

Life and Death and Consciousness

M. Pitkänen

Email: matpitka6@gmail.com.

<http://tgdtheory.com/>.

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Abstract

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

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

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1 Introduction

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

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

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

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

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

Corresponding causalities are independent and quantum jump replaces entire time evolution with a new one so that the conflict between the causalities is resolved.

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

State function reduction occurs in cascade like matter proceeding to shorter scales and from system to the sub-system if system decomposes to a product of unentangled sub-systems in the reduction. The outcome at passive boundary of CD is a set of inherently negentropically entangled subsystems having no entanglement between themselves. These systems can be seen as sub-selves of self experiencing these subsystems as mental images.

For given CD state function reduction occurs repeatedly to what I call passive (light-like) boundary of CD and leaves members of state pairs at it invariant. Also the passive boundary itself remains unchanged. The members of state pairs at opposite, *active* boundary of CD experiences the analog of unitary time evolution followed by a reduction passive boundary: this occurs repeatedly as in Zeno effect. Active boundary also drifts further away from the passive boundary whereas nothing happens at the passive boundary.

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

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

1. The approach is that of physicist but not of physicalist. TGD tries to extend physics as a theory of regularities of conscious experience to a theory of consciousness. TGD does not try to reduce consciousness to a property of some system as physicalist would do, and therefore also avoids the hard problem plaguing monistic and dualistic approaches. For physicist the idea that consciousness would be assignable only to brain, human brain, or even male brain is extremely non-feasible and bring in mind the view about Earth as the center of Universe. One could blame TGD for panpsychism. This kind of view is adopted also by Tononi and Koch in IIT approach [J6] (for TGD based criticism of IIT see [L9]). Self hierarchy is the key prediction challenging the standard neuroscience based view, and combined with the identification of sub-selves as mental images gives rise to a rather powerful and predictive approach. Hence in the following life and death are seen as universal notions expected to make sense in much wider framework than biological systems.

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

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

3. In ZEO physical states are replaced with something analogous to events, pairs of positive and negative energy states with opposite total quantum numbers. This is also new and difficult to comprehend. For people thinking in terms eastern philosophies ZEO might be easier notion but for a “westener” the idea that there are only observations of events and that physical world as something absolute and given is only a narrative, looks weird. ZEO is of course consistent with the laws of physics, in particular conservation laws, but implies their scale dependence accepted already in quantum field theories.

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

4. The assumption about fixed arrow of time is not usually questioned. ZEO forces to give up this belief, and predicts the notions of time-reversed self and re-incarnation. These can be argued to be very weird predictions, and they might be of course wrong. This can be tested. TGD inspired theory of consciousness is indeed a theory and good theories usually predict something not consistent with naive everyday intuitions. Libet’s strange findings about active aspect of consciousness [J1] could be understood if the arrow of time changes in motor actions.
5. The notion of macroscopic quantum coherence is central and represents new physics relevant for quantum biology. The new quantum biology comes from several sources: the hierarchy of Planck constants $h_{eff} = n \times h$ making possible macroscopic quantum coherence for large enough values of n assignable to dark matter as phases of ordinary matter so that dark matter would become key player in the drama of living matter.

Second new notion is what I call many-sheeted space-time. In field theory and general relativity limit of TGD the effects of many-sheeted space-time show as small anomalies [K27] but in biology this notion becomes central.

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

One can compress the general vision to following mnemonics: ZEO, CD, NMP, NE, and Zeno effect. In the sequel I describe TGD more precisely. The article [L6] gives a more detailed view about TGD, TGD inspired theory of consciousness, and TGD inspired quantum biology. Appendix of this article contains a summary of TGD inspired quantum biology.

2 TGD

General theory of relativity (GRT) plagued by the problem that the notions of energy and momentum are not well-defined for curved space-time. The proposal for overcoming the energy problem (made 1977, thesis came 1982) was that space-times are not abstract 4-D manifolds but representable as 4-D surfaces in certain 8-dimensional space-time $H = M^4 \times CP_2$, which is empty Minkowski space M^4 with points replaced with certain very small 4-D space CP_2 fixed uniquely from the condition that standard model symmetries and standard model fields can be geometrized. This choice of H is uniquely fixed both by twistorial considerations [K38, K35] or by the condition that theory is consistent with standard model symmetries.

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

TGD Universe is predicted to be fractal: this replaces the naive Planck length scale reductionism with fractality for which the simplest realization would be p-adic length scale hypothesis emerging from p-adic thermodynamics and dark matter hierarchy. Non-trivial predictions emerge in all scales from Planck length to cosmology and this makes it very difficult to communicate TGD for colleagues believing firmly on naive length scales reductionism.

In what follows I will proceed from quantum TGD to classical TGD without starting from particle physics observations - it would be extremely boring to repeat same old arguments again and again and reader can find these arguments from [K28].

2.1 Quantum TGD

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

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

The condition that the entire quantum theory is geometrized requires infinite-dimensional geometric structure instead of space-time and the “world of classical worlds” (WCW) identified roughly as the space of space-time surfaces is the natural identification [K3, K7].

1. The construction of quantum TGD leads to a generalization of the notion of super-space of Wheeler and to construction of infinite-dimensional geometry that I call “World of Classical Worlds” (WCW) having rough mathematical identification as space of 3-surfaces in H (ZEO dictates the identification in more detail). The mere mathematical existence of WCW geometry fixes it essentially uniquely - this is true already for the loop spaces of string model [A1] - and therefore physics. A huge generalization of the symmetries of super-string models emerges giving hopes of understanding the theory.

The geometrization of hermitian conjugation of quantum theory requires that WCW allows complex structure its metric is Kähler metric [K7] and coded by Kähler function identified in terms of Kähler action for a preferred extremal: this gives direct connection with classical physics since induced Kähler form define classical U(1) field, for the U(1) factor of electroweak gauge group assignable with weak hyper-charge. twistor lift implies the presence of a volume term identifiable in terms of cosmological constant. It would bring also Planck length into the theory as the radius of twistor sphere [K38].

2. Quantum states are identified as classical WCW spinor fields so that there is no need to perform quantization and state function reduction is the only genuinely quantal aspect of TGD [K21, K31]. Spinor structure requires identification of gamma matrices anticommuting

to WCW metric and if the metric is Kähler metric, the anti-commutation relations are completely analogous to those of fermionic oscillator operators and one can indeed express the gamma matrices as linear superpositions of fermionic oscillator operators at space-time surface. Second quantization at space-time level is a purely classical notion at WCW level and becomes geometrized in WCW context.

3. ZEO (Zero Energy Ontology) is an essential element of theory. Usually one assumes that in classical physics generalized positions and their time derivatives (generalized velocities) giving at given moment of time in 3-D snapshot of space-time dictated the time evolution. This has generalization to Schrödinger equation. One has initial value problem.

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

ZEO is much more flexible than ordinary ontology since any zero energy state can be created from vacuum whereas in standard classical ontology only one solution of field equations is realized and in principle it is not possible to test the theory without additional assumptions. ZEO is especially natural in biology and neuroscience: the notions like function, behavioral pattern, and habit are not easy to describe in terms of the state of organism as 3-D snapshot of time evolution.

The two time=constant snapshots are actually replaced with past and future boundaries of CD, which is the intersection of future and past directed light-cones of Minkowski space with each point replaced with CP_2 . The ends of space-time surfaces are at the these boundaries. Zero energy states have opposite conserved quantum numbers at the opposite boundaries of CD: this guarantees that conservation laws are satisfied and the system is consistent with standard laws of physics. CDs form a fractal hierarchy. There are CDs within CDs and CDs can also overlap.

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

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

This eventually led to the realization that partonic 2-surfaces and string world sheets should be enough for the formulation of WCW geometry and quantum TGD [K2]. Classical fields in the interior of space-time surface would be needed only in quantum measurement theory, which demands classical physics in order to interpret the experiments. The outcome is SH stating that quantum physics should be coded by string world sheets and partonic 2-surfaces inside given CD. SH is very much analogous to the AdS/CFT correspondence but is much simpler: the simplicity is made possible by much larger group of conformal symmetries. 2-dimensionality of space-time regions carrying fermion field can be deduce also from the condition that electromagnetic charge is well-defined for spinor modes: this requires that W boson fields vanish and this implies in the generic case 2-D string world sheets. Number theoretic vision suggests the interpretation of string world sheets and partonic 2-surfaces as commutative or co-commutative sub-manifolds of the space-time having quaternionic (associative) tangent space as a 4-surface in the imbedding space with octonionic (non-associative) tangent space [K18, K32].

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

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

2.1.2 Quantum Criticality and hierarchy of Planck constants as dark matter hierarchy

The Kähler coupling strength α_K appearing in Kähler action is analogous to temperature. In its original form [K7] QC stated that this coupling strength is analogous to critical temperature and therefore has discrete spectrum. This idea makes sense even if Kähler action is generalized to contain additional terms: all coupling constants would be analogous to critical thermodynamical parameters.

Indeed, the twistor lift of TGD [K38, K35] replacing space-time surfaces with their twistor spaces in 12-dimensional product of twistor spaces of M^4 and CP_2 indeed brings in cosmological constant Λ and Planck length as radius of the sphere S^2 serving as the fiber of twistor space. This lift makes sense only for $M^4 \times CP_2$ making this choice unique. If Planck length and cosmological constant emerge in this manner their spectrum would be fixed by QC condition. The negative pressure implying accelerated cosmic expansion can be also assigned to magnetic flux tubes with monopole flux so that the situation remains open.

The meaning of QC at the level of dynamics has become only gradually clearer. The development of several apparently independent ideas generated for about decade ago have led to the realization that QC [K29] is behind all of them. Behind QC are in turn number theoretic vision and strong forms of general coordinate invariance (GCI) and holography (SGCI and SH).

1. The hierarchy of Planck constants labelling a hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of the super-symplectic algebra assignable to the boundary of CD with points replaced with CP_2 . The conformal weights are n -ples of those for the entire algebra. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question. For $n > 1$ the hierarchy levels are interpreted in terms of dark matter. What is highly non-trivial that the conformal weights itself need not be integers or half integers as usually. The generators of algebra could have conformal weights which are proportional to zeros of zeta and poles of zeta so that the number of generating elements (finite for ordinary super-conformal algebras) would be infinite [K33]. Physical states would however have real conformal weights which would be half integers (conformal confinement).

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

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

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

3. The hierarchy of algebraic extensions of rationals defines the values of the parameters characterizing the 2-surfaces, and one obtains a number theoretical realization of an evolutionary hierarchy. One can also algebraically continue the space-time surfaces to various number fields - reals and the algebraic extensions of p-adic number fields. Physics becomes adelic [K32].

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

4. The assignment of the hierarchy of Planck constant to a hierarchies of inclusions of hyperfinite factors of type II_1 is natural. Also the interpretation in terms of finite measurement resolution makes sense. As n increases the sub-algebra acting as conformal gauge symmetries is reduced so that some gauge degrees of freedom are transformed to physical ones. The transitions increasing n occur spontaneously since criticality is reduced. A good metaphor for TGD Universe is as a hill at the top of a hill at the top.... In biology this interpretation is especially interesting since living systems can be seen as systems doing their best to stay at criticality using metabolic energy feed as a tool to achieve this. Ironically, the increase of \hbar would mean increase of measurement resolution and evolution!
5. If twistor lift is not performed, the only coupling constant of the theory is Kähler coupling constant $\alpha_K = g_K^2/4\pi\hbar$, which appears in the definition of the Kähler function K characterizing the geometry of WCW. In the most general case α_K has a spectrum of critical values and this conjecture seems at this moment the most reasonable one. It has indeed turned out that the discrete spectrum could have interpretation in terms of discretized coupling constant evolution for U(1) coupling constant of standard model. The identification of the spectrum in terms of zeros of so called fermionic zeta function expressible in terms of Riemann zeta is attractive [K33]. The exponent of K defines vacuum functional analogous to the exponent of Hamiltonian in thermodynamics. The allowed values of $\alpha_K = g_K^2/4\pi\hbar_{eff}$ should be analogous to critical temperatures and determined by QC requirement.

2.2 Classical TGD

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

2.2.1 Space-time surfaces as preferred extremals of Kähler action

Preferred extremal of Kähler action have remained for a long time one of the basic poorly defined notions of TGD. There are pressing motivations for understanding what “preferred” really means. For instance, the conformal invariance of string models naturally generalizes to 4-D invariance defined by quantum Yangian of quantum affine algebra (Kac-Moody type algebra) characterized by two complex coordinates and therefore explaining naturally the effective 2-dimensionality [K38].

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

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

2.2.2 Many-sheeted space-time and topological field quantization

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

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

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

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

The notion of magnetic body carrying dark matter identified as macroscopically quantum coherent $h_{eff} = n \times h$ phases has become central in TGD inspired quantum biology [K23, K22]. Magnetic body becomes intentional agent using biological body as a sensory receptor and motor instrument. Communication and control would be based EEG and its fractally scaled variants consisting of dark photons. The size of magnetic body is rather large, at EEG frequency range the size scale is defined by the wave length of photons involved and is of the order of the size scale of Earth. The proposal is that bio-photons are created in a phase transition transforming dark photons to ordinary photons [K24]: since bio-photons have energies are in the range of visible and UV photons, this requires that the value of h_{eff}/h is roughly the ratio of the frequency of EEG photon with the frequency of visible photon and rather large.

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

2.2.3 New ontology

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

1. At space-time level many-sheeted space-time represents new piece of ontology. Single space-time sheet is extremely simple objects and the information needed to construct it is by SH 2-dimensional. Complexity emerges at quantum field theory limit when the sheets of the many-sheeted space-time are replaced with single slightly curved region of M^4 .
2. The hierarchy of Planck constants identified in terms of dark matter as phases of ordinary matter represents second new ontological element. Dark matter is assumed to reside at magnetic body which also represents a new ontological element.
3. A further modification of ontology is the replacement of the usual positive energy ontology (PEO) with what I call ZEO already described. In ZEO quantum states are superpositions of quantum evolutions connecting the positive and negative energy parts of the states. Zero energy states are essentially 4-D and only the positive and negative energy parts are 3-D. Quantum jumps/state function reductions re-create the zero energy states with new ones and this allows to solve the basic paradox of ordinary quantum measurement theory due to the fact that non-determinism of state function reduction is in conflict with the determinism of unitary time evolution. One also ends up with identification of "self" as conscious entity: self corresponds to generalized Zeno effect: to a sequence of state function reduction to say positive (positive) energy part of zero energy state [K1] [L8]. Self dies when the first reduction to negative (positive) part occurs. Also the origin for the flow of experienced time can be understood.

2.2.4 Hierarchies

TGD Universe is characterized by various hierarchies. At space-time level there is a hierarchy of space-time sheets labelled by a hierarchy of p-adic length scales coming as primes near powers of two and probably generalizing to primes near powers of prime [K26, K32]. In ZEO and at imbedding space level there is a hierarchy of CDs labelled by their size scales coming as integer multiples of CP_2 scales. The fractal hierarchy of symplectic sub-algebras leads to a generalization of quantum theory based on a hierarchy of Planck constants characterizing hierarchy of dark matters [K5, K29], hierarchies of inclusions of hyper-finite factors [K20], hierarchies of breakings of super-symplectic gauge symmetry [K21, K31] associated with a hierarchy of quantum criticalities [K29]. There is also a number theoretic hierarchy of algebraic extensions of rationals accompanied by those of p-adic number fields [K32] allowing to see evolution as a gradual increase of the complexity for extensions of rationals assignable to the parameters characterizing string world sheets and partonic 2-surfaces. In TGD inspired theory of consciousness [K9] self hierarchy emerges.

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

By SH implied by the SGCI the core of the mathematical description of quantum TGD reduces to that for 2-D systems associated with partonic 2-surfaces and string world sheets. Although space-time is 4-D, all that can be said mathematically about quantum physics can be reduced to these 2-D "space-time genes". 4-D space-time surfaces are however necessary for the classical description of TGD necessary to interpret quantum measurements in terms of frequencies and wavelengths classical space-time picture about particles. This reduction implies that the representations of charges of super-symplectic Yangian [K38, K35] are in terms of fermionic strings connecting partonic 2-surfaces, which means enormous simplification of the theory. This representation also involves a generalization of AdS/CFT duality to TGD framework as manifestation of SGCI basically [K2].

2.3 Number theoretical physics

Number theoretical physics involves several threads [K32].

1. p-Adic physics as correlate for cognition, imagination, and intentionality [K17] p-Adic physics was originally inspired by the challenge of understanding the mass scales of elementary particles but it soon turned that the interpretation in terms of mathematical correlates of cognition and imagination is very natural. This in turn forced the conclusion that cognition is probably present in all length scales, rather than only at the level of brain. The eventual outcome was a fusion of real and p-adic physics in terms of adelic physics.
2. Classical number fields emerge very naturally in TGD framework [K18]. For instance, the conjecture is that space-time surfaces as preferred extremals of Kähler action are quaternionic sub-manifolds of imbedding space endowed with octonionic structure. Also quaternion analyticity [A3, A2] as a generalization of complex analyticity central in string models is very attractive conjecture [K38] in accordance with the original vision that 2-D analyticity in some sense generalizes to its 4-D variant.
3. Infinite primes [K16] are constructed by a repeated second quantization of arithmetic quantum field theory and could be essential for understand of quantum TGD.

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

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

1. The attempt to understand elementary particle mass spectrum led to the hypothesis that p-adic number fields - one for each prime $p = 2, 3, 5, \dots$, which are completions of rationals like real numbers, allow to construct what I called p-adic thermodynamics allowing to understand particle masses as kind of thermal masses resulting when massless particles suffer slight thermal mixing with particles with mass scale given by CP_2 mass of order 10^{-4} Planck masses.
2. The failure of well-orderedness property for p-adic numbers brings in the corresponding failure due to a finite measurement resolution and leads to the vision that p-adic numbers are ideal for describing the effects of finite measurement resolution and cognitive resolution.
3. The failure of strict determinism for the partial differential equations suggest strongly that it serves as a correlate for cognition, imagination, and maybe also intention is closely related.
4. The fusion of real physics and various p-adic physics (identified as correlates for cognition, imagination, and intentionality) to single coherent whole leads to adelic physics [K32]. Adeles associated with given extension of rationals are Cartesian product of real number field with all p-adic number fields extended by the extension of rationals. Besides algebraic extensions also the extension by any root of e is possible since it induces finite-dimensional p-adic extension. One obtains hierarchy of adeles and of corresponding adelic physics interpreted as an evolutionary hierarchy.

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

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

$$S = - \sum_k P_k \log(P_k) \rightarrow \sum_k P_k \log(N_p(P_k)) . \quad (2.1)$$

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

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

The possibility of NE together with NMP [K10] implies that the reduction does not always lead to an unentangled state but can generate NE. Living systems would be systems generating NE and biological evolution could be seen as a gradual generation of negentropic resources - I have called them Akashic Records. For rational probabilities entanglement negentropy equals to real entropy [L5]. This might relate to the Jeremy England's vision that high entropy is relevant for living matter.

What is important that entanglement negentropy and thermodynamical entropy are *not* negatives of each other. Hence NMP is not in conflict with the second law but predicts it for the ordinary matter as a consequence of non-determinism of state function reduction. It is however true that large entropic resources realized as a large number of states with the same energy makes possible both large thermodynamical entropy and NE with large negentropy.

2.3.2 The extension of real physics to adelic physics

In TGD framework cognition is described in terms of p-adic number fields and has led to a fusion of real and various p-adic physics to what I call adelic physics [K32]. Real physics corresponds to sensory experience and p-adic physics to cognition and imagination. Originally I talked about p-adic physics as physics of cognition and intentionality but I have become ambivalent about intentionality: this issue remains unsettled.

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

1. The naive idea is that rationals belong to the intersection of reals and p-adics. More generally, points in algebraic extension of rationals would be common to realities and p-adicities which correspond to "thought bubbles" or imaginations. This hierarchy defines a hierarchy of adeles having interpretation in terms of evolution leading to increasingly complex algebraic extensions of rationals.
2. The first guess was that this means at space-time level that imbedding space points with rational valued coordinates (or values in the extension of rationals) correspond to common points of real and p-adic space-time surfaces. This picture however leads to problems with both GCI and key symmetries of TGD. What are the preferred coordinates of space-time surface which would be in algebraic extension of rationals in the intersection? Should one restrict symmetry groups to their discrete subgroups?
3. A partial resolution of the problem came from the realization that the intersection of realities and p-adicities corresponds to space-time surfaces, whose representation is such that they make sense both in real and p-adic sense [K32]. This requires that the WCW coordinates of these surfaces are invariant under various symmetries and general coordinate transformations of space-time belong to the extension of rationals in question. At the level of WCW the coordinates are highly unique on basis of symmetries and by GCI at space-time level. This also means discretization of the infinite-dimensional WCW and together with huge isometry group of WCW gives hopes about computability of TGD.

4. As often happens, also the original idea about points of given algebraic extension of rationals as common to real and p-adic space-time surfaces makes sense: one can say that these discrete points define cognitive representations in the real world. The point is that space-time surfaces can be identified as 4-surfaces in H and discretization is induced by that of H . At the first step, the pieces of hyperboloids inside CD and CP_2 can be replaced with their discrete variants making sense both in real and p-adic sense [L7].

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

The outcome is a precise mathematical formulation for the p-adic counterparts of space-time surfaces as preferred extremals of Kähler action. The p-adic variants of coset spaces can be seen as discretizations of real coset spaces with discrete points replaced by p-adic continua analogous to the monads of Leibniz [L7]. This would make possible discretization without losing differentiability central for field equations. One can define p-adic field equations inside these monads and strong SH makes sense in both real and p-adic sector.

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

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

2.3.3 p-Adic physics as physics of imagination

A further step in the progress came from the discovery of SH [K2]. 2-dimensional surfaces (string world sheets and partonic 2-surfaces) are fundamental objects and 4-D physics is a kind of algebraic continuation from this intersection of reality and various p-adicities in both real and p-adic sectors of the adelic Universe. 4-D space-time surfaces are preferred extremals of Kähler action making them effectively 2-D in the sense that the 2-D surfaces serve as “space-time genes”. Also the quantum states assignable to the 2-D surfaces can be algebraically continued to the entire 4-D space-time.

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

This argument becomes more precise as one realizes that SH is slightly broken: even information theoretically one has only effective 2-dimensionality [K32]. This means that 4-surfaces as preferred extremals are dictated by the data at string world sheets and possibly also partonic 2-surfaces and by data discrete set of points with preferred imbedding space coordinates in the extension of rationals defining the adelic structure by inducing the extensions of p-adic number fields. For p-adic number fields pseudo-constants make it easy to construct the algebraic continuation to a

preferred extremal containing the discretization. For reals this is possible only in special cases. These discretizations correspond to realizable imaginations.

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

2.3.4 Negentropic entanglement (NE)

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

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

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

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

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

1. The Hilbert spaces defining state spaces has as their coefficient field always some algebraic extension of rationals so that number theoretic entropies make sense for all primes. p-Adic numbers as coefficients cannot be used and reals are not allowed. Since the same Hilbert space is shared by real and p-adic sectors, a given state function reduction in the intersection has real and p-adic space-time shadows.
2. State function reductions at these 2- surfaces at the ends of CD take place in the intersection of realities and p-adicities if the parameters characterizing these surfaces are in the algebraic extension considered. It is however not absolutely necessary to assume that the coordinates of WCW belong to the algebraic extension although this looks very natural.
3. Does NMP apply to the sum of real and p-adic entropies (Option 1) or only to the sum of p-adic entanglement entropies (which can be negative) (Option 2). The situation is not settled yet.

- (a) For Option 1 the total entropy vanishes identically for *rational* probabilities and NMP would say nothing about the situation [L5]. NMP would not prevent or favor state function reduction. It is not clear whether this situation corresponds to that in the physics of ordinary matter as opposite to that of living matter. For algebraic probabilities there would be a competition between real and p-adic sectors and p-adic sectors would win for algebraic extensions in the sense that p-adic entropy would be larger than real entropy.
- (b) For Option 2 NMP would stabilize NE also for rational probabilities. One can wonder whether one obtains the ordinary state function reduction at all for this option. In ZEO state function reductions to the opposite boundary of CD would be however forced to occur and second law would be the outcome also in this case.

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

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

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

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

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

TGD inspired theory of consciousness can be seen as a generalization of the quantum measurement theory by making observer part of physical system as conscious entity subject to laws of quantum physics. I will talk about this conscious entity as self and pose no a priori restrictions what self can be. The basic vision is that quantum measurement theory must be generalized so that observer ceases to be an outsider and is described by the quantum physics. ZEO plays a key role in this generalization and makes highly non-trivial predictions. Raising quantum measurement to a universal physical phenomenon requires the identification of the density matrix of subsystem as a universal observable and introduction of Negentropy Maximization Principle (NMP) [K10] as the fundamental variational principle of consciousness.

3.1 ZEO

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

1. In TGD framework the answer is ZEO [K10]. The concept of quantum state is generalized. States are now analogs for physical events characterized by initial and final quantum state that is pairs of positive and negative energy states. The conserved quantum numbers of the members are opposite so that zero energy states can be created from vacuum. This is a radical generalization of the physicalist world of view but entirely consistent with conservation laws: there is no need to give laws of physics in order to have free will. Positive and negative energy parts of the zero energy states can be assigned to opposite light-like boundaries of CDs, which are intersections of future and past directed light-cones multiplied by CP_2 . CDs form a fractal scale hierarchy. They can be seen as imbedding space correlates for the 4-D perceptive fields of selves.
2. CD is a central notion in ZEO and serves as imbedding space correlate for self. State function reduction can occur to either boundary of CD (“upper” or “lower”). Self can be seen as a generalized Zeno effect - a sequence of state function reductions to either boundary of CD. These two kinds of selves can be said to be time reversals of each other. The period of non-boiling pot corresponds to the passive boundary of CD not changing in the reductions: also the parts of zero energy states at this boundary remain unaffected. The opposite - active - boundary is shifted towards future reduction by reduction and states at it are changed. The shifting the geometric future gives rise to the experienced time flow. This is the analog of unitary time evolution.

3.2 NMP as variational principle of consciousness

One must generalize standard quantum measurement theory to a theory of consciousness. The notions of NMP, entanglement negentropy and negentropic entanglement (NE) are the key notions.

1. Negentropy Maximization Principle (NMP) [K10] is the variational principle of consciousness in TGD framework reducing to quantum measurement theory in Zero Energy Ontology assuming adelic physics. Negentropy Maximization Principle or something akin to it should be consistent with the standard rules of quantum measurement theory and possibly generalize them. In particular, NMP should tell which observables are measured in given entangled situation. The density matrix defined by the entanglement is the unique candidate for the universal observable. All systems could be said to give rise to quantum measurements. NMP must decide how long the self “lives”: self lives as long as repeated state function reductions at the same boundary give the maximal negentropy gain.
2. One must have a mathematical definition of negentropy [K10]. When NE is possible and what is the measure for the negentropy? Shannon entropy is the natural starting point but it cannot have negative values in real context. One could define information as a reduction of entropy as conscious observer learns the state of the system under consideration: the IIT approach of Tononi [J6], [L9, L6] relies on this notion and leads to a circular definition of conscious information. Now however the conscious entity would be this system and this definition of information does not apply. One must find a genuine measure of information assignable to entanglement as entanglement negentropy rather than lack of information about the state of either entangled member of entangled by identifiable as entanglement entropy (ordinary Shannon entropy).

Here one cannot avoid number theory and I can only apologize. The p-adic generalization of Shannon entropy by replacing the logarithms of probabilities with the logarithms of their p-adic norms provides a possible solution of the problem [K10, K1]. It is well defined for algebraic entanglement probabilities belonging to the algebraic extension of rationals defining also the extensions of various various p-adic number fields) [L5].

Adelicity (roughly: adeles correspond to Cartesian product of positive real numbers and all p-adic number fields) holds true in the sense that the sum of real and p-adic information measures (finite number of primes contribute) over all primes vanishes for rational entanglement probabilities. This is not the case for the algebraic extensions of adeles induced by those of rationals [L5].

It is not quite clear whether NMP applies to the sum of p-adic entropies or to the sum of real and p-adic entropies providing alternative definitions of information. Both options conform with the fact that large entropy seems to be prerequisite for life as proposed Jeremy England [I4] [K30] [L2].

3. NE (negentropic entanglement) is a further key notion and entanglement negentropy identified as number theoretic entanglement entropy, which can be negative. NE can only increase in state function reductions and this brings in evolution forced by NMP.

In the formulation of NMP in terms of maximal negentropy gain one considers divisions of the system into subsystem and complement and finds the pair for which the reduction of entanglement would give maximum reduction of entropy. If the system is irreducible this kind of pair characterized by entropic entanglement cannot be found. The eigenstates of density matrix for negentropically entangled subsystems are in 1-1 correspondence. An interesting question is whether associations in the sense of neuro science corresponds to NE between the states of associated systems.

State function reduction cascade is a key notion. State function reduction sequences is a top down cascade propagating downwards to smaller system sized. First the reduction in CD scale occurs. The resulting two subsystems decompose to two parts and so on until decomposition is not possible anymore because it would not generate negentropy.

There is an obvious analogy with the Integrated Information Theory (IIT) of Tononi and Koch. The quantity Φ postulated by Tononi and Koch [J6] resembles negentropy in TGD [L9]. The basic objection against IIT is that the notion of conscious information is circular being based on entropy as fundamental notion. Information is defined as reduction of entropy when conscious entity learns what the state of system is. The notion of conscious information cannot involve this kind of dependence. The outcome is a paradox: printer printer text is conscious if no-one knows about the contents of the file, not if some-one already knows since the definition of conscious information reduces it to conscious information gained by the outsider. This is not surprising, since entropy as a notion belongs to the physics of outsider about object rather than subject.

In TGD framework negentropy for entanglement does not involve this kind of assumption since conscious information represents abstraction or rule with the superposed state pairs (a_i, b_i) representing the instances of a rule (A, B) and A and B representing concepts.

3.3 Details related to NMP

What happens in state function reduction and what NMP really says is still far from being completely clear. The basic condition is that standard measurement theory emerges as a special case and is forced by NMP [K10]. This does not however fix the NMP completely.

1. *Adelic NMP as the only reasonable option*

I have considered two options for NMP.

1. In the original approach to NMP it was assumed that both generic entanglement with real entanglement probabilities and entanglement with algebraic entanglement probabilities are possible. Real entanglement is entropic and demands standard measurement theory leading to a 1-D eigen-space of the density matrix. Algebraic entanglement can be negentropic in number theoretic sense for some p-adic primes, and in this case state function reduction occurs only if it increases negentropy. It takes place to N-dimensional eigen-space of the density matrix. The basic objection is that real entanglement is transcendental in the generic case reducing to algebraic entanglement only as a special case. Algebraic entanglement is also extremely rare without additional physical assumptions.
2. In the adelic approach entanglement coefficients and therefore also entanglement probabilities are always algebraic numbers from the condition that the notion of p-adic Hilbert space makes sense. Also extensions of rationals defining finite-dimensional extension of p-adic numbers (roots of e can appear in extension) must be allowed. Same entanglement can be seen from both real (sensory) and p-adic perspectives (cognitive). The entanglement is always entropic in the real sector but can be negentropic in some p-adic sectors. It is now clear that the adelic option is the only sensible one.

2. Variants of the adelic NMP

The adelic option allows to consider several variants.

1. Negentropy could correspond **a)** to the sum $N = N_R + \sum_p N_p$ of real and various p-adic negentropies or **b)** to the sum $N = \sum N_p$ of only p-adic negentropies. N_p is non-vanishing for a finite number of p-adic primes only as is easy to find. In both cases $\sum_p N_p$ could be interpreted as negentropy assignable to cognition. N_R might have interpretation as a measure of ignorance of one of the entangled systems about the state of other.
2. NMP implies that state function reduction (measurement of density matrix leading to its eigen-space) occurs if negentropy **1)** is not reduced or **2)** increases. This means that NE is stable against NMP.

Can one select between these options?

1. For option **a)** NMP becomes trivial for rational entanglement probabilities as is easy to find: one has $N = N_R + \sum_p N_p = 0$. NMP does not force state function reduction to occur but it could occur and imply ordinary state function reduction as a special case for option **1)** (when eigen-spaces are 1-dimensional). Therefore one would have option **1a)**.
2. If option **1a)** is unrealistic, only the options **1b)** and **2b)** with $N = \sum_p N_p$ are left. For option **2b)** state function necessarily occurs for $N = \sum_p N_p < 0$ but not for $N = 0$ - not even in rational case. For option **2b)** the state function reduction could occur also for $N = 0$. However, since N_p is proportional to $\log(p)$ and the numbers $\log(p)$ are algebraically independent, $N = 0$ is not actually possible so that **1b)** and **2b)** are equivalent. Therefore NMP states that $N = \sum_p N_p$ must increase for $N < 0$: this forces state function reduction to an eigen-space of density matrix.

But is it really possible to have $\sum N_p < 0$ making possible ordinary state function reduction? For rational entanglement probabilities this is not possible by $S_R = \sum_p N_p$ and one might even speculate that for algebraic extensions one has $\sum_p N_p \geq S_R$. Mathematician could probably check the situation. $\sum_p N_p \geq S_R$ holds true, entanglement is stable against NMP and ordinary state function reduction is not possible. This would leave only the option **1a)** and NE with $N > 0$ would be stable also now. $N = 0$ entanglement (possibly rational always) would allow ordinary state function reduction.

This leaves still two options. Negentropy gain is **A)** maximal or **B)** non-negative but not necessarily maximal: I have considered the latter option earlier. For option **1a)** reduction is possible only for $N = 0$ and in this case negentropy gain is zero for all possible eigen-spaces of density matrix and maximality condition does not say anything.

1. For option **1a)** reduction is possible only for $N = 0$ and in this case negentropy gain is zero for all possible eigen-spaces of density matrix and **A)** and **B)** are equivalent. One obtains ordinary state function reductions.
2. Consider next the equivalent options **1b)** and **2b)** making sense if $\sum_p N_p < 0$ is possible. For option **A)** negentropy gain is maximal and the reduction occurs to an eigen-space with maximum dimension $N = N_{max}$. There can be several eigen-spaces with the same maximal dimension. As a special case one obtains ordinary state function reduction. The reduction probability is same as in standard quantum measurement theory.

For option **B)** the reduction could occur also to any N -dimensional eigen-space or its sub-space. The idea would be that NMP allows something analogous to a choice between good and evil: the negentropy gain could in this case be also smaller than the maximal one corresponding to $\log(N_{max})$. This would conform with the intuition that we do not seem to live in best possible world. On the other hand, negentropy transfer between systems could be also seen as stealing in some situations and metabolism identified as negentropy transfer could be seen as the fundamental "crime" to which all other forms of reduce.

To sum up, the only option which guarantees without additional assumptions (possibility of $\sum N_p < 0$) ordinary state function reduction and stability of NE is option **1a**).

3. *Could quantum measurement involve also adelic localization?*

For option **B**) there is still one possible refinement involved. p-Adic mass calculations lead to the conclusion that elementary particles are characterized by p-adic primes and that p-adic length scale hypothesis $p \simeq 2^k$ holds true: a more general form of hypothesis allows also to consider primes near powers q^n of some small prime such as $q = 3$.

Could state function reduction imply also adelic/cognitive localization in the sense that the negentropy is nonzero and positive for only single p-adic prime in the final state? The reduction would occur to p^k -dimensional eigen-space with p^k dividing N : any divisor would be allowed. Note that Hilbert spaces with prime dimension are prime with respect to the decomposition to tensor product so that reduction would select prime power factor of the eigen-space. This would in general reduce negentropy gain.

The information theoretic meaning would be that prime-dimensional Hilbert spaces are stable against decomposition to tensor products so that the notion of entanglement would not make sense and therefore also the change of the state by the reduction of entanglement would be impossible. I have considered the possibility that prime-dimensional state spaces could make possible stable storage of quantum information [L11]. The prime-dimensional state when imbedded to higher-dimensional space - say space representing N qubits - could be interpreted as an entangled state and would be unstable with respect to state function reduction.

This hypothesis would provide considerable insights to the origin of p-adic length scale hypothesis. To get a contact with physics consider electron as an example.

1. In the case of electron one would have $p = M_{127} = 2^{127} - 1 \sim 10^{38}$. Could electron decompose to two entangled subsystems with density matrix equal to $p \times p$ identity matrix? The dimension of eigen-space would be huge and electron would carry negentropy of 127 bits: also p-adic mass calculations combined with a generalization of Hawking-Bekenstein formula suggest that electron carries entropy of 127 bits: in adelic picture these views are mutually consistent.

The recent view indeed is that all elementary particles correspond to closed monopole magnetic flux tubes with a shape of highly flattened rectangles with short sides identifiable as extremely short wormhole contacts (CP_2 size) and long sides with length of order Compton length. Magnetic monopole flux traverses along first space-time sheet between wormhole throats, goes through wormhole contact, and returns back along second space-time sheet. Many-fermion states are assigned with the throats and are located at the ends of strings traversing along the flux tubes.

Could this structure be in the case of electron a 127-sheeted structure such that the two wormhole contacts carry a superposition of pairs formed by states containing $n \in \{1, \dots, 127\}$ fermions at second contact and n antifermions with opposite charges at second contact so that $2^{127} - 1$ dimensional eigen-space would be obtained for a fermion with given spin and isospin. For instance, $n = 0$ state with no fermion-pairs could be excluded.

2. Right-handed neutrinos and antineutrinos are candidates for the generators of $N = 2$ supersymmetry in TGD framework. It however seems that SUSY is not manifested at LHC energies, and one can wonder whether right-handed neutrinos might be realized in some other manner. Also the mathematics involved remains still somewhat unclear. For right-handed neutrinos, which are not covariantly constant transformation to left-handed neutrinos is possible and leads to the mixing and massivation of neutrinos. For covariantly constant right handed neutrino spinors this does not happen but they can included into the spectrum only if they have non-vanishing norm.

This might be the case with a proper definition of norm with $\bar{\Psi} p^k \gamma_k \Psi$ replaced by $\bar{\Psi} n^k \gamma_k \Psi$: here n^k defines normal of the light-like boundary of CD. Covariantly constant right-handed neutrinos have neither electro-weak, color, nor gravitational interactions so that their NE would be highly stable. Unfortunately, the situation is still unclear and this leaves open the idea that right-handed neutrinos might play fundamental role in cognition and negentropy

storage. Amusingly, I proposed the notion of cognitive neutrino long time ago but based on arguments which turned out to be wrong.

One could indeed consider the possibility that each sheet of the 127-sheeted structure contains at most one ν_R at the neutrino end of the flux tube accompanied by $\bar{\nu}_R$ at anti-neutrino end. One would have a superposition $p = 2^{127} - 1$ states formed by many-neutrino states and their CP conjugates at opposite “ends” of the flux tube. It is also possible that $\bar{\nu}_R - \nu_R$ pairs are spin singlets so that one has superposition over many-particle states formed from these analogous to coherent state.

This is not the only possibility. The proposal for how the finite range of weak interactions emerges suggests a possible realization for how the number of states in superposition reduces from 2^{127} to $2^{127} - 1$. The left weak isospin of fermion at wormhole throat is compensated by the opposite weak isospin of neutrino/antineutrino plus $\bar{\nu}_R/\nu_R$ or cancelling its fermion number: therefore weak charges vanish in scales longer than the flux tube length of order of the Compton length. The physical picture is that massless weak boson exchanges occur inside the flux tube which therefore defines the range of weak interactions. Same mechanism could be at work for both wormhole throat pairs and therefore also for fermion and anti-fermion at opposite wormhole throats defining building bricks of bosons. The state $\bar{\nu}_R - \nu_R$ would be excluded from the superposition of pairs of many-particle states and superposition would contain $p = 2^{127} - 1$ states.

3. Could this relate to $h_{eff} = n \times h$ hypothesis? It has been assumed that $h_{eff}/h = n$ corresponds to space-time surfaces representable as n -fold singular coverings, whose sheets co-incide at the 3-D ends of the space-time surface at opposite boundaries of CD. There is of course no need to assume that the covering considered above corresponds to singular covering and the vision that only particles with same value of n appear in same vertices suggests that $n = 1$ holds true for visible matter.

One can still ask whether the elementary particle characterized by $p \simeq 2^k$ could corresponds to k -fold singular covering and to $h_{eff}/h = k$? This would require that phase transitions changing the value of k take place at the lines of scattering diagrams to guarantee that all particles have the same value of k in given vertex. These phase transitions are a key element of TGD inspired quantum biology.

In the first order of perturbation theory this would not mean any deviations from standard quantum theory for given k and the general vision that loop corrections from the functional integration over WCW vanish suggests that there are no effects in perturbation theory for given k . p-Adic coupling constant evolution would be discrete and make itself visible by the phase transitions at the lines of scattering diagrams (not identifiable as Feynman diagrams). The different values of $h_{eff}/h = n$ be also seen through non-perturbative effects assignable to the bound states and also via the proportionality of p-adic mass scales to $p^{-1/2} \simeq 2^{-k/2}$ predicted by p-adic mass calculations.

3.4 The notion of self

Self is identified as a generalized Zeno effect and corresponds to a sequence of state function reductions to a fixed (passive) boundary of CD remaining unaffected in the sequence of reductions: also the members of state pairs defining zero energy states at it are unaffected. Active boundary drifts farther away state function reduction by state function reduction and the state at it also changes. The analogy of unitary time evolution is in question and the experienced time corresponds to the increase of the temporal distance between the tips of CD.

1. One possibility is that sensory input and mental images (“Maya”) generated by it can be assigned with the active boundary of CD. A more elegant assumption suggested by quantum measurement theory is that the passive boundaries for sub-CDs give rise to mental images as outcomes of repeated quantum measurements. The unchanging part of self (“Self”) is associated with the passive boundary. It corresponds to negentropically entangled subsystem having no entanglement with environment. In ordinary ontology it would not be possible keep self un-entangled from the environment.

2. State function reductions occur at either boundary of CD as long as they produce maximal negentropy gain. If the reduction at opposite boundary produces larger negentropy gain, it occurs. Self dies and re-incarnates as time reversed self. During repeated state function reductions at same boundary the part of state at that boundary and boundary itself remains unaffected (this corresponds to unchanging part of self) whereas the state at opposite boundary changes and the boundary also shifts outwards. The increase of the distance between the tips of CD corresponds to the flow of geometric time and gives precise meaning for the ageing of self. For instance, sensory-motor rhythm could correspond to the sequence of repeated state function reductions to opposite boundaries of CD. Motor action would correspond to reversed arrow of time: this conforms with the finding of Libet that conscious decision is preceded by neural activity used to argue that there is no free will.

Time reversed self evolves as reductions shifting the opposite boundary of CD to opposite time direction so that the size of CD continues to increase and defines a measure for the duration of the entire sequence of re-incarnations. This implies quantum physical realization for the idea about transmigration of souls!

3. Repeated state function reductions form a sequence for analogs of unitary time evolutions lasting time Δt , which corresponds to the increase of the temporal distance between tips of initial and final CD. Ordinary Hamiltonian clock time evolution does not make sense except as idealization. Is Δt constant or is it determined by the reduction statistically? The most general and the only non adhoc assumption is that a superposition of CDs with different values of $\Delta t > 0$ is formed and that each repeated state function reductions perform a position measurement - that is localization of the active boundary of CD - so that one Δt is selected and Δt is thus varying. One can speak about average Δ as a kind of chronon of clock-time.
4. Suppose that self dies and thus re-incarnates as time reversed self S_1 , and S_1 in turn dies and reincarnates as S_2 having the same arrow of time as S . Does S_2 re-incarnate at the time when S died? This does not make sense. Also the first reduction to opposite boundary of CD must involve non-vanishing Δt . This conforms with what is known about claimed re-incarnations and might allow to test re-incarnation hypothesis.
5. The totally unexpected prediction is therefore that life is not just a brief spark in cosmic darkness. This particular life is only one in a sequence of lives: the next life will be lived at the opposite boundary of personal CD to opposite direction of geometric time. The negentropy gained during his life will be usable as possibly unconscious knowledge during the next life. What our next life will be depends how much we gather negentropic resources for the next life.
6. Self can also make moral choices since NMP in its weak form leaves us freedom to make also bad choices or especially negentropic choices (for details see [K10]). Possible are also choices, which do not yield optimal negentropy gain. By allowing sin NMP also makes possible really big negentropy gains: NMP would be like venture capitalist in this sense. In statistical sense there is however an evolution as increase of the negentropic sources of the Universe. Crime is part of being alive: living creatures are fighting desperately for NE and a clever but immoral manner to gain it is to eat other living beings.
7. One big news is that selves form a hierarchy (CDs within CDs) and sub-selves are identified as mental images. In TGD framework it is also possible for sub-selves of two unentangled selves to entangle negentropically. This corresponds to sharing of mental images and means that our conscious experience is not completely private. The pool of shared mental images might in fact make possible communication and social structures. Sharing of mental images is possible only in many-sheeted space-time forcing to generalize the standard view about subsystem.

4 Questions related to the notion of self and time

The notion of self and the relation between subjective and geometric time involves unclear aspects. In the following I try to articulate the problematic issues as clearly as possible.

1. The precise nature of the hierarchy of causal diamonds (CDs) as correlate of self hierarchy should be characterized. The basic prediction that sub-selves have also time reversed variants should be interpreted and one can ask whether sensory-motor dichotomy is a sensible interpretation.
2. Are sub-selves always experienced as mental images and whether after images really represent re-incarnations of sub-selves.
3. Can the rather dramatic prediction of re-incarnations be transformed to an experimentally testable predictions. If one takes seriously the notion of self hierarchy and identifies the EEG correlates of self in a manner proposed by Fingelkurts brothers [J2], this kind of prediction is possible.

4.1 Hierarchies of causal diamonds and space-time surfaces as geometric correlates for self hierarchy

CDs are obtained from the intersections of future and past directed light-ones by replacing their points with CP_2 : as a matter fact, CP_2 plays no active role in the definition. I have not been able to nail down the precise definition for the hierarchy of causal diamonds. Self hierarchy demands that CDs serving as imbedding space correlates for selves have sub-CDs identifiable as mental images of self. The basic question is whether CDs can also overlap. If so then finite unions of CDs could be allowed.

Selves as conscious entities are assumed to have space-time surfaces within CDs as space-time correlates. These CDs are dynamical: the other boundary remains unaffected during sequence of repeated state function reductions as also the states at it. Second boundary shifts so that that the distance between the tips of CD increases and defines the experienced flow of time. These space-time surfaces form also a hierarchy. One could consider also a more precise identification of self. By SH string world sheets and/or partonic 2-surfaces or their light-like orbits could serve as space-time correlates of selves. The orbit of partonic 2-surface is indeed analogous to nervous system residing at the boundary between internal (Euclidian) and external (Minkowskian) worlds.

Given space-time surface has both Minkowskian and Euclidian regions - wormhole contacts - separated by wormhole throats at which the signature of the induced metric changes. Minkowskian space-time sheets are connected by extremely short CP_2 sized Euclidian wormhole contacts and in GRT-standard model approximation are approximated by single GRT space-time. If the magnetic flux through wormhole contact is monopole flux, the wormhole contact connecting two Minkowskian space-time sheets has interpretation as a building brick of elementary particles. Minkowskian space-time sheets at different levels of hierarchy are disjoint and separated by Euclidian wormhole contacts. This forces to modify the notion of quantum mechanical subsystem as a tensor factor of the state space.

What is new that two Minkowskian space-time sheets glued to larger disjoint Minkowskian space-time sheets can be connected by magnetic flux tube serving as a correlate for (negentropic) entanglement just as wormholes in ER-EPR proposal of Maldacena and Susskind [?, ?] (see <http://tinyurl.com/y7za98cn>) serve as correlates for maximal entanglement between blackholes. Two unentangled systems can therefore have subsystems, which are entangled and correspond to two space-time sheets connected by magnetic flux tubes! This is possible only in many-sheeted space-time and the hypothesis has been that two selves, which have no entanglement at their own level of self-hierarchy, can have entangled subselves and that this negentropic entanglement (NE) means sharing of mental images giving rise to a kind of stereo consciousness. The fusion of right and left visual fields would be example of stereo consciousness. Stereo consciousness would make also possible to communicate besides bits also their meaning: during conscious communication the mental images of two selves would fuse temporarily to single mental image by the reconnection of magnetic flux tubes. This reconnection would make possible also directed attention.

What does this situation mean at the level of CDs? It would seem that the CDs associated with selves sharing mental images overlap and that the space-time surfaces assignable to fused mental images/subselves belong to the intersection of CDs. Thus it seems that one must allow unions of also overlapping CDs.

4.2 Are time reversed sub-selves always experienced as mental images?

In the proposed vision about self as generalized Zeno effect self dies as the first state function reduction to the opposite boundary of CD takes place. This implies the re-incarnation of self with the property that the geometric time flows in opposite direction since the opposite boundary of CD shifts such that the temporal distance between it and the opposite static boundary increases in repeated state function reductions leaving the states at static boundary un-affected.

Subselves correspond to mental images. The question is whether self really experiences the time reversed sub-selves as a mental image and if this is the case, what can one conclude about this. For sub-sub...-selves this problem is not acute if sub-sub-selves are experienced as kind of statistical averages.

A possible interpretation for self and its time reversal is in terms of sensory input and motor action. I have indeed proposed that motor action is essentially sensory experience in reversed time direction and Libet's discovery [J1] that conscious decision is preceded by neural activity (with respect to geometric time) provides a support for this interpretation. The time reversal of sensory mental image would represent motor action and at the level next below our level of hierarchy would be directly experienced as volitional act.

I have considered also other interpretations. One is suggested by visual illusion in which the picture of dancer is experienced to make either right or left pirouette. The direction of rotation would distinguish between mental images and its time reversal. It however seems that the sensory-motor dichotomy provides the most plausible and economical interpretation.

One can also wonder what happens, when mental the image is associated with a boundary of CD_1 , which overlaps with CD in such a manner that the opposite boundary is outside of CD. Does self experience the mental image associated with CD but not its time reversal?

4.3 Re-incarnation and EEG

It is amusing how fast the attitudes change as ideas evolve and experimental data emerge. Only few years ago I could not say anything definite about reincarnation in the framework of TGD inspired theory of consciousness. Now it has become an unavoidable prediction of ZEO, which itself is a "must" in TGD framework.

The prediction related to re-incarnation is however not quite what one might have expected. In death of self a reincarnation as time reversed conscious entity takes place. For time reversed self subjective time evolution corresponds to evolution in a reverse direction of geometric time. The next death/reincarnation after this re-incarnation gives rise to a self for which the arrow of geometric time is the original one.

Can one test this prediction? If one accepts the predicted fractal self hierarchy in which sub-selves correspond to mental images of self, this is possible. I am too lazy to retype basics about ZEO, CDs, and about how self as generalized Zeno effect emerges and just assume that reader knows the basic concepts or sees to trouble to refresh her knowledge about them.

1. Self hierarchy predicts that also our mental images are conscious entities. Motor-sensory dichotomy naturally corresponds to sub-self and time reversed sub-self. That is sensory mental image and that associated with motor action induced by sensory input. Motor action initiated in the geometric past at the opposite boundary of CD (this explains Libet's finding that conscious decision is preceded by neural activity in geometric time). Note that motor action does not proceed from brain to muscles but in reversed time direction from muscles to brain! This conforms with the vision in which magnetic body is intentional agent.
2. To proceed one must identify EEG correlates for the sub-selves (mental images) and their time reversed re-incarnates. Here the work of Fingelkurts brothers (see <http://tinyurl.com/jpszfpy>) working in Finland helps [J2]. They postulate what they call operational architecture of brain (OA) having operations (O) and operational modules (OM) as building

bricks. Quasi-stationary EEG segments are assumed to serve as correlates for operations and synchrony of these segments associated with various locations in brain tells that they belong to the same OM.

Synchrony means spatio-temporal coherence - not only spatial - and is very natural concept in ZEO, where 4-D CDs and space-time surfaces inside them serve as geometric correlates of selves. Synchrony implies that these EEG segments at different spatial locations begin and end at the same time. Between EEG segments there is rapid transition period (RTP) allowing to distinguish segments from each other. Quasi-stationary segments of EEG have average duration is about .3 seconds.

The translation of this picture to TGD framework is rather straightforward. Operations correspond to sub-selves and OMs to collections of them forming sub-selves of self. CDs (sub-CDs) in turn serve as geometric correlates for selves (sub-selves). The quasi-stationary segments of EEG become correlates for sub-selves/mental images. Operational module corresponds to a self/CD having sub-selves/sub-CDs with synchronous EEG segments. The average duration of mental image would be about .3 seconds.

Two sub-sequent quasi-stationary segments separated by RTP would correspond to sub-self and its re-incarnation in the original time direction. Note that a very brief period of geometric time defined by the duration of RTP identifiable as the duration of a unitary time evolution between two sub-sequent state function reductions at the same boundary of CD corresponds to a finite duration of experienced time - the lifetime of the time reversed mental image!

The testable prediction is that the segment corresponding to time-reversed sub-self is located in geometric past and runs in opposite direction of geometric time. This EEG segment should be assignable to motor response accompanying sensory mental image. This is a highly non-trivial prediction testing the new view about time.

3. One can check whether these EEG segments appear as pairs with first member assignable to sensory mental image and second one to motor mental image. Time reversal implies that second law is obeyed in "wrong" time direction for EEG segment assignable to the motor output and this can be tested. Already Fantappie [J5] discovered that both directions of (geometric) time appear in living matter and introduced the notion of syntropy as time reversal of entropy. Spontaneous molecular self-assembly is a basic example of a syntropic process and identifiable as a decay process in reverse direction of geometric time. Phase conjugation is known to occur for phase conjugate laser light and sound. Does a process analogous to self-assembly occur for segments of EEG associated with motor actions: is the motor part of EEG time reversed? To answer this question one needs phase information about EEG besides power spectrum. In principle this information is contained in EEG.

4.4 After images as reincarnations of mental images?

After images (see <http://tinyurl.com/kevnzqg>) appear periodically as one can easily find by looking and lamp and closing eyes. They also change colors. Could these after images be interpreted as re-incarnations? This sounds attractive but one must be very careful. A sub-self S , which dies and transforms to its time reversal S_1 reincarnates eventually as sub-self S_2 with the original arrow of time. According to the assumption about first reduction to opposite boundary made S_2 emerges at time later than S died and this conforms with what is known. The time interval between two subsequence after images would give information about the average value of Δt . The after images need not be identical copies of the original and their color indeed changes.

An alternative interpretation is that after images are not re-incarnations but belong to a 4-D population of sub-selves. Our geometric past is alive and changes all the subjective time. This is not so confusing when one realize that ZEO means that conscious existence is essentially 4-dimensional. Also our memories are dynamical and change all the subjective time. Negative energy signals to geometric past which correspond to time reversed sub-selves indeed affect the geometric past and memory representations. In principle this kind of signalling could be carried out artificially to manipulate geometric past.

4.5 Re-incarnation and time reversed selves as basic predictions of TGD inspired theory of consciousness

Life has been hard for skeptics during last two decades. A typical skeptic has as building bricks of his ego the items in the list of notions that they regard as pseudoscientific. This allows to attack the people who have the gift of imagination and passion for genuine understanding, which skeptics unfortunately do not possess. What makes attacks easy that no arguments based on contents are needed and the skeptic need not waste his time by trying to understand the arguments of the person to be labelled as pseudoscientist or crackpot.

The typical rhetoric tricks used begin from replacement of Dr X with Mr X and end up with the “conclusion” that the work of Mr X is totally incomprehensible. I have learned that rather often skeptic of this kind is an academic dropout who never managed to do his MsC. Obviously, the role of skeptic became a manner to survive socially and retain the illusion “I am a scientist”. During last decades the list of pseudoscientific notions has shortened item by item as quantum biology and quantum consciousness have emerged as respected branches of science. The notion of re-incarnation (see <http://tinyurl.com/jfpowqg>) has been certainly regarded as one of safest pillars supporting the ego of skeptic but even this pillar is in danger to fall down. Poor skeptics.

It is indeed amusing how fast the attitudes change as ideas evolve and experimental data emerge. Only few years ago I could not say anything definite about reincarnation in the framework of TGD inspired theory of consciousness. Now it has become an unavoidable prediction of zero energy ontology (ZEO), which itself is a “must” in TGD framework.

4.5.1 Reincarnation: a testable prediction?

The prediction related to re-incarnation is however not quite what one might have expected. In death of self a reincarnation as time reversed conscious entity takes place. For time reversed self subjective time evolution corresponds to evolution in a reverse direction of geometric time. The next death/reincarnation after this re-incarnation gives rise a mental image for which the arrow of geometric time is the original one.

Can one test this prediction? If one accepts the predicted fractal self hierarchy in which sub-selves correspond to mental images of self, this is possible. I am too lazy to retype basics about ZEO, CDs, and about how self as generalized Zeno effect emerges and just assume that reader knows the basic concepts or sees to trouble to refresh her knowledge about them.

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2. To proceed one must identify EEG correlates for the sub-selves (mental images) and their time reversed re-incarnates. Here the work of Fingelkurts brothers (see <http://tinyurl.com/jpszfpy>) working in Finland helps [J2]. They postulate what they call operational architecture of brain (OA) having operations (O) and operational modules (OM) as building bricks. Quasi-stationary EEG segments are assumed to serve as correlates for operations and synchrony of these segments associated with various locations in brain tells that they belong to the same OM.

Synchrony means spatio-temporal coherence - not only spatial - and is very natural concept in ZEO, where 4-D CDs and space-time surfaces inside them serve as geometric correlates of selves. Synchrony implies that these EEG segments at different spatial locations begin and end at the same time. Between EEG segments there is rapid transition period (RTP) allowing to distinguish segments from each other. Quasi-stationary segments of EEG have average duration is about .3 seconds.

The translation of this picture to TGD framework is rather straightforward. Operations correspond to sub-selves and OMs to collections of them forming sub-selves of self. CDs (sub-CDs)

in turn serve as geometric correlates for selves (sub-selves). The quasi-stationary segments of EEG become correlates for sub-selves/mental images. Operational module corresponds to a self/CD having sub-selves/sub-CDs with synchronous EEG segments. The average duration of mental image would be about .3 seconds.

Two sub-sequent quasi-stationary segments separated by RTP would correspond to sub-self and its re-incarnation in the original time direction. Note that a very brief period of geometric time defined by the duration of RTP identifiable as the duration of a unitary time evolution between two sub-sequent state function reductions at the same boundary of CD corresponds to a finite duration of experienced time - the lifetime of the time reversed mental image!

The testable prediction is that the segment corresponding to time-reversed sub-self is located in geometric past and runs in opposite direction of geometric time. This EEG segment should be assignable to motor response accompanying sensory mental image. This is a highly non-trivial prediction testing the new view about time.

3. One can check whether these EEG segments appear as pairs with first member assignable to sensory mental image and second one to motor mental image. Time reversal implies that second law is obeyed in "wrong" time direction for EEG segment assignable to the motor output and this can be tested. Already Fantappie [J5] discovered that both directions of (geometric) time appear in living matter and introduced the notion of syntropy as time reversal of entropy. Spontaneous molecular self-assembly is a basic example of a syntropic process and identifiable as a decay process in reverse direction of geometric time. Phase conjugation is known to occur for phase conjugate laser light and sound. Does a process analogous to self-assembly occur for segments of EEG associated with motor actions: is the motor part of EEG time reversed? To answer this question one needs phase information about EEG besides power spectrum. In principle this information is contained in EEG.

4.5.2 Do conscious entities with different time arrows interact?

Zero Energy Ontology (ZEO) predicts conscious entities with both arrows of geometric time. I find that forcing myself to think and write about this is difficult. The fear is that the whole nice scenario falls down by predicting something totally absurd. The questions that I try to avoid are following. What could these ghostly time-reversed entities be? Do they interact with those with standard time orientation? How could they do so?

Let us first briefly recall what ZEO based theory of consciousness says.

1. In ZEO self corresponds to a generalized Zeno effect that is sequence of state function reductions leaving the passive boundary of CD unaffected as also the members of state pairs associated with 3-surfaces at it. At active boundary the members of state pairs change and the active boundary drifts reduction by reduction farther away from passive boundary. The temporal distance between the tips of CD increases gradually and corresponds to the experience about flow of time.
2. Negentropy Maximization Principle (NMP) [K10] forces eventually self to die by making the first reduction to the passive boundary of its causal diamond (CD), which now becomes the active boundary: a new time reversed self is born. This option is forced because it produces more negentropy. For this self the arrow of geometric time would be opposite since now the formerly passive boundary would be active and shift in opposite direction of time: in this manner CD would steadily increase in size.

Also the time-reversed self would eventually die and make the first reduction to the opposite - the original - boundary of CD. The position of the boundary of active boundary in first reduction would be shifted to the geometric future from the original position. The first and - as will be found - probably wrong guess for the size of shift towards geometric future from the position at the moment of previous death would be as the average increase of the temporal distance between tips of CD during Zeno period. This increment could be rather small as compared to the size of CD itself.

This picture raises questions.

1. Do we make this kind jump to time-reverse life at some level of our personal self hierarchy as we fall sleep? If wake-up period corresponds to re-incarnation in the original time direction, time increment of CD from its previous value would be the duration of sleeping period as seen by a larger conscious system. This is much longer than the subjective chronon for sensory mental images about .1 seconds.

Remark: Note that EEG splits to pieces of duration about 300 ms and it might be possible to identify in EEG periods, which correspond to mental images and their time reversals. These periods could differ by a phase conjugation although the power spectrum would have the same typical behavior (sound wave and its phase conjugate have same power spectrum but we can distinguish sound and its time-reversal from each other).

Could the first big reduction correspond to a time increment, which is of the same order of magnitude as the total time duration of life-cycle of the time-reversed self? The size of 3-surfaces at the boundary of time-reversed CD has increased by about life-time. Could the first reduction to the opposite boundary increase the size of the 3-surface at this boundary by the same amount? If so, the re-incarnations for human life cycles would take roughly life-time after the death.

Could one identify negative energy time reversed signal as time-reversed self at some level of hierarchy? If so then the selves associated with CDs could gradually increase their energy by dying and re-incarnating repeatedly since the opposite boundary would increase also the magnitude of the negative energy at the opposite boundary. This is in principle possible since conservation laws hold true by the very definition of zero energy states as well as for classical time evolutions appearing in their quantum superposition. The average energy for a given member of pair defining zero energy state would increase gradually. The size of the CD associated with re-incarnating self could become arbitrary large and gain an arbitrary high total energy: the wildest speculation is that cosmologies correspond to very large selves [L3].

2. Could selves/systems living in opposite directions of time have direct interactions? If the vision that motor actions are realized as negative energy signals travelling to brain of the geometric past and induce neural activity fraction of second earlier than the conscious decision was made (Libet's finding), this could be the case. Motor action could correspond to a death of sensory self, reincarnation as time-reversed motor-self, and a re-incarnation as sensory self in time scale of .1 seconds. Sensory-motor cycle would correspond to a sequence of re-incarnations as time reversed sub-self.
3. How the time reversed selves could reveal themselves? If their presence can be indeed detected, a key signature would be the opposite direction of the thermodynamical arrow of time for them. Heat would be apparently transferred in wrong direction: from cold to hot. This kind of apparent breakings of second law have been observed: phase conjugate laser waves and acoustic signals represent examples of this. Fantappie suggested that they occur routinely in living matter and introduce the notion of syntropy as time reverse counterpart of entropy [J5]. The strange cooling of the air at magnetic walls associated with the rotating magnetic systems [L10] provides second example.
4. Good music is claimed to send cold shivers in spine and sensations of cold are assigned also with the perception of ghosts. Could the claims about encounters of ghosts be due to a perception of time reversed selves? I remember that in my personal great experience for three decades ago the entire body went into a state analogous to that created by a good music. Did I interact with a time reversed conscious entity? My experience indeed was that I was in contact with what I called Great Mind. This is of course just a subjective experience and the skeptic scientist knows that I was in a psychotic state since it is completely obvious from my scientific work even without reading it that I am a madman.

5 Appendix: TGD and quantum biology

The ontology behind the applications involves the notion of many-sheeted space-time, ZEO, hierarchy of Planck constants identified in terms of dark matter, and p-adic physics as physics of

cognition. Also magnetic body (MB) carrying dark matter and energy having non-standard value of Planck constant $h_{eff} = n \times h$ identified as intentional agent represents new ontology. The additional assumption $h_{eff} = h_{gr}$ identifying h_{eff} with gravitational Planck constant is rather powerful. Also p-adic length scale hypothesis is also central in applications. NMP is the basic variational principle of consciousness and means that living systems must do their best to build negentropy resources to avoid the first reduction to the opposite boundary of personal CD. This strongly suggests that metabolic energy necessary for survival is needed to transfer NE from the nutrients and the ADP-ATP cycle is essentially transfer of NE in molecular scale.

5.1 The notion of magnetic body (MB)

MB is assumed to be carrier of dark matter.

1. The flux tubes of MB can suffer h_{eff} changing phase transitions inducing the change of the length of flux tube. This leads to a view about living matter as a network of bio-molecules connected by magnetic flux tubes. The ability of biomolecules to find each other in the dense molecular soup would rely on the reduction of h_{eff} bringing molecules near each other. The reconnections of flux tubes possible if the field strengths are same and therefore also cyclotron frequencies are identical are also expected to central element in bio-communications since they change the topology of the network and make possible analogs of relays.

The receptors to which information molecules attach could be seen as plugs to which magnetic flux tubes having information molecule at its end attach and give rise to a fusion of two flux tubes to a longer flux tube connection. For instance, nerve pulse transmission would be more like building quantum connections than communication.

2. Flux tubes with large h_{eff} make possible high T_c superconductivity [K13, K14]. Superconducting structures would be pairs of flux tubes carrying magnetic fluxes which have same or opposite directions. Cooper pairs would have members at separate flux tubes.

5.1.1 MB as intentional agent

Magnetic field associated with a given system decomposes to flux tubes and sheets to that system has MB (MB). The physics of MBs could be a new chapter in physics and MB could define the basic space-time correlate for non-locality.

1. Flux tubes of MB would serve as correlates for quantum entanglement, which in TGD framework can be negentropic and for this reason rather stable under state function reductions. In GRT context the idea about wormholes as correlates of entanglement between blackholes is highly analogous. The problem with wormholes is that they are highly unstable. Magnetic flux tubes carrying monopole flux are stable since flux conservation prevents their pinching. The pairs of flux tubes with opposite fluxes can however split to two U-shaped flux tubes by reconnection. It is important to notice that magnetic flux tubes are necessarily closed and can be regarded as flux running along different space-time sheets in opposite direction and from sheet to another through the wormhole contacts at ends.

One can of course ask whether the braiding of flux tubes could be the correlate for entanglement. To my opinion entanglement without braiding is possible.

2. MB and dark matter at it would serve as intentional agent in biological systems [K29]. The organism-environment duality would be replaced by the trinity MB-organism-environment. For instance, EEG and its strong correlation with brain state and consciousness could be understood in terms of communication of sensory data from cell membranes to MB and control and coordination signals from MB to biological body [K4]. Signals would consist of dark photons with energies $E = h_{eff}f = n \times hf$ in bio-photon energy range and thus above thermal energies. For instance, the recently observed synchrony between hemispheres in absence of corpus callosum [J3] could be understood in terms of MB serving as “boss”.
3. The formation of flux tube reconnections would serve as a correlate for directed attention - attention could be directed to objects of external world or to their representations in brain.

The reconnection would take place for U-shaped flux tubes serving as kind of magnetic tentacles and lead to a formation of pairs of flux tubes connecting the two systems. If flux tubes carry monopole flux as one has reasons to expect, the flux tubes would be actually closed two-sheeted structures (also elementary particles would be this kind of structures) and flux tube pair would be pair of these. The flux tubes of MBs would serve as analogs of wave guides along with precisely targeted communications of dark photon signals (“massless extremals” (MEs)) would be possible. Also supra currents would be possible and the TGD based model of high T_c superconductivity relies on the same mechanism [K13]. These communications would be essential in living matter.

4. The formation of reconnections and phases transitions $n \rightarrow m$ changing $h_{eff} = n \times h$ would be a basic mechanism behind biocochemistry. U-shaped flux tubes would act like tentacles emerging from the system and reconnection of the tentacles would build a connection between two systems. The reduction of Planck constant would shorten the connecting flux tubes and could force the systems in the vicinity of each other after which bio-catalysis could take place. Braiding and its 2-braid variant for string world sheets and partonic 2-surfaces in 4-D space-time instead of strings in 3-D space would make possible realization of quantum computer program like structures.

5.1.2 MB is 4-dimensional

MB as preferred extremal represents in terms of space-time topology and geometry 4-D self-organization patterns, behaviors, functions, and skills. What is new that self-organization occurs for 4-D patterns rather than 3-D ones. The entire process is replaced with a new one. Sequence of state function reductions leads from a 4-D self-organization pattern to an asymptotic 4-D self-organization pattern [K23].

Morphogenesis provides examples of this kind of phenomena [I2, I3, I6]. The first key idea is that DNA and cell replication is induced by the replication of MBs serving as information carriers (see <http://tinyurl.com/ydg6okkk>) [K23]. The second key idea is that in ZEO MB is 4-dimensional and represents behavioral patterns rather than only 3-dimensional patterns.

According to Michael Levin, concerning morphogenesis and morphostasis the basic challenge is to understand how the shape of the organism is generated and how it is preserved. The standard local approach based on belief on genetic determinism does not allow one to answer these questions satisfactorily.

1. The first approach to this problem relies on a self-organization paradigm in which the local dynamics of cells leads to large scale structures as self-organization patterns. In TGD framework 3-D self-organization is replaced with 4-D self-organization (the failure of strict determinism of the classical dynamics is essential motivating zero energy ontology (ZEO)). One can speak about 4-D healing: expressing it in somewhat sloppy manner, the space-time surface serving as a classical correlate for the patient is as a whole replaced with the healed one: after the 4-D healing process the organism was never ill in geometrical sense! Note that in quantal formulation one must speak of quantum superposition of space-time surfaces.
2. Second approach could be seen as computational. The basic idea is that the process is guided by a template of the target state and morphogenesis and healing are computational processes. What Levin calls morphogenetic fields would define this template. It is known that organisms display a kind of coordinate grid providing positional information that allows cells to “decide” about the profile of genetic expression (for references see [I3]). In TGD framework MB forming coordinate grid formed from flux tubes is a natural candidate for this structure. They would also realize topological quantum computation (TQC) with basic computational operations realized at the nodes of flux tubes to which it is natural to associate some biological sub-structures.

The assumption about final goal defining a template can be argued to be too strong: much weaker principle defining a local direction of dynamics and leading automatically to the final state as something analogous to free energy minimum in thermodynamics might be enough. Unfortunately, second law is the only principle that standard physics can offer. Negentropy Maximization Principle

(NMP) provides the desired principle in TGD framework. Also the approach of WCW spinor field to the maximum of vacuum functional (or equivalently that of Kähler function) gives a goal for the dynamics after the perturbation of the organism causing "trauma". If Kähler function is classical space-time correlate for entanglement negentropy, these two views are equivalent.

TGD thus suggests an approach, which could be seen as a hybrid of approaches based on self-organization and computationalism. The MB becomes the key notion and codes also for learned behaviors as TQC programs coded by the braiding of flux tubes. The replication of the MB means also the replication of the programs behind behavioral patterns (often somewhat misleadingly regarded as synonymous with long term memories): both structure and function are replicated. This hypothesis survives the killer tests provided by the strange findings about planaria cut into two and developing new head or tail while retaining its learned behaviors: the findings indicate that behavioral programs are preserved although planaria develops a new brain.

5.1.3 $h_{gr} = h_{eff}$ hypothesis

Nottale [E1] introduced originally the notion of gravitational Planck constant $h_{gr} = GMm/v_0$, where M is large mass such as that of Earth or Sun and m the mass of quantum coherent object and v_0 is a parameter with dimensions of velocity [E1]. Nottale did not propose macroscopic quantum coherence in astrophysical scales but in TGD framework this is a natural option [K15, K12].

The obvious question is whether the gravitational Planck constant deduced from the Nottale's considerations and the effective Planck constant $h_{eff} = n \times h$ deduced from ELF effects on vertebrate brain and explained in terms of non-determinism of Kähler action could be identical. At first this seems to be non-sensical idea since $h_{gr} = GMm/v_0$ has a gigantic value. The hypothesis $h_{eff} = h_{gr}$ leads to much stronger predictions [K30, K29] than either hypothesis alone. One can also introduce analogs of h_{gr} for other interactions: the idea is that when the coupling strength between two charges becomes so large that perturbation theory does not exist, a phase transition increasing the Planck constant happens and guarantees the convergence.

The essential point is that h_{eff} and h_{gr} would characterized body parts of MB: this allows to understand the dependent on masses of two particles. The flux tubes with a given value of h_{eff} would carry only particles of particular mass m so that the random soup of biomolecules would become a highly ordered structure analogous to library in which each book type is its own shelf. Furthermore, the cyclotron energies $E_c \propto h_{eff}/m$ would be same irrespective of particle mass m although cyclotron frequencies are different.

The proposed identification of the energy range of dark photon cyclotron energies in living matter is as visible and UV range assigned to bio-photons which would therefore result in the transformation of dark photons to ordinary photons. Further important point, is that the energy spectrum would be in the range of molecular excitation energies (visible and UV range) so that dark photons transformed to ordinary ones would allow MBs to control biochemistry.

By Equivalence Principle one can describe gravitational interaction by reducing it to elementary particle level. For instance, gravitational Compton lengths do not depend at all on the masses of particles. Also the radii of the planetary orbits are independent of the mass of particle mass in accordance with Equivalence Principle. For elementary particles the values of h_{gr} are in the same range as in quantum biological applications. Typically 10 Hz ELF radiation should correspond to energy $E = h_{eff}f$ of UV photon if one assumes that dark ELF photons have energies of biophotons and transform to them. The order of magnitude for n would be therefore $n \simeq 10^{14}$.

The experiments of M. Tajmar et al [E2, E3] discussed in [K27] provide a support for this picture. The value of gravimagnetic field needed to explain the findings is 28 orders of magnitude higher than theoretical value if one extrapolates the model of Meissner effect to gravimagnetic context. The amazing finding is that if one replaces Planck constant in the formula of gravimagnetic field with h_{gr} associated with Earth-Cooper pair system and assumes that the velocity parameter v_0 appearing in it corresponds to the Earth's rotation velocity around its axis, one obtains correct order of magnitude for the effect requiring $r \simeq 3.6 \times 10^{14}$.

The most important implications are in quantum biology and Penrose's vision about importance of quantum gravitation in biology might be correct.

1. This result allows by Equivalence Principle the identification $h_{gr} = h_{eff}$ at elementary particle level at least so that the two views about hierarchy of Planck constants would be

equivalent. If the identification holds true for larger units it requires that space-time sheet identifiable as quantum correlates for physical systems are macroscopically quantum coherent and gravitation causes this. If the values of Planck constant are really additive, the number of parallel space-time sheets corresponding to non-determinism evolution for the flux tube connecting systems with masses M and m is proportional to the masses M and m using Planck mass as unit. Information theoretic interpretation is suggestive since hierarchy of Planck constants is assumed to relate to negentropic entanglement very closely in turn providing physical correlate for the notions of rule and concept.

2. That gravity would be fundamental for macroscopic quantum coherence would not be surprising since by EP all particles experience same acceleration in constant gravitational field, which therefore has tendency to create coherence unlike other basic interactions. This in principle allows to consider hierarchy in which the integers $h_{gr,i}$ are additive but give rise to the same universal dark Compton length.
3. An interesting question is how large systems can behave as coherent units with $\hbar_{gr} = GMm/v_0$. In living matter one might consider the possibility that entire organism might be this kind of system. Interestingly, for larger masses the gravitational quantum coherence would be easier. For particle with mass m $h_{gr}/h > 1$ requires larger mass to satisfy $M > M_P^2/m_e$. The first guess that life has evolved from long to shorter scales and reached elementary particle last. Planck mass is the critical mass corresponds to the mass of water blob with volume of size scale of 10^{-4} m (big neuron) is the limit.

The general proposal discussed above is testable. In particular, a detailed study of molecular energies with those associated with resonances of EEG could be highly rewarding and reveal the speculated spectroscopy of consciousness.

5.1.4 EEG as communications between MB and BB

Models of EEG and nerve pulse are basic applications of the notion of MB in neuroscience. The basis idea is that EEG and its fractal counterparts are communications to the various layers of MB having onion-like structure with cyclotron frequency correlating with the size of the layer. Josephson junctions about which basic example is cell membrane would communicate sensory information to MB as dark photons.

The general model for EEG follows neatly from this picture combined with the general model of high T_c superconductivity [K13, K14]. A fractal hierarchy of EEGs and its generalizations identified in terms of generalized Josephson radiation is predicted with levels labeled by p-adic length scales and the value of \hbar at various levels of dark matter hierarchy [K4]. At macrolevel one can approximate neuronal and axonal (and also cell-) membrane as Josephson junction formed by the two lipid layers of the membrane. At microscopic level ionic pumps and channels defined by Josephson junctions involving magnetic flux tubes connecting interior and exterior of the cell.

“Generalized” means that Josephson frequency as energy difference $E = ZeV/h_{eff}$ of Cooper pair for membrane potential is replaced with the sum of difference of cyclotron energies and E . This implies that the variations of membrane potential by oscillations and nerve pulses induced frequency modulation of the frequency of dark photons sent to the MB. This defines a coding of the information carried by nerve pulses do dark photons. Whale’s song represents a good analogy for the coding. Besides EEG one would have its counterparts for various organs, organelles and even cell.

5.1.5 Experimental evidence for MB

The team led by Michael Tyszka, associate director of Caltech Brain Imaging Center, has however discovered that the resting state network seems to work normally in people born without corpus callosum [J3] (see <http://tinyurl.com/3gjhtgb>)! As if brain hemispheres were communicating by some other means than neural signalling! This finding challenges not only the views about the origin of brain synchrony as being created by neural circuits but also the models of autism and schizophrenia explaining them in terms of impaired communications between hemispheres.

The MB of entire brain controls it and could naturally do this via the intermediate control of brain hemispheres forcing them to operate in the same rhythm. Brain synchrony and resting

network would not be produced by resonant neuro-circuits as usually believed but by the spatiotemporal coherence of the EEG radiation from the MB of entire brain forcing brain hemisphere MBs to oscillate in the same rhythm and in turning synchronizing the brain hemispheres [K22]. This would be like forcing soldiers to march in the same pace and brain hemispheres could cooperate without any neural communication between hemispheres. The communication between hemispheres would be needed for more refined collaboration involving “discussion” between hemispheres: hemispheres of a person without corpus callosum would be like soldiers obeying blindly the orders. This might be also an essential element of autism and schizophrenia.

5.2 MB and biology

MB could play a key role in biology as intentional agent using biological body as motor instrument. MB could even serve as a template for biomolecules and even that fundamental bio-chemical processes are induced by those for MB. Dark cyclotron photons transformed to ordinary photons would be the fundamental control tool of MB. Also reconnection of flux tubes, change of length of flux tubes induced by the change of the value of $h_{eff} = h_{gr}$, superconductivity associated with a pair of flux tubes could be fundamental control mechanisms.

5.2.1 MB, biophotons, and biochemistry

The model for quantum biology relying on the notions of MB and dark matter as hierarchy of phases with $h_{eff} = nh$, and biophotons [K25, K24] identified as decay products of dark photons. The assumption $h_{gr} \propto m$ becomes highly predictable since cyclotron frequencies would be independent of the mass of the ion.

1. If dark photons with cyclotron frequencies decay to biophotons, one can conclude that biophoton spectrum reflects the spectrum of endogenous magnetic field strengths. In the model of EEG [K4] it has been indeed assumed that this kind spectrum is there: the inspiration came from music metaphors suggesting that musical scales are realized in terms of values of magnetic field strength. The new quantum physics associated with gravitation would also become key part of quantum biophysics in TGD Universe.
2. For the proposed value of h_{gr} 1 Hz cyclotron frequency associated to DNA sequences would correspond to ordinary photon frequency $f = 3.6 \times 10^{14}$ Hz and energy 1.2 eV just at the lower limit of visible frequencies. For 10 Hz alpha band the energy would be 12 eV in UV. This plus the fact that molecular energies are in eV range suggests very simple realization of biochemical control by MB. Each ion has its own cyclotron frequency but same energy for the corresponding biophoton.
3. Biophoton with a given energy would activate transitions in specific bio-molecules or atoms: ionization energies for atoms except hydrogen have lower bound about 5 eV (<http://tinyurl.com/233vcad>). The energies of molecular bonds are in the range 2-10 eV (<http://tinyurl.com/yccmm7mm>). If one replaces v_0 with $2v_0$ in the estimate, DNA corresponds to 6.2 eV photon with energy of order metabolic energy currency and alpha band corresponds to 6 eV energy in the molecular region and also in the region of ionization energies.

Each ion at its specific magnetic flux tubes with characteristic palette of magnetic field strengths would resonantly excite some set of biomolecules. This conforms with the earlier vision about dark photon frequencies as passwords.

It could be also that biologically important ions take care of their ionization self. This would be achieved if the magnetic field strength associated with their flux tubes is such that dark cyclotron energy equals to ionization energy. EEG bands labelled by magnetic field strengths could reflect ionization energies for these ions.

It must be made clear that TGD has had an interpretational problem related to the identification of biophotons as decay product of dark photons [K29, K30]. The resolution of this problem leads to conclusion that both Earth’s and galactic MBs control living matter with EEG related by scaling. This would be rather dramatic realization of non-locality.

The problem is following. If one wants bio-photon spectrum to be in visible-UV range assuming that bio-photons correspond to cyclotron photons, one must reduce the value of $r = h_{gr}B_{end}/mv_0$ for Earth particle system by a factor of order $k = 2 \times 10^{-4}$. r does not depend on the mass of the charged particle. One can replace B_{end} with some other magnetic field having value which is considerably smaller. One can also increase the value of v_0 .

1. For h_{gr} determined by Earth's mass and $v_0 = v_{rot}$, where $v_{rot} \simeq 1.55 \times 10^{-6}c$ is the rotation velocity of Earth around its axis and for $B_{end} \rightarrow B_{gal} = 1$ nT, where B_{gal} is typical strength of galactic magnetic field, the energy of dark cyclotron energy is 45 eV (UV extends to 124 eV). This is roughly by a factor 50 higher than the lower bound for the range of bio-photon energies. One possibility is that B_{gal} defines the upper limit of the dark photon energies and has variation range of at least 7 octaves with lower limit roughly 1/50 nT.

One can also consider the possibility B_{gal} defines lower bound for the magnetic field strengths involved and one has $v_0 > v_{rot}$. For sun the rotation velocity at Equator is $v_{rot} = 2 \times 10^{-5}$ m/s and v_0 is $v_0 \simeq 5.8 \times 10^{-4}c$. One has $v_0/v_{rot} \simeq 29.0$. If same is true in case of Earth, the value of the energy comes down from 25 eV to 1.6 eV which corresponds to visible wave length.

The assignment of B_{gal} to gravitational flux tubes is very natural. Now however the frequencies of dark variants of bio-photons would not be in EEG range: 10 Hz frequency would correspond to 5×10^{-4} Hz with period of 42 min. The time scale of 42 min is however very natural concerning consciousness and could be involved with longer bio-rhythms. Scaled EEG spectrum with alpha band around 46 min naturally assignable to diurnal sub-rhythms could be a testable prediction. Natural time would be sidereal (galactic) time with slightly different length of day and this allows a clear test. Recall the mysterious looking finding of Spottiswoode that precognition seems to be enhanced at certain time of sidereal day [J4]. Cyclotron frequency 1 Hz would correspond to 7 hours. One can ask whether 12 hours (25) is the natural counterpart for the cyclotron frequency 1 Hz assignable to DNA. This would correspond to lower bound $B_{gal} \rightarrow 7B_{gal}/12 \simeq .58$ nT or to $v_0 \rightarrow 1.7v_0$.

2. The idea has been that it is dark EEG photons, which correspond to bio-photons. Could one assign bio-photons also to dark EEG so that magnetic fields of Earth and galaxy would correspond to two different control levels? If $B_{end} = .2$ Gauss is assumed to determine the scale of the magnetic field associated with the flux tubes carrying gravitational flux tubes, one must reduce h_{gr} . The reduction could be due to $M \rightarrow M_D = kM$ and due to the change of v_0 . k could characterize the dark matter portion of Earth but this assumption is not necessary.

This would require $k = M_{dark,E}/M_E \simeq 5 \times 10^{-5}$ if one does not change the value of v_0 . This value of k equals to the ratio of B_{gal}/B_{end} and would be 1/4:th of $k = 2 \times 10^{-4}$. One might argue that it is indeed dark matter to which the gravitational flux tubes with large value of Planck constant connect biomatter.

3. Suppose that one does not give up the idea that also Earth mass gives rise to h_{gr} and scaled analog of EEG. Then M_D must correspond to some mass distinguishable from and thus outside Earth. The simplest hypothesis is that a spherical layer around Earth is in question. TGD based model for spherical objects indeed predict layered structures [K19]. There are two separate anomalies in the solar system supporting the existence of a spherical layer consisting of dark mass and with radius equal to the distance of Moon from Earth equal to 60.3 Earth radii [K15]. The first anomaly is so called Flyby anomaly and second one involves a periodic variation of both the value of the measured Newton's constant at the surface of Earth and of the length of the day. The period is about 6 years and TGD predicts it correctly.

One can imagine that dark particles reside at the flux tubes connecting diametrically opposite points of the spherical layer. Particles would experience the sum of gravitational forces summing up to zero in the center of Earth. Although the layer would be almost invisible (or completely invisible by argument utilizing the analogy with conducting shell) gravitationally in its interior, $h_{gr} = M_D m/v_0$ would make itself visible in the dynamics of dark particles! This layer could represent magnetic Mother Gaia and EEG would take care of communications to this layer.

The rotation velocity $v_{rot,M} \simeq 2.1 \times v_{rot,E}$ of Moon around its axis is the first guess for the parameter v_0 identifiable perhaps as rotation velocity of the spherical layer. A better guess is that the ratio $r = v_0/v_{rot,M}$ is the same as for Sun and as assumed above for Earth. This would give for the ratio of cyclotron frequency scales $r = (B_{end}/B_{gal}) \times 2.1$. 66.7 min, which corresponds to $B_{gal} = .63$ nT, would correspond to .1 s. For this choice 1 Hz DNA cyclotron frequency would correspond 11.7 h rather near to 12 h. This encourages the hypothesis that 72 min is the counterpart of .1 s cyclotron time. The cyclotron time of DNA (very weakly dependent on the length of DNA double strand) in B_{gal} (or its minimum value) would be 12 h.

Magnetic body of Earth controlling bio-dynamics would be a dramatic manifestation of non-locality to say nothing about the control performed by galactic magnetic body. M_D would be associated with the magnetic Mother Gaia making life possible at Earth together with magnetic Mother Galactica. Both MBs would be in continual contact with biomolecules like ATP and the molecules for which ATP attaches or provides the phosphate. Metabolic energy would be used to this process. These MBs would be Goddesses directing its attention to tiny bio-molecules. If this picture is correct, the ideas about consciousness independent on material substrate and assignable to a running computer program can be safely forgotten.

5.2.2 Model for the flux tube connections between biomolecules

A more concrete TGD based model for the flux tubes connections between molecules relies on the general ideas of TGD inspired quantum biology [K34].

1. Biomolecules containing aromatic rings are known to play a fundamental role. For instance, most neurotransmitters and psychoactive drugs involve aromatic rings). All DNA nucleotides contain them and there are 4 proteins, which also have them. Trp and phe are of special importance and form a pair structurally analogous to a base pair in DNA strand. The rings are assumed to carry the analog of supra current and be in or at least be able to make transition to a state with large $h_{eff} = n \times h$. The delocalization of electron pairs in aromatic ring could be a signature of $h_{eff}/h > 1$.
2. Trp-phe pairing [K34] would be responsible for information molecule-receptor pairing. Information molecule and receptor would be at the ends of flux tubes serving as communication lines, and the attachment of info molecule to receptor would fuse the two flux tubes to longer one. After that communication would become possible as dark photon signals and dark supra currents. Formation of info molecule-receptor complex would be like clicking icon generating a connection between computers in net. Info molecules would generate the communication channels - they would not yet be the signals. This distinguishes TGD view from standard neuroscience.
3. All quantum critical phenomena involve generation of large h_{eff} phases and changes of h_{eff} in the sense that their values are different at different ends of space-time surface at boundaries of CD. Folding emerges or disappears at QC possible in certain temperature range of width about 40 K and depending on pH. The flux tubes associated with phe and trp containing aromatic rings carrying "supra current" would become dark (either $h \rightarrow h_{eff}$ or $h_{eff} > h$ increases) and thus much longer and reconnect temporarily and force phe and trp in a close contact after the reverse transition inducing shortening. This is a general mechanism making biomolecules able to find each other in what looks like molecular soup in the eyes of standard biochemist. The contacts between amino-acids phe and trp formed in this manner would be structurally identical with the hydrogen bonding between members of DNA base pairs and they would fix the final folding pattern to high degree.

5.2.3 Pollack's mechanism

The discovery of negatively charged exclusion zone formed in water bounded by gel phase has led Pollack to propose the notion of gel like fourth phase of water [L1, I7, I5] (see <http://tinyurl.com/oyhstc2>). The proposal is that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water -

say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the MB assignable to the exclusion zone and outside it [L1] [K34].

This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to form dark nuclear strings whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner [K11, K6]. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs.

Pollack's exclusion zones (EZs) might for instance explain why DNA is negatively charged. EZs or their generalization could play fundamental role in metabolism with protons running through mitochondrial membrane being dark as also other biologically important ions involved. EZs could be important even in electrolysis and allow to explain what happens in cold fusion. These hypothesis could be tested.

5.2.4 Why metabolism is needed?

The simplest and at the same time most difficult question that innocent student can make about biology class is simple: "Why we must eat?". Or using more physics oriented language: "Why we must get metabolic energy?". The answer of the teacher might be that we do not eat to get energy but to get order. The stuff that we eat contains ordered energy: we eat order. But order in standard physics is lack of entropy, lack of disorder. Student could get nosy and argue that excretion produces the same outcome as eating but is not enough to survive.

We could go to a deeper level and ask why metabolic energy is needed in biochemistry. Suppose we do this in TGD Universe with dark matter identified as phases characterized by $h_{eff}/h = n$. At deeper level metabolic energy should closely relate to negentropic entanglement (NE) and thus information. Identification of these two is however not possible. I have considered several answers to the question why metabolic energy is needed. Here two answers will be discussed.

1. Conscious information could be the basic currency and the transfer of metabolic energy and metabolites would make possible transfer of NE. Is the transfer of metabolic energy essentially transfer of NE? Could the transfer of NE require metabolic energy? NE transfer could be transfer of systems consisting of negentropically entangled parts or it could be transfer of NE with larger system, even Earth. NMP would force the systems to fight for NE and this would lead to the fight for metabolic resources. The transfer of entanglement is the basic mechanism in quantum computation and would mean in biology stealing of NE, the fundamental crime! The ideas related to metabolism in TGD Universe are discussed in detail in [K8].
2. Could metabolic energy needed to generate NE from scratch? For this option the molecules providing the metabolic energy contain dark atoms. Of course, the nutrients could already contain the negentropic entanglement and photosynthesis could serve as fundamental generator of NE. The following naive model for dark atoms obtained by replacing h with h_{eff} supports this view.
 - (a) The binding energy spectrum of dark hydrogen atom is scaled by $1/n^2$, $n = h_{eff}/h$ (do not confuse this n with the integer n labelling the states of hydrogen atom!) so that generation of dark hydrogen atoms would require energy. Dark atoms have smaller binding energies and their creation by a phase transition increasing the value of n demands a feed of energy - metabolic energy! If the metabolic energy feed stops, n is gradually reduced. System gets tired, loses consciousness, and eventually dies. Also in case of cyclotron energies the positive cyclotron energy is proportional to h_{eff} so that metabolic energy is needed to generate larger h_{eff} and prerequisites for negentropy.
 - (b) The analogy of weak form of NMP following from mere adelic physics makes it analogous to second law. Could one consider the purely formal generalization of $dE = TdS - ..$ to $dE = -TdN - ..$, where E refers to metabolic energy and N refers to entanglement negentropy? No: the situation is different. The system is not closed system; N is not

the negative of thermodynamical entropy S ; and E is the metabolic energy feeded to the system, not the system's internal energy. $dE = TdN - \dots$ might however make sense for a system to which metabolic energy is feeded.

The identification of N is still open: N could be identified either as $N = \sum_p N_p - S$, where one has sum of p-adic entanglement negentropies and real entanglement entropy S or as $N = \sum_p N_p$. For the first option one would have $N = 0$ for rational entanglement and $N \geq 0$ for extensions of rationals. Could rational entanglement be interpreted as that associated with dead matter in this case?

- (c) Bio-catalysis and $ATP \leftrightarrow ADP$ process need not require metabolic energy. A transfer of negentropy from nutrients to ATP to acceptor molecule would be in question. Metabolic energy would be needed to reload ADP with negentropy to give ATP by using ATP synthase as a mitochondrial power plant. Metabolites could be carriers of dark atoms of this kind possibly carrying also NE. They could also carry NE associated with the dark cyclotron states as suggested earlier and in this case the value of $h_{eff} = h_{gr}$ would be much larger than in the case of dark atoms.
- (d) What is remarkable that the scale of atomic binding energies decreases with n only in dimension $D = 3$. In other dimensions it increases and in $D = 4$ one cannot even speak of bound states! This can be easily found by a study of Schrödinger equation for the analog of hydrogen atom in various dimensions [L4]. Life based on atomic metabolism seems to make sense only in spatial dimension $D = 3$. Note however that there are also other quantum states than atomic states with different dependence of energy on h_{eff} .

5.2.5 Identification of NE possibly transferred in metabolism

I have considered several identifications of NE.

1. NE could be small scale entanglement - say between molecules having dark atoms. The short scale of entanglement does not conform with the large values of h_{gr} . One can however have also $h_{eff}/h = h_{em}/h = Z_1 Z_2 \alpha_{em}$. This would give rise to NE in short scales. The transfer of metabolic energy in $ATP \leftrightarrow ADP$ process could correspond to the transfer of short ranged NE.
2. NE could be between nutrient and larger structure - say Earth, Sun, or some other large enough structure to give a value of $h_{gr} = GMm/v_0$ guaranteeing that dark cyclotron energies (no dependence on mass m) in the range of bio-photon energies (visible and UV) and guarantee that EEG frequencies correspond to these energies. This option discussed in [K30]. Also long range entanglement could be present and correspond to a higher evolutionary level. A possible candidate for the larger structure could be a spherical layer at the distance of Moon from Earth would give correct value for $h_{eff} = h_{gr}$ [K30].

Nutrients could be carriers of both metabolic energy and of NE - both short and long ranged. Even electrons can provide metabolic energy and in TGD framework therefore also NE for some bacteria (see <http://tinyurl.com/o8xqh6g>): in this case only short range entanglement would be involved.

3. NE could be also between a larger structure and phosphate molecule added to ADP using metabolic energy. This option would predict that phosphates are in unique role as standard entanglers to mass M . Any source of metabolic energy is in principle possible since metabolic energy is only needed to transfer the flux tube connecting phosphate to mass M to ADP so that ATP is obtained. The flux tube would represent the "high energy phosphate bond". ATP in turn attaches the flux tube to biomolecule, which becomes negentropically entangled. Metabolism would make the transfer of NE possible. Metabolites would not contain information but it would be assignable to the flux tube between phosphate and mass M . Magnetic Mother Gaia would have very concrete meaning.

5.2.6 What happens in bio-catalysis?

Bio-catalysis is key mechanism of biology and its extreme efficacy remains to be understood. Enzymes are proteins and ribozymes RNA sequences acting as biocatalysts.

1. Conditions on bio-catalysis

What catalysis demands?

1. Catalyst and reactants must find each other. How this could happen is very difficult to understand in standard biochemistry in which living matter is seen as soup of biomolecules. I have already considered the mechanisms making it possible for the reactants to find each other. For instance, in the translation of mRNA to protein tRNA molecules must find their way to mRNA at ribosome. The proposal is that reconnection allowing U-shaped magnetic flux tubes to reconnect to a pair of flux tube connecting mRNA and tRNA molecule and reduction of the value of $h_{eff} = n \times h$ inducing reduction of the length of magnetic flux tube takes care of this step. This applies also to DNA transcription and DNA replication and bio-chemical reactions in general.
2. Catalyst must provide energy for the reactants (their number is typically two) to overcome the potential wall making the reaction rate very slow for energies around thermal energy. The TGD based model for the hydrino atom having larger binding energy than hydrogen atom claimed by Randell Mills [?] suggests a solution [L4]. Some hydrogen atom in catalyst goes from (dark) hydrogen atom state to hydrino state (state with smaller h_{eff}/h and liberates the excess binding energy kicking the either reactant over the potential wall so that reaction can process. After the reaction the catalyst returns to the normal state and absorbs the binding energy.
3. In the reaction volume catalyst and reactants must be guided to correct places. The simplest model of catalysis relies on lock-and-key mechanism. The generalized Chladni mechanism forcing the reactants to a two-dimensional closed nodal surface is a natural candidate to consider. There are also additional conditions. For instance, the reactants must have correct orientation. For instance, the reactants must have correct orientation and this could be forced by the interaction with the em field of ME involved with Chladni mechanism.
4. One must have also a coherence of chemical reactions meaning that the reaction can occur in a large volume - say in different cell interiors - simultaneously. Here MB would induce the coherence by using MEs. Chladni mechanism might explain this if there is there is interference of forces caused by periodic standing waves themselves represented as pairs of MEs.

2. Phase transition reducing the value of $h_{eff}/h = n$ as a basic step in bio-catalysis

Hydrogen atom allows also large $h_{eff}/h = n$ variants with $n > 6$ with the scale of energy spectrum behaving as $(6/n)^2$ if the $n = 4$ holds true for visible matter. The reduction of n as the flux tube contracts would reduce n and liberate binding energy, which could be used to promote the catalysis.

The notion of high energy phosphate bond is somewhat mysterious concept and manifests as the ability provide energy in ATP to ADP transition. There are claims that there is no such bond. I have spent considerable amount of time to ponder this problem. Could phosphate contain (dark) hydrogen atom able to go to the a state with a smaller value of h_{eff}/h_i and liberate the excess binding energy? Could the phosphorylation of acceptor molecule transfer this dark atom associated with the phosphate of ATP to the acceptor molecule? Could the mysterious high energy phosphate bond correspond to the dark atom state. Metabolic energy would be needed to transform ADP to ATP and would generate dark atom.

Could solar light kick atoms into dark states and in this manner store metabolic energy? Could nutrients carry these dark atoms? Could this energy be liberated as the dark atoms return to ordinary states and be used to drive protons against potential gradient through ATP synthase analogous to a turbine of a power plant transforming ADP to ATP and reproducing the dark atom and thus the "high energy phosphate bond" in ATP? Can one see metabolism as transfer of dark atoms? Could possible negentropic entanglement disappear and emerge again after $ADP \rightarrow ATP$.

Here it is essential that the energies of the hydrogen atom depend on $\hbar_{eff} = n \times h$ in as \hbar_{eff}^m , $m = -2 < 0$. Hydrogen atoms in dimension D have Coulomb potential behaving as $1/r^{D-2}$ from Gauss law and the Schrödinger equation predicts for $D \neq 4$ that the energies satisfy $E_n \propto$

$(h_{eff}/h)^m$, $m = 2 + 4/(D - 4)$. For $D = 4$ the formula breaks since in this case the dependence on \hbar is not given by power law. m is negative only for $D = 3$ and one has $m = -2$. There $D = 3$ would be unique dimension in allowing the hydrino-like states making possible bio-catalysis and life in the proposed scenario.

It is also essential that the flux tubes are radial flux tubes in the Coulomb field of charged particle. This makes sense in many-sheeted space-time: electrons would be associated with a pair formed by flux tube and 3-D atom so that only part of electric flux would interact with the electron touching both space-time sheets. This would give the analog of Schrödinger equation in Coulomb potential restricted to the interior of the flux tube. The dimensional analysis for the 1-D Schrödinger equation with Coulomb potential would give also in this case $1/n^2$ dependence. Same applies to states localized to 2-D sheets with charged ion in the center. This kind of states bring in mind Rydberg states of ordinary atom with large value of n .

The condition that the dark binding energy is above the thermal energy gives a condition on the value of $h_{eff}/h = n$ as $n \leq 32$. The size scale of the dark largest allowed dark atom would be about 100 nm, 10 times the thickness of the cell membrane.

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