), 2012. Available at: `https://www.ploscompbiol.org/article/info:doi/10.1371/journal.pcbi.1002421`.

[J76] Halifax L Grof S. *The Human Encounter with Death.* Souvenir Press, London, 1977.

[J77] Phillips H. Perchange to learn. *New Scientist*, 163:2205, 1999.

[J78] Schmidt H. The strange properties of psychokinesis. *J Sci Expl*, 1(2), 1987. Available at: `https://www.fourmilab.ch/rpkp/strange.html`. See also other other articles on RPK at Available at: `https://www.fourmilab.ch/rpkp/`.

[J79] Stapp H. Theoretical model of a purported empirical violation of the predictions of quantum theory. *Phys*, 1994.

[J80] Geissler H-G. Is there a way from behavior to non-linear brain dynamics? On quantal periods in cognition and the place of alpha in brain resonances. *Int J Psychophysiol*, 26, 1997.

[J81] Barbour J. *The End of Time; The Next Revolution in Physics.* Weidenfeld & Nicholson, 1999.

[J82] Brown J. Martial arts students influence the past. *New Scientist*, 1994.

[J83] Hawkins J. *On Intelligence.* St. Martin's Griffin, New York, 2004.

[J84] Henkel J. How life learns: an epistemological basis for consciousness, 1998. Available at: `https://www.tiac.net/users/knowweb/liflern2.htm`.

[J85] Jaynes J. *The origin of consciousness in the breakdown of the bicameral mind.* Princeton University Press, 1982.

[J86] McCrone J. Left Brain , Right Brain , 1999. Available at: `https://www.rense.com/general2/rb.html`.

[J87] McMoneagle J. *Remote Viewing Secrets.* Hampton Roads Publishing Company, Inc., 2000.

[J88] Spottiswoode J. Geomagnetic fluctuations and free response anomalous cognition: a new understanding. *J Parapsychol*, 2002. Available at: `https://www.jsasoc.com/docs/JP-GMF.pdf`.

[J89] Cowan JD. Spontaneous symmetry breaking in large-scale nervous activity. *Int J Quant Chem*, 22:1059–1082, 1982.

[J90] Miller JP. Brain Waves Deciphered. *Nature*, 1996. Article about the work of Wehr and Laurent.

[J91] Dunne JW. *An experiment with time.* Hampton Roads Publishing Company, Inc., 2001. First published in 1927.

[J92] Raudive K. *Breakthrough; An Amazing Experiment in Electronic Communication with the Dead.* Taplinger, New York, 1972.

[J93] Wilber K. *Waves, Streams, States, and Self–A Summary of My Psychological Model.* Shambala Publications. Available at: `https://wilber.shambhala.com/html/books/psych_model/psych_model2.cfm/.`, 2005.

[J94] Jessel TM Kandel ER, Schwartz JH. *Principles of neural science.* Prentice-Hall International Inc., 1991.

[J95] Pribram KH. The Neurophysiology of Remembering. *Sci Am*, 1969.

[J96] Lashley KS. *Brain Mechanisms and Intelligence.* Dover Publications, New York, 1963.

[J97] Fantappie L. *Teoria Unitaria del Mondo Fisico e Biologico.* Di Renzo Editore, Roma, 1942.

[J98] Osborne L. Savant for a Day, 2003. Available at: `https://www.nytimes.com/2003/06/22/magazine/22SAVANT.html`.

[J99] Sidorov L. The imprinting and transmission of mentally-directed bio-information, 2002. Available at: `https://www.emergentmind.org/sidorov_I.htm`.

[J100] Ellis AW Lambon-Ralph MA, Jarvis C. Life in a mirrored world: report of a case showing mirror reversal in reading and writing and for non-verbal materials. *J Neurosci*, 1(4), 1997. Available at: `https://www.colorado.edu/Honors/honr4000-882dubin/nc.html`.

[J101] Jaffe LF. Calcium Waves, 2001. Available at: `https://waves.mbl.edu/calcium.waves.html`.

[J102] Squire LR. Memory and the Hippocampus : A Synthesis From Findings With Rats, Monkeys, and Humans. *Psychol Rev*, 99(2):195–231, 1992.

[J103] Fordahl M. Scientists trigger neuron regeneration in mouse brain, 2000. Available at: `https://www.nandotimes.com`.

[J104] Germine M. Experimental verification of Stapp's theory', 2000. Available at: `https://listserv.arizona.edu/lsv/www/quantum-mind.html`.

[J105] Germine M. Scientific Validation of Planetary Consciousness. *J Non-Locality and Remote Mental Interactions*, 1(3), 2002. Available at: `https://www.emergentmind.org/germineI3.htm`.

[J106] Persinger M. *Neuropsychological Bases of God Beliefs.* Praeger Publishers, 1987.

[J107] Persinger M. On the possibility of directly accessing every human brain by electromagnetic induction of fundamental algorithms. *Percept Mot Skills*, 80(3):791–799, 1995.

[J108] Persinger M. The tectonic strain theory as an explanation for UFO phenomena, 1999. Available at: `https://www.laurentian.ca/www/neurosci/tectonicedit.htm`.

[J109] Persinger M. The tectonic strain theory as an explanation for UFO phenomena, 1999. Available at: `https://www.laurentian.ca/www/neurosci/tectonicedit.htm`.

[J110] Solms M. Dreaming and REM sleep are controlled by different brain mechanisms. *Behav & Brain Sci*, 23(6), 2000.

[J111] Tegmark M. The importance of quantum de-coherence in brain processes, 1999. Available at: `https://arxiv.org/abs/quant-ph/9907009`.

[J112] James CL May EC, Spottiswoode SJP. Shannon entropy as an intrinsic target property: towards a reductionistic model of anomalous cognition, 1994. Available at: `https://www.jsasoc.com/docs/entropy.pdf`.

[J113] Daneman M Mericle PM. Memory for unconsciously perceived events: evidence for anesthetized patients. *Conscious & Cognition*, 5:525, 1996.

[J114] Miller I Miller R. Schumann's Resonances and Human Psychobiology. *Nexus*, 2003. Available at: `https://www.nexusmagazine.com`.

[J115] Cherry N. Conference report on effects of ELF fields on brain, 2000. Available at: `https://www.tassie.net.au/emfacts/icnirp.txt`.

[J116] Reissman SS Nevandee DA. Measurement of the electroencephalogram (EEG) coherence in group meditation. 1996.

[J117] Sacks O. *The man who mistook his wife for a hat.* 1998. Available at: First edition 1985.

[J118] Sacks O. *Musicophilia.* Picador, 2011.

[J119] Pietch P. Shuffle Brain: the The Quest for Hologramic Mind, 1972. Available at: `https://www.indiana.edu/~pietsch/shufflebrain-book00.html`.

[J120] Presi P. The paranomal in the laboratory: a comparison of "psychophonic voices", "telephonic" voices and "direct voices". *ITC J*, (1), 2000. Available at: `https://eureka.ya.com/cadernostci`.

[J121] Presi P. The paranomal in the laboratory: a comparison of "psychophonic voices", "telephonic" voices and "direct voices". *ITC J*, (5), 2001. Available at: `https://eureka.ya.com/cadernostci`.

[J122] Lavallee F C Persinger MA. Theoretical and Experimental Evidence of Macroscopic Entanglement between Human Brain Activity and Photon Emissions: Implications for Quantum Consciousness and Future Applications. *J Consc Expl & Res*, 1(7):785–807, 2010.

[J123] Nunez PL. Toward a Quantitative Description of Large Scale Neocortical Dynamic Function and EEG. *Behav & Brain Sci*, 23, 2000.

[J124] Westlake PR. The Possibilities of Neural Holographic Processes Within the Brain . *Kybernetik*, 7:129–153, 1970.

[J125] Goldman-Rakic PS. The "psychic" neuron of the cerebral cortex. *Ann N Y Acad Sci*, 868:13–26.

[J126] Cytowich R. *Psyche*, 2(10), 1995. Available at: `https://psyche.cs.monash.edu.au/v2/psyche-2-10-cytowic.html`.

[J127] Determayer R. History and development of ITC. *ITC J*, (8), 2001. Available at: `https://eureka.ya.com/cadernostci`.

[J128] Merrick R. *Interference: A Grand Scientific Musical Theory*. 2009. Available at: `https://interferencetheory.com/files/Interference.pdf`.

[J129] Moody R. *Life After Life*. Covinda, Gal: Mockingbird, 1975.

[J130] Penrose R. *The Emperor's New Mind*. Oxford University Press, Oxford, 1989.

[J131] Penrose R. *Shadows of the Mind*. Vintage, 1994.

[J132] Peoch R. Chicken-robot interaction. *Medical Network.*, 62, 1995. Available at: `https://paranormal.se/psi/pk/djur.html`.

[J133] Schuerger R. Alien abductions, seismic activity, and the brain em- are they related? *NeuroSci*, 1999. Available at: `https://neuroscience.miningco.com/health/neuroscience/library/weekly/aa122898.htm`.

[J134] Becker RO. *Cross Currents*. Penguin Putnam Inc., New York, 1990.

[J135] Blackmore S. *Beyond the Body*. Granada, London, 1983.

[J136] Blackmore S. Near death experiences: in or out of the body? *Skeptical Inquirer*, 1991:34–45, 1991. Available at: `https://www.uwe.ac.uk/fas/staff/sb/si91nde.html`.

[J137] Blackmore S. *The Meme Machine*. Oxford University Press, Oxford, 1999.

[J138] Grof S. *The Adventure of Self-discovery*. State University of New York Press, Albany, 1988.

[J139] Klein S. Libet's Research on Timing of Conscious Intention to Act: A Commentary. *Consc & Cogn*, 11, 2002. Available at: `https://tinyurl.com/jqp1`.

[J140] Pinker S. *How the Mind Works*. W. W. Norton & Company, Inc., New York, 1997.

[J141] Cowey Q Stoerig P. Blind sight in men and monkey. *Brain*, 190(3), 1997.

[J142] Puthoff H Targ R. Information transmission under conditions of sensory shielding. *Nature*, 251, 1974.

[J143] Dibble WEJr Tiller WA. New experimental data revealing an unexpected dimension to materials science and engineering. *Mat Res Innovat*, 5:21–34, 2001.

[J144] Dibble WEJr Tiller WA. Anomalous Temperature Oscillation Behavior Near a Source in a "Conditioned" Space: part I, The Spatial Variation, 2002. Available at: `https://tillerfoundation.com/newpapers.htm`.

[J145] Kohane MJ Tiller WA, Dibble WEJr. *Conscious Acts of Creation: the Emergence of a New Physics*, volume 17. Pavior Publishing, 2001. Available at: `https://www.pavior.com/`.

[J146] Corpo Di U. The conflict between entropy and syntropy: the vital needs model. 2007. Available at: `https://www.scientificexploration.org/`.

[J147] Fidelman U. Cerebral asymmetry implies that a total theory of the universe amd of the mind is impossible. *Science*, 2002.

[J148] Krippner S Ullman M. Dream Studies and Telepathy: An Experimental Approach, 1970. New York: Parapsychology Foundation.

[J149] Eastman KE Vertes RP. The case against memory consolidation in REM sleep. *Behav & Brain Sci*, 23(6).

[J150] Tiller WA. Towards a Quantitative Science and Technology that Includes Human Consciousness. *Vision-In-Action*, 4, 2003. Available at: `https://www.via-visioninaction.org`.

[J151] Neppe WM. The Out-of-Body Experiece: a Phenomenological Categorization. *Parapsych J South Africa*, 6(2):110–110, 1985.

[J152] Merali Z. I'm quantum, therefore I am. *New Scientist*, (2626), 2007.

[J153] Guzman-Karlsson MC Zovkic IB and Sweatt JD. Epigenetic regulation of memory formation and maintenance. *Learn Mem*, 20(2):61–74, 2013. Available at: `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3549063/`.

Books related to TGD

[K1] Pitkänen M. *Topological Geometrodynamics.* 1983. Thesis in Helsinki University 1983.

[K2] Pitkänen M. DNA as Topological Quantum Computer. In *Quantum - and Classical Computation in TGD Universe.* `https: // tgdtheory. fi/ tgdhtml/ Btgdcomp. html`. Available at: `https://tgdtheory.fi/pdfpool/dnatqc.pdf`, 2015.

[K3] Pitkänen M. Topological Quantum Computation in TGD Universe. In *Quantum - and Classical Computation in TGD Universe.* `https: // tgdtheory. fi/ tgdhtml/ Btgdcomp. html`. Available at: `https://tgdtheory.fi/pdfpool/tqc.pdf`, 2015.

[K4] Pitkänen M. Philosophy of Adelic Physics. In *TGD as a Generalized Number Theory: Part I.* `https: // tgdtheory. fi/ tgdhtml/ Btgdnumber1. html`. Available at: `https://tgdtheory.fi/pdfpool/adelephysics.pdf`, 2017.

[K5] Pitkänen M. A Model for Protein Folding and Bio-catalysis. In *TGD and Quantum Biology: Part I.* `https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html`. Available at: `https://tgdtheory.fi/pdfpool/foldcat.pdf`, 2023.

[K6] Pitkänen M. About Absolute Galois Group. In *TGD as a Generalized Number Theory: Part III.* `https: // tgdtheory. fi/ tgdhtml/ Btgdnumber3. html`. Available at: `https://tgdtheory.fi/pdfpool/agg.pdf`, 2023.

[K7] Pitkänen M. About Nature of Time. In *TGD Inspired Theory of Consciousness: Part I.* `https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html`. Available at: `https://tgdtheory.fi/pdfpool/timenature.pdf`, 2023.

[K8] Pitkänen M. About Preferred Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I.* `https: // tgdtheory. fi/ tgdhtml/ Btgdclass1. html`. Available at: `https://tgdtheory.fi/pdfpool/prext.pdf`, 2023.

[K9] Pitkänen M. About the New Physics Behind Qualia. In *Bio-Systems as Self-Organizing Quantum Systems.* `https: // tgdtheory. fi/ tgdhtml/ BbioSO. html`. Available at: `https://tgdtheory.fi/pdfpool/newphys.pdf`, 2023.

[K10] Pitkänen M. About twistor lift of TGD? In *Quantum TGD: Part III.* `https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html`. Available at: `https://tgdtheory.fi/pdfpool/hgrtwistor.pdf`, 2023.

[K11] Pitkänen M. Anomalies Related to the Classical Z^0 Force and Gravitation. In *TGD and Fringe Physics.* `https: // tgdtheory. fi/ tgdhtml/ Bfreenergies. html`. Available at: `https://tgdtheory.fi/pdfpool/Zanom.pdf`, 2023.

[K12] Pitkänen M. Are dark photons behind biophotons? In *TGD and Quantum Biology: Part I.* `https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html`. Available at: `https://tgdtheory.fi/pdfpool/biophotonslian.pdf`, 2023.

[K13] Pitkänen M. Basic Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I.* `https: // tgdtheory. fi/ tgdhtml/ Btgdclass1. html` . Available at: `https://tgdtheory.fi/pdfpool/class.pdf`, 2023.

[K14] Pitkänen M. *Bio-Systems as Conscious Holograms.* Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/holography.html.`, 2023.

[K15] Pitkänen M. Bio-Systems as Conscious Holograms. In *TGD Universe as a Conscious Hologram.* `https: // tgdtheory. fi/ tgdhtml/ Bholography. html` . Available at: `https://tgdtheory.fi/pdfpool/hologram.pdf`, 2023.

[K16] Pitkänen M. *Bio-Systems as Self-Organizing Quantum Systems.* Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/bioselforg.html.`, 2023.

[K17] Pitkänen M. Bio-Systems as Super-Conductors: Part I. In *Bio-Systems as Self-Organizing Quantum Systems.* `https: // tgdtheory. fi/ tgdhtml/ BbioSO. html` . Available at: `https://tgdtheory.fi/pdfpool/superc1.pdf`, 2023.

[K18] Pitkänen M. Bio-Systems as Super-Conductors: part II. In *Bio-Systems as Self-Organizing Quantum Systems.* `https: // tgdtheory. fi/ tgdhtml/ BbioSO. html` . Available at: `https://tgdtheory.fi/pdfpool/superc2.pdf`, 2023.

[K19] Pitkänen M. Biological Realization of Self Hierarchy. In *Bio-Systems as Self-Organizing Quantum Systems.* `https: // tgdtheory. fi/ tgdhtml/ BbioSO. html` . Available at: `https://tgdtheory.fi/pdfpool/bioselfc.pdf`, 2023.

[K20] Pitkänen M. Category Theory and Quantum TGD. In *TGD and Hyper-finite Factors.* `https: // tgdtheory. fi/ tgdhtml/ BHFF. html` . Available at: `https://tgdtheory.fi/pdfpool/categorynew.pdf`, 2023.

[K21] Pitkänen M. Classical TGD. In *Topological Geometrodynamics: Overview: Part I:`https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html`* . Available at: `https://tgdtheory.fi/pdfpool/tgdclass.pdf`, 2023.

[K22] Pitkänen M. Conscious Information and Intelligence. In *TGD Inspired Theory of Consciousness: Part II.* `https: // tgdtheory. fi/ tgdhtml/ Btgdconsc2. html` . Available at: `https://tgdtheory.fi/pdfpool/intsysc.pdf`, 2023.

[K23] Pitkänen M. Construction of elementary particle vacuum functionals. In *p-Adic Physics.* `https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html` . Available at: `https://tgdtheory.fi/pdfpool/elvafu.pdf`, 2023.

[K24] Pitkänen M. Construction of Quantum Theory: M-matrix. In *Quantum TGD: Part I.* `https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html` . Available at: `https://tgdtheory.fi/pdfpool/towards.pdf`, 2023.

[K25] Pitkänen M. Construction of Quantum Theory: Symmetries. In *Quantum TGD: Part I.* `https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html` . Available at: `https://tgdtheory.fi/pdfpool/quthe.pdf`, 2023.

[K26] Pitkänen M. Construction of WCW Kähler Geometry from Symmetry Principles. In *Quantum Physics as Infinite-Dimensional Geometry.* `https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html` . Available at: `https://tgdtheory.fi/pdfpool/compl1.pdf`, 2023.

[K27] Pitkänen M. Criticality and dark matter: part I. In *Dark Matter and TGD:* `https: // tgdtheory. fi/ tgdhtml/ Bdark. html` . Available at: `https://tgdtheory.fi/pdfpool/qcritdark1.pdf`, 2023.

[K28] Pitkänen M. Criticality and dark matter: part II. In *Dark Matter and TGD:* `https: // tgdtheory. fi/ tgdhtml/ Bdark. html` . Available at: `https://tgdtheory.fi/pdfpool/qcritdark2.pdf`, 2023.

[K29] Pitkänen M. Criticality and dark matter: part III. In *Dark Matter and TGD:* *https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/qcritdark3.pdf, 2023.

[K30] Pitkänen M. Crop Circles and Life at Parallel Space-Time Sheets. In *Magnetospheric Consciousness.* *https://tgdtheory.fi/tgdhtml/Bmagnconsc.html*. Available at: https://tgdtheory.fi/pdfpool/crop1.pdf, 2023.

[K31] Pitkänen M. Crop Circles and Life at Parallel Space-Time Sheets. In *Magnetospheric Consciousness.* *https://tgdtheory.fi/tgdhtml/Bmagnconsc.html*. Available at: https://tgdtheory.fi/pdfpool/crop2.pdf, 2023.

[K32] Pitkänen M. Dark Forces and Living Matter. In *Bio-Systems as Self-Organizing Quantum Systems.* *https://tgdtheory.fi/tgdhtml/BbioSO.html*. Available at: https://tgdtheory.fi/pdfpool/darkforces.pdf, 2023.

[K33] Pitkänen M. Dark Matter Hierarchy and Hierarchy of EEGs. In *TGD and EEG: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/eegdark.pdf, 2023.

[K34] Pitkänen M. Did Tesla Discover the Mechanism Changing the Arrow of Time? In *TGD and Fringe Physics.* *https://tgdtheory.fi/tgdhtml/Bfreenergies.html*. Available at: https://tgdtheory.fi/pdfpool/tesla.pdf, 2023.

[K35] Pitkänen M. Does Riemann Zeta Code for Generic Coupling Constant Evolution? In *TGD as a Generalized Number Theory: Part III.* *https://tgdtheory.fi/tgdhtml/Btgdnumber3.html*. Available at: https://tgdtheory.fi/pdfpool/fermizeta.pdf, 2023.

[K36] Pitkänen M. Does TGD Predict a Spectrum of Planck Constants? In *Dark Matter and TGD:* *https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/Planck, 2023.

[K37] Pitkänen M. From Principles to Diagrams. In *Quantum TGD: Part III.* *https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/diagrams.pdf, 2023.

[K38] Pitkänen M. Fusion of p-Adic and Real Variants of Quantum TGD to a More General Theory. In *TGD as a Generalized Number Theory: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdnumber1.html*. Available at: https://tgdtheory.fi/pdfpool/mblocks.pdf, 2023.

[K39] Pitkänen M. General Theory of Qualia. In *TGD Inspired Theory of Consciousness: Part I.* *https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/qualia.pdf, 2023.

[K40] Pitkänen M. *Genes and Memes.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/genememe.html., 2023.

[K41] Pitkänen M. Genes and Memes. In *Genes and Memes: Part I.* *https://tgdtheory.fi/tgdhtml/Bgenememe1.html*. Available at: https://tgdtheory.fi/pdfpool/genememec.pdf, 2023.

[K42] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *TGD Universe as a Conscious Hologram.* *https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: https://tgdtheory.fi/pdfpool/homeoc.pdf, 2023.

[K43] Pitkänen M. *Hyper-finite Factors and Dark Matter Hierarchy.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/neuplanck.html., 2023.

[K44] Pitkänen M. Identification of the WCW Kähler Function. In *Quantum Physics as Infinite-Dimensional Geometry.* *https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/kahler.pdf., 2023.

[K45] Pitkänen M. Macro-Temporal Quantum Coherence and Spin Glass Degeneracy. In *TGD Universe as a Conscious Hologram.* *https: // tgdtheory. fi/ tgdhtml/ Bholography. html*. Available at: https://tgdtheory.fi/pdfpool/macro.pdf, 2023.

[K46] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part I. In *TGD Universe as a Conscious Hologram.* *https: // tgdtheory. fi/ tgdhtml/ Bholography. html*. Available at: https://tgdtheory.fi/pdfpool/metab. pdf, 2023.

[K47] Pitkänen M. Macroscopic Quantum Phenomena and CP_2 Geometry. In *TGD and Condensed Matter.* *https: // tgdtheory. fi/ tgdhtml/ BTGDcondmat. html*. Available at: https://tgdtheory.fi/pdfpool/super.pdf, 2023.

[K48] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and Quantum Biology: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html*. Available at: https://tgdtheory.fi/ pdfpool/mec.pdf, 2023.

[K49] Pitkänen M. *Magnetospheric Consciousness.* Online book. Available at: https://www. tgdtheory.fi/tgdhtml/magnconsc.html., 2023.

[K50] Pitkänen M. Magnetospheric Sensory Representations. In *Magnetospheric Consciousness.* *https: // tgdtheory. fi/ tgdhtml/ Bmagnconsc. html*. Available at: https://tgdtheory. fi/pdfpool/srepres.pdf, 2023.

[K51] Pitkänen M. Many-Sheeted DNA. In *Genes and Memes: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Bgenememe1. html*. Available at: https://tgdtheory.fi/pdfpool/genecodec. pdf, 2023.

[K52] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html*. Available at: https://tgdtheory. fi/pdfpool/mless.pdf, 2023.

[K53] Pitkänen M. *Mathematical Aspects of Consciousness Theory.* Online book. Available at: https://www.tgdtheory.fi/tgdhtml/mathconsc.html, 2023.

[K54] Pitkänen M. Matter, Mind, Quantum. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html*. Available at: https://tgdtheory. fi/pdfpool/conscic.pdf, 2023.

[K55] Pitkänen M. Meditation, Mind-Body Medicine and Placebo: TGD point of view. In *TGD Inspired Theory of Consciousness: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html*. Available at: https://tgdtheory.fi/pdfpool/panel.pdf, 2023.

[K56] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html*. Available at: https://tgdtheory.fi/pdfpool/nmpc.pdf, 2023.

[K57] Pitkänen M. New Physics Predicted by TGD: Part I. In *p-Adic Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html*. Available at: https://tgdtheory. fi/pdfpool/TGDnewphys1.pdf, 2023.

[K58] Pitkänen M. New Physics Predicted by TGD: Part II. In *p-Adic Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html*. Available at: https://tgdtheory. fi/pdfpool/TGDnewphys2.pdf, 2023.

[K59] Pitkänen M. Non-locality in quantum theory, in biology and neuroscience, and in remote mental interactions: TGD perspective. In *TGD Inspired Theory of Consciousness: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html*. Available at: https://tgdtheory. fi/pdfpool/nonlocal.pdf, 2023.

[K60] Pitkänen M. Nuclear String Hypothesis. In *TGD and Nuclear Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bnucl. html*. Available at: https://tgdtheory.fi/pdfpool/ nuclstring.pdf, 2023.

[K61] Pitkänen M. Number theoretic vision, Hyper-finite Factors and S-matrix. In *Quantum TGD: Part I*. *https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html*. Available at: `https://tgdtheory.fi/pdfpool/UandM.pdf`, 2023.

[K62] Pitkänen M. *p-Adic length Scale Hypothesis*. Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/padphys.html`., 2023.

[K63] Pitkänen M. p-Adic Numbers and Generalization of Number Concept. In *TGD as a Generalized Number Theory: Part I*. *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber1. html*. Available at: `https://tgdtheory.fi/pdfpool/padmat.pdf`, 2023.

[K64] Pitkänen M. p-Adic Physics as Physics of Cognition and Intention. In *TGD Inspired Theory of Consciousness: Part II*. *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc2. html*. Available at: `https://tgdtheory.fi/pdfpool/cognic.pdf`, 2023.

[K65] Pitkänen M. p-Adic Physics: Physical Ideas. In *TGD as a Generalized Number Theory: Part I*. *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber1. html*. Available at: `https://tgdtheory.fi/pdfpool/phblocks.pdf`, 2023.

[K66] Pitkänen M. Physics as a Generalized Number Theory. In *Topological Geometrodynamics: Overview: Part I*. *https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html*. Available at: `https://tgdtheory.fi/pdfpool/tgdnumber.pdf`, 2023.

[K67] Pitkänen M. Quantum Adeles. In *TGD as a Generalized Number Theory: Part III*. *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber3. html*. Available at: `https://tgdtheory.fi/pdfpool/galois.pdf`, 2023.

[K68] Pitkänen M. Quantum Antenna Hypothesis. In *Bio-Systems as Self-Organizing Quantum Systems*. *https: // tgdtheory. fi/ tgdhtml/ BbioSO. html*. Available at: `https://tgdtheory.fi/pdfpool/tubuc.pdf`, 2023.

[K69] Pitkänen M. Quantum Arithmetics and the Relationship between Real and p-Adic Physics. In *TGD as a Generalized Number Theory: Part III*. *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber3. html*. Available at: `https://tgdtheory.fi/pdfpool/qarithmetics.pdf`, 2023.

[K70] Pitkänen M. Quantum Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II*. *https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html*. Available at: `https://tgdtheory.fi/pdfpool/qastro.pdf`, 2023.

[K71] Pitkänen M. Quantum Control and Coordination in Bio-Systems. In *Bio-Systems as Self-Organizing Quantum Systems*. *https: // tgdtheory. fi/ tgdhtml/ BbioSO. html*. Available at: `https://tgdtheory.fi/pdfpool/qcococII.pdf`, 2023.

[K72] Pitkänen M. Quantum Control and Coordination in Bio-systems: Part I. In *Bio-Systems as Self-Organizing Quantum Systems*. *https: // tgdtheory. fi/ tgdhtml/ BbioSO. html*. Available at: `https://tgdtheory.fi/pdfpool/qcococI.pdf`, 2023.

[K73] Pitkänen M. Quantum gravity, dark matter, and prebiotic evolution. In *Evolution in TGD Universe*. *https: // tgdtheory. fi/ tgdhtml/ Btgdevolution. html*. Available at: `https://tgdtheory.fi/pdfpool/hgrprebio.pdf`, 2023.

[K74] Pitkänen M. Quantum Hall effect and Hierarchy of Planck Constants. In *TGD and Condensed Matter*. *https: // tgdtheory. fi/ tgdhtml/ BTGDcondmat. html*. Available at: `https://tgdtheory.fi/pdfpool/anyontgd.pdf`, 2023.

[K75] Pitkänen M. *Quantum Hardware of Living Matter*. Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/bioware.html`., 2023.

[K76] Pitkänen M. Quantum Mind and Neuroscience. In *TGD and EEG: Part I*. *https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html*. Available at: `https://tgdtheory.fi/pdfpool/lianPN.pdf`, 2023.

[K77] Pitkänen M. Quantum Mind, Magnetic Body, and Biological Body. In *TGD and Quantum Biology: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: `https://tgdtheory.fi/pdfpool/lianPB.pdf`, 2023.

[K78] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and Quantum Biology: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: `https://tgdtheory.fi/pdfpool/biosupercondI.pdf`, 2023.

[K79] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and Quantum Biology: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Bqbio1. html* . Available at: `https://tgdtheory.fi/pdfpool/biosupercondII.pdf`, 2023.

[K80] Pitkänen M. Quantum Model for Hearing. In *TGD and EEG: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Btgdeeg2. html* . Available at: `https://tgdtheory.fi/pdfpool/hearing.pdf`, 2023.

[K81] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: `https://tgdtheory.fi/pdfpool/nervepulse.pdf`, 2023.

[K82] Pitkänen M. Quantum Model for Paranormal Phenomena. In *TGD Inspired Theory of Consciousness: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html* . Available at: `https://tgdtheory.fi/pdfpool/parac.pdf`, 2023.

[K83] Pitkänen M. Quantum Model for Sensory Representations. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: `https://tgdtheory.fi/pdfpool/expc.pdf`, 2023.

[K84] Pitkänen M. Quantum Model of EEG. In *TGD and EEG: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdeeg1. html* . Available at: `https://tgdtheory.fi/pdfpool/eegII.pdf`, 2023.

[K85] Pitkänen M. Quantum Model of Memory. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: `https://tgdtheory.fi/pdfpool/memoryc.pdf`, 2023.

[K86] Pitkänen M. *Quantum TGD*. Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/tgdquantum.html.`, 2023.

[K87] Pitkänen M. Quantum Theory of Self-Organization. In *Bio-Systems as Self-Organizing Quantum Systems.* *https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: `https://tgdtheory.fi/pdfpool/selforgac.pdf`, 2023.

[K88] Pitkänen M. Recent View about Kähler Geometry and Spin Structure of WCW . In *Quantum Physics as Infinite-Dimensional Geometry.* *https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: `https://tgdtheory.fi/pdfpool/wcwnew.pdf`, 2023.

[K89] Pitkänen M. Self and Binding: Part I. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: `https://tgdtheory.fi/pdfpool/selfbindc.pdf`, 2023.

[K90] Pitkänen M. Self and Binding: Part II. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: `https://tgdtheory.fi/pdfpool/selfbindcapp.pdf`, 2023.

[K91] Pitkänen M. Semi-trance, Mental Illness, and Altered States of Consciousness. In *Magnetospheric Consciousness.* *https: // tgdtheory. fi/ tgdhtml/ Bmagnconsc. html* . Available at: `https://tgdtheory.fi/pdfpool/semitrancec.pdf`, 2023.

[K92] Pitkänen M. Semitrance, Language, and Development of Civilization. In *Magnetospheric Consciousness.* *https: // tgdtheory. fi/ tgdhtml/ Bmagnconsc. html* . Available at: `https://tgdtheory.fi/pdfpool/langsoc.pdf`, 2023.

[K93] Pitkänen M. Some questions about IIT. In *TGD Inspired Theory of Consciousness: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc2. html* . Available at: `https://tgdtheory.fi/pdfpool/panel2016.pdf`, 2023.

[K94] Pitkänen M. Some questions related to the twistor lift of TGD. In *Quantum TGD: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html* . Available at: `https://tgdtheory.fi/pdfpool/twistquestions.pdf`, 2023.

[K95] Pitkänen M. SUSY in TGD Universe. In *p-Adic Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bpadphys. html* . Available at: `https://tgdtheory.fi/pdfpool/susychap.pdf`, 2023.

[K96] Pitkänen M. Symmetries and Geometry of the "World of Classical Worlds". In *Quantum Physics as Infinite-Dimensional Geometry.* *https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: `https://tgdtheory.fi/pdfpool/wcwsymm.pdf`, 2023.

[K97] Pitkänen M. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html* . Available at: `https://tgdtheory.fi/pdfpool/astro.pdf`, 2023.

[K98] Pitkänen M. TGD and Cosmology. In *Physics in Many-Sheeted Space-Time: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Btgdclass2. html* . Available at: `https://tgdtheory.fi/pdfpool/cosmo.pdf`, 2023.

[K99] Pitkänen M. *TGD and EEG.* Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/tgdeeg.html`, 2023.

[K100] Pitkänen M. *TGD and Fringe Physics.* Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/freenergy.html.`, 2023.

[K101] Pitkänen M. TGD and M-Theory. In *Topological Geometrodynamics: Overview: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html* . Available at: `https://tgdtheory.fi/pdfpool/MTGD.pdf`, 2023.

[K102] Pitkänen M. TGD as a Generalized Number Theory: Infinite Primes. In *TGD as a Generalized Number Theory: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber1. html* . Available at: `https://tgdtheory.fi/pdfpool/visionc.pdf`, 2023.

[K103] Pitkänen M. TGD as a Generalized Number Theory: p-Adicization Program. In *Quantum Physics as Number Theory: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber1. html* . Available at: `https://tgdtheory.fi/pdfpool/visiona.pdf`, 2023.

[K104] Pitkänen M. TGD as a Generalized Number Theory: Quaternions, Octonions, and their Hyper Counterparts. In *TGD as a Generalized Number Theory: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber1. html* . Available at: `https://tgdtheory.fi/pdfpool/visionb.pdf`, 2023.

[K105] Pitkänen M. TGD Based Model for OBEs. In *TGD Inspired Theory of Consciousness: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html* . Available at: `https://tgdtheory.fi/pdfpool/OBE.pdf`, 2023.

[K106] Pitkänen M. *TGD Based View About Living Matter and Remote Mental Interactions.* Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/tgdlian.html`, 2023.

[K107] Pitkänen M. TGD Inspired Comments about Integrated Information Theory of Consciousness. In *TGD Inspired Theory of Consciousness: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc2. html* . Available at: `https://tgdtheory.fi/pdfpool/tononikoch.pdf`, 2023.

[K108] Pitkänen M. *TGD Inspired Theory of Consciousness.* Online book. Available at: `https://www.tgdtheory.fi/tgdhtml/tgdconsc.html.`, 2023.

[K109] Pitkänen M. TGD inspired view about remote mental interactions and paranormal. In *TGD Inspired Theory of Consciousness: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc3. html* . Available at: https://tgdtheory.fi/pdfpool/lianPRM.pdf, 2023.

[K110] Pitkänen M. The classical part of the twistor story. In *Quantum TGD: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdquantum3. html* . Available at: https://tgdtheory.fi/pdfpool/twistorstory.pdf, 2023.

[K111] Pitkänen M. The Geometry of the World of the Classical Worlds. In *Topological Geometrodynamics: Overview: Part I:https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html* . Available at: https://tgdtheory.fi/pdfpool/tgdgeom.pdf, 2023.

[K112] Pitkänen M. The Notion of Free Energy and Many-Sheeted Space-Time Concept. In *TGD and Fringe Physics.* *https: // tgdtheory. fi/ tgdhtml/ Bfreenergies. html* . Available at: https://tgdtheory.fi/pdfpool/freenergy.pdf, 2023.

[K113] Pitkänen M. The Notion of Wave-Genome and DNA as Topological Quantum Computer. In *Quantum - and Classical Computation in TGD Universe.* *https: // tgdtheory. fi/ tgdhtml/ Btgdcomp. html* . Available at: https://tgdtheory.fi/pdfpool/gari.pdf, 2023.

[K114] Pitkänen M. The Relationship Between TGD and GRT. In *Physics in Many-Sheeted Space-Time: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdclass1. html* . Available at: https://tgdtheory.fi/pdfpool/tgdgrt.pdf., 2023.

[K115] Pitkänen M. Three new physics realizations of the genetic code and the role of dark matter in bio-systems. In *Genes and Memes: Part II.* *https: // tgdtheory. fi/ tgdhtml/ Bgenememe2. html* . Available at: https://tgdtheory.fi/pdfpool/dnatqccodes.pdf, 2023.

[K116] Pitkänen M. Time and Consciousness. In *TGD Inspired Theory of Consciousness: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdconsc1. html* . Available at: https://tgdtheory.fi/pdfpool/timesc.pdf, 2023.

[K117] Pitkänen M. *Topological Geometrodynamics: an Overview.* Online book.Available at: https://www.tgdtheory.fi/tgdhtml/tgdview.html., 2023.

[K118] Pitkänen M. Topological Geometrodynamics: Three Visions. In *Topological Geometrodynamics: Overview: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdview1. html* . Available at: https://tgdtheory.fi/pdfpool/tgd2010.pdf, 2023.

[K119] Pitkänen M. Unified Number Theoretical Vision. In *TGD as a Generalized Number Theory: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber1. html* . Available at: https://tgdtheory.fi/pdfpool/numbervision.pdf, 2023.

[K120] Pitkänen M. Was von Neumann Right After All? In *TGD and Hyper-finite Factors.* *https: // tgdtheory. fi/ tgdhtml/ BHFF. html* . Available at: https://tgdtheory.fi/pdfpool/vNeumann.pdf, 2023.

[K121] Pitkänen M. WCW Spinor Structure. In *Quantum Physics as Infinite-Dimensional Geometry.* *https: // tgdtheory. fi/ tgdhtml/ Btgdgeom. html* . Available at: https://tgdtheory.fi/pdfpool/cspin.pdf, 2023.

[K122] Pitkänen M. What p-Adic Icosahedron Could Mean? And What about p-Adic Manifold? In *TGD as a Generalized Number Theory: Part III.* *https: // tgdtheory. fi/ tgdhtml/ Btgdnumber3. html* . Available at: https://tgdtheory.fi/pdfpool/picosahedron.pdf, 2023.

[K123] Pitkänen M. Wormhole Magnetic Fields. In *Bio-Systems as Self-Organizing Quantum Systems.* *https: // tgdtheory. fi/ tgdhtml/ BbioSO. html* . Available at: https://tgdtheory.fi/pdfpool/wormc.pdf, 2023.

[K124] Pitkänen M. Zero Energy Ontology. In *Quantum TGD: Part I.* *https: // tgdtheory. fi/ tgdhtml/ Btgdquantum1. html*. Available at: `https://tgdtheory.fi/pdfpool/ZEO.pdf`, 2023.

Articles about TGD

[L1] Pitkänen M. A Strategy for Proving Riemann Hypothesis. Available at: `https://arxiv.org/abs/math/0111262.`, 2002.

[L2] Pitkänen M. Further Progress in Nuclear String Hypothesis. Available at: `https://tgdtheory.fi/public_html/articles/nuclstring.pdf.`, 2007.

[L3] Pitkänen M. A Model for Protein Folding and Bio-catalysis. Available at: `https://tgdtheory.fi/public_html/articles/prebiotic.pdf.`, 2008.

[L4] Pitkänen M. DNA as Topological Quantum Computer. Available at: `https://tgdtheory.fi/public_html/articles/dnatqcart.pdf.`, 2008.

[L5] Pitkänen M. Evolution in Many-Sheeted Space-Time. Available at: `https://tgdtheory.fi/public_html/articles/prebiotic.pdf.`, 2008.

[L6] Pitkänen M. Quantum Model for Nerve Pulse and EEG . Available at: `https://tgdtheory.fi/public_html/articles/pulseeg.pdf.`, 2008.

[L7] Pitkänen M. TGD Inspired Quantum Model of Living Matter. Available at: `https://tgdtheory.fi/public_html/articles/quantumbio.pdf.`, 2008.

[L8] Pitkänen M. TGD Inspired Theory of Consciousness. Available at: `https://tgdtheory.fi/public_html/articles/tgdconsc.cpdf.`, 2008.

[L9] Pitkänen M. Physics as Generalized Number Theory II: Classical Number Fields, 2010.

[L10] Pitkänen M. Physics as Infinite-dimensional Geometry I: Identification of the Configuration Space Kähler Function, 2010.

[L11] Pitkänen M. Physics as Infinite-dimensional Geometry II: Configuration Space Kähler Geometry from Symmetry Principles, 2010.

[L12] Pitkänen M. Physics as Generalized Number Theory I: p-Adic Physics and Number Theoretic Universality, 2010.

[L13] Pitkänen M. Physics as Generalized Number Theory III: Infinite Primes, 2010.

[L14] Pitkänen M. Physics as Infinite-dimensional Geometry III: Configuration Space Spinor Structure, 2010.

[L15] Pitkänen M. Physics as Infinite-dimensional Geometry IV: Weak Form of Electric-Magnetic Duality and Its Implications, 2010.

[L16] Pitkänen M. The Geometry of CP_2 and its Relationship to Standard Model, 2010.

[L17] Pitkänen M. CMAP representations about TGD, and TGD inspired theory of consciousness and quantum biology. Available at: `https://www.tgdtheory.fi/tgdglossary.pdf.`, 2014.

[L18] Pitkänen M. Geometric theory of harmony. Available at: `https://tgdtheory.fi/public_html/articles/harmonytheory.pdf.`, 2014.

[L19] Pitkänen M. Morphogenesis, morphostasis, and learning in TGD framework. Available at: `https://tgdtheory.fi/public_html/articles/morpho.pdf.`, 2014.

[L20] Pitkänen M. Psychedelic induced experiences as key to the understanding of the connection between magnetic body and information molecules? Available at: `https://tgdtheory.fi/public_html/articles/psychedelics.pdf.`, 2014.

[L21] Pitkänen M. Pythagoras, music, sacred geometry, and genetic code. Available at: `https://tgdtheory.fi/public_html/articles/pythagoras.pdf.`, 2014.

[L22] Pitkänen M. Jeremy England's vision about life and evolution: comparison with TGD approach . Available at: `https://tgdtheory.fi/public_html/articles/englandtgd.pdf.`, 2015.

[L23] Pitkänen M. TGD based model for anesthetic action. Available at: `https://tgdtheory.fi/public_html/articles/anesthetes.pdf.`, 2015.

[L24] Pitkänen M. What Music Could Teach about Consciousness? Available at: `https://tgdtheory.fi/public_html/articles/musicophilia.pdf.`, 2015.

[L25] Pitkänen M. What went wrong with symmetries? Available at: `https://tgdtheory.fi/public_html/articles/whatiswrong.pdf.`, 2015.

[L26] Pitkänen M. Hydrinos again. Available at: `https://tgdtheory.fi/public_html/articles/Millsagain.pdf.`, 2016.

[L27] Pitkänen M. Is the sum of p-adic negentropies equal to real entropy? Available at: `https://tgdtheory.fi/public_html/articles/adelicinfo.pdf.`, 2016.

[L28] Pitkänen M. Number theoretical feats TGD inspired theory of consciousness. Available at: `https://tgdtheory.fi/public_html/articles/numberfeats.pdf.`, 2016.

[L29] Pitkänen M. p-Adicizable discrete variants of classical Lie groups and coset spaces in TGD framework. Available at: `https://tgdtheory.fi/public_html/articles/padicgeom.pdf.`, 2016.

[L30] Pitkänen M. TGD Inspired Comments about Integrated Information Theory of Consciousness. Available at: `https://tgdtheory.fi/public_html/articles/tononikoch.pdf.`, 2016.

[L31] Pitkänen M. Are we all artists?: or what my "Great Experience" taught me about consciousness. Available at: `https://tgdtheory.fi/public_html/articles/greatexperience.pdf.`, 2017.

[L32] Pitkänen M. Artificial Intelligence, Natural Intelligence, and TGD. Available at: `https://tgdtheory.fi/public_html/articles/AITGD.pdf.`, 2017.

[L33] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry?: part I. Available at: `https://tgdtheory.fi/public_html/articles/ratpoints1.pdf.`, 2017.

[L34] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry?: part II. Available at: `https://tgdtheory.fi/public_html/articles/ratpoints2.pdf.`, 2017.

[L35] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: `https://tgdtheory.fi/public_html/articles/valenceheff.pdf.`, 2017.

[L36] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: `https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11`, 2017.

[L37] Pitkänen M. Philosophy of Adelic Physics. Available at: `https://tgdtheory.fi/public_html/articles/adelephysics.pdf.`, 2017.

[L38] Pitkänen M. Questions about twistor lift of TGD. Available at: `https://tgdtheory.fi/public_html/articles/twistquestions.pdf.`, 2017.

[L39] Pitkänen M. Re-examination of the basic notions of TGD inspired theory of consciousness. Available at: `https://tgdtheory.fi/public_html/articles/conscrit.pdf.`, 2017.

[L40] Pitkänen M. Could also RNA and protein methylation of RNA be involved with the expression of molecular emotions? Available at: `https://tgdtheory.fi/public_html/articles/synapticmoods.pdf.`, 2018.

[L41] Pitkänen M. Could cancer be a disease of magnetic body? Available at: `https://tgdtheory.fi/public_html/articles/nanotesla.pdf.`, 2018.

[L42] Pitkänen M. Dark valence electrons and color vision. Available at: `https://tgdtheory.fi/public_html/articles/colorvision.pdf.`, 2018.

[L43] Pitkänen M. Emotions as sensory percepts about the state of magnetic body? Available at: `https://tgdtheory.fi/public_html/articles/emotions.pdf.`, 2018.

[L44] Pitkänen M. Getting philosophical: some comments about the problems of physics, neuroscience, and biology. Available at: `https://tgdtheory.fi/public_html/articles/philosophic.pdf.`, 2018.

[L45] Pitkänen M. New results in the model of bio-harmony. Available at: `https://tgdtheory.fi/public_html/articles/harmonynew.pdf.`, 2018.

[L46] Pitkänen M. TGD view about coupling constant evolution. Available at: `https://tgdtheory.fi/public_html/articles/ccevolution.pdf.`, 2018.

[L47] Pitkänen M. The experiments of Masaru Emoto with emotional imprinting of water. Available at: `https://tgdtheory.fi/public_html/articles/Emoto.pdf.`, 2018.

[L48] Pitkänen M. The Recent View about Twistorialization in TGD Framework. Available at: `https://tgdtheory.fi/public_html/articles/smatrix.pdf.`, 2018.

[L49] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: `https://tgdtheory.fi/public_html/articles/gcharm.pdf.`, 2019.

[L50] Pitkänen M. Are fundamental entities discrete or continous and what discretization at fundamental level could mean? Available at: `https://tgdtheory.fi/public_html/articles/zetaspecu.pdf.`, 2019.

[L51] Pitkänen M. Copenhagen interpretation dead: long live ZEO based quantum measurement theory! Available at: `https://tgdtheory.fi/public_html/articles/Bohrdead.pdf.`, 2019.

[L52] Pitkänen M. Earhquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology. Available at: `https://tgdtheory.fi/public_html/articles/earthquakes.pdf.`, 2019.

[L53] Pitkänen M. $M^8 - H$ duality and consciousness. Available at: `https://tgdtheory.fi/public_html/articles/M8Hconsc.pdf.`, 2019.

[L54] Pitkänen M. $M^8 - H$ duality and the two manners to describe particles. Available at: `https://tgdtheory.fi/public_html/articles/susysupertwistor.pdf.`, 2019.

[L55] Pitkänen M. New results related to $M^8 - H$ duality. Available at: `https://tgdtheory.fi/public_html/articles/M8Hduality.pdf.`, 2019.

[L56] Pitkänen M. Quantum self-organization by h_{eff} changing phase transitions. Available at: `https://tgdtheory.fi/public_html/articles/heffselforg.pdf.`, 2019.

[L57] Pitkänen M. Scattering amplitudes and orbits of cognitive representations under subgroup of symplectic group respecting the extension of rationals . Available at: `https://tgdtheory.fi/public_html/articles/symplorbsm.pdf.`, 2019.

[L58] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: `https://tgdtheory.fi/public_html/articles/zeoquestions.pdf.`, 2019.

[L59] Pitkänen M. TGD inspired theory of consciousness and living systems. Available at: `https://tgdtheory.fi/public_html/articles/badenbaden.pdf.`, 2019.

[L60] Pitkänen M. TGD view about McKay Correspondence, ADE Hierarchy, and Inclusions of Hyperfinite Factors. Available at: `https://tgdtheory.fi/public_html/articles/McKay.pdf.`, 2019.

[L61] Pitkänen M. TGD view about McKay Correspondence, ADE Hierarchy, Inclusions of Hyperfinite Factors, $M^8 - H$ Duality, SUSY, and Twistors. Available at: `https://tgdtheory.fi/public_html/articles/McKaygeneral.pdf.`, 2019.

[L62] Pitkänen M. Trying to understand why ramified primes are so special physically. Available at: `https://tgdtheory.fi/public_html/articles/ramified.pdf.`, 2019.

[L63] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: `https://tgdtheory.fi/public_html/articles/M8H1.pdf.`, 2020.

[L64] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: `https://tgdtheory.fi/public_html/articles/M8H2.pdf.`, 2020.

[L65] Pitkänen M. Could brain be represented as a hyperbolic geometry? Available at: `https://tgdtheory.fi/public_html/articles/hyperbolicbrain.pdf.`, 2020.

[L66] Pitkänen M. How to compose beautiful music of light in bio-harmony? Research Gate: `https://www.researchgate.net/publication/344623253_How_to_compose_beautiful_music_of_light_in_bio-harmony.`, 2020.

[L67] Pitkänen M. How to compose beautiful music of light in bio-harmony? `https://tgdtheory.fi/public_html/articles/bioharmony2020.pdf.`, 2020.

[L68] Pitkänen M. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group. Available at: `https://tgdtheory.fi/public_html/articles/SSFRGalois.pdf.`, 2020.

[L69] Pitkänen M. Zero energy ontology, hierarchy of Planck constants, and Kähler metric replacing unitary S-matrix: three pillars of new quantum theory (short version). Available at: `https://tgdtheory.fi/public_html/articles/kahlersm.pdf.`, 2020.

[L70] Pitkänen M. About the role of Galois groups in TGD framework. `https://tgdtheory.fi/public_html/articles/GaloisTGD.pdf.`, 2021.

[L71] Pitkänen M. Is genetic code part of fundamental physics in TGD framework? Available at: `https://tgdtheory.fi/public_html/articles/TIH.pdf.`, 2021.

[L72] Pitkänen M. Negentropy Maximization Principle and Second Law. Available at: `https://tgdtheory.fi/public_html/articles/nmpsecondlaw.pdf.`, 2021.

[L73] Pitkänen M. Some questions concerning zero energy ontology. `https://tgdtheory.fi/public_html/articles/zeonew.pdf.`, 2021.

[L74] Pitkänen M. TGD as it is towards the end of 2021. `https://tgdtheory.fi/public_html/articles/TGD2021.pdf.`, 2021.

[L75] Pitkänen M. About TGD counterparts of twistor amplitudes: part I. `https://tgdtheory.fi/public_html/articles/twisttgd1.pdf.`, 2022.

[L76] Pitkänen M. About TGD counterparts of twistor amplitudes: part II. `https://tgdtheory.fi/public_html/articles/twisttgd2.pdf.`, 2022.

[L77] Pitkänen M. Finite Fields and TGD. `https://tgdtheory.fi/public_html/articles/finitefieldsTGD.pdf.`, 2022.

[L78] Pitkänen M. Intersection form for 4-manifolds, knots and 2-knots, smooth exotics, and TGD. `https://tgdtheory.fi/public_html/articles/finitefieldsTGD.pdf.`, 2022.

[L79] Pitkänen M. Some New Ideas Related to Langlands Program *viz.* TGD. `https://tgdtheory.fi/public_html/articles/Langlands2022.pdf.`, 2022.

[L80] Pitkänen M. Trying to fuse the basic mathematical ideas of quantum TGD to a single coherent whole. `https://tgdtheory.fi/public_html/articles/fusionTGD.pdf.`, 2022.

[L81] Pitkänen M. Two objections against p-adic thermodynamics and their resolution. `https://tgdtheory.fi/public_html/articles/padmass2022.pdf.`, 2022.

[L82] Pitkänen M. About long range electromagnetic quantum coherence in TGD Universe. `https://tgdtheory.fi/public_html/articles/hem.pdf.`, 2023.

[L83] Pitkänen M. Holography and Hamilton-Jacobi Structure as 4-D generalization of 2-D complex structure. `https://tgdtheory.fi/public_html/articles/HJ.pdf.`, 2023.

[L84] Pitkänen M. New result about causal diamonds from the TGD view point of view. `https://tgdtheory.fi/public_html/articles/CDconformal.pdf.`, 2023.

[L85] Pitkänen M. Reduction of standard model structure to CP_2 geometry and other key ideas of TGD. `https://tgdtheory.fi/public_html/articles/cp2etc.pdf.`, 2023.

[L86] Pitkänen M. Symmetries and Geometry of the "World of Classical Worlds" . `https://tgdtheory.fi/public_html/articles/wcwsymm.pdf.`, 2023.

[L87] Pitkänen M. A fresh look at M^8H duality and Poincare invariance. `https://tgdtheory.fi/public_html/articles/TGDcritics.pdf.`, 2024.

[L88] Pitkänen M. What gravitons are and could one detect them in TGD Universe? `https://tgdtheory.fi/public_html/articles/whatgravitons.pdf.`, 2024.

[L89] Pitkänen M and Rastmanesh R. Arrow of time and neuroscience: TGD based view. Available at: `https://tgdtheory.fi/public_html/articles/precognize.pdf.`, 2020.

[L90] Pitkänen M and Rastmanesh R. DNA and Time Reversal. Research Gate: `https://www.researchgate.net/publication/344637491_DNA_and_Time_Reversal_immediate_October_12_2020.`, 2020.

[L91] Pitkänen M and Rastmanesh R. DNA and Time Reversal. Available at: `https://tgdtheory.fi/public_html/articles/DNAtimereversal.`, 2020.

[L92] Pitkänen M and Rastmanesh R. Homeostasis as self-organized quantum criticality. Available at: `https://tgdtheory.fi/public_html/articles/SP.pdf.`, 2020.

[L93] Pitkänen M and Rastmanesh R. Why the outcome of an event would be more predictable if it is known to occur? `https://tgdtheory.fi/public_html/articles/scavhunt.pdf.`, 2021.

Index