New Developments in TGD and Their Implications for TGD Inspired Theory of Consciousness

M. Pitkänen[1], February 1, 2006

[1] Department of Physical Sciences, High Energy Physics Division,
PL 64, FIN-00014, University of Helsinki, Finland.
matpitka@rock.helsinki.fi, http://www.physics.helsinki.fi/∼matpitka/.
Recent address: Puutarhurinkatu 10,10960, Hanko, Finland.

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Abstract

The conflict between the non-determinism of state function reduction and determinism of time evolution of Schrödinger equation is serious enough a problem to motivate the attempt to extend physics to a theory of consciousness by raising the observer from an outsider to a key notion also at the level of physical theory. Further motivations come from the failure of the materialistic and reductionistic dogmas in attempts to understand consciousness in neuroscience context.

There are reasons to doubt that standard quantum physics could be enough to achieve this goal and the new physics predicted by TGD is indeed central in the proposed theory. The developments in quantum TGD during last years have led to a fusion of real and p-adic physics by using generalization of number concept, to the realization of the crucial role of hyper-finite factors of type II_1 for quantum TGD, to the generalization of the imbedding space implying hierarchy of quantized values of Planck constant, to so called zero energy ontology, and to the reduction of quantum TGD to parton level with parton understand as 2-D surface whose orbit is light-like 3-surface, and to the realization that quantum TGD can be formulated as almost topological quantum field theory using category theoretical framework.

These developments have considerably simplified the conceptual framework behind both TGD and TGD inspired theory of consciousness and provided justification for various concepts of consciousness theory deduced earlier from quantum classical correspondence and properties of many-sheeted space-time.

The notions of quantum jump and self can be unified in the recent formulation of TGD relying on dark matter hierarchy characterized by increasing values of Planck constant. Negentropy Maximization Principle serves as a basic variational principle for the dynamics of quantum jump and must be modified to the case of hyper-finite factors of type II_1 The new view about the relation of geometric and subjective time together with zero energy ontology leads to a new view about memory and intentional action. The quantum measurement theory based on finite measurement resolution and realized in terms of hyper-finite factors of type II_1 justifies the notions of sharing of mental images and stereo-consciousness deduced earlier on basis of quantum classical correspondence. A new element is finite resolution of quantum measurement and cognitive and sensory experience. Qualia reduce to quantum number increments associated with quantum jump. Self-referentiality of consciousness can be understood from quantum classical correspondence implying a symbolic representation of contents of consciousness at space-time level updated in each quantum jump. p-Adic physics provides space-time correlates for cognition and intentionality.

1 Introduction

The conflict between the non-determinism of state function reduction and determinism of time evolution of Schrödinger equation is serious enough a problem to motivate the attempt to extend physics to a theory of consciousness by raising the observer from an outsider to a key notion also at the level of physical theory. Further motivations come from the failure of the materialistic and reductionistic dogmas in attempts to understand consciousness in neuroscience context.

There are reasons to doubt that standard quantum physics could be enough to achieve this goal and the new physics predicted by TGD is indeed central in the proposed theory. The developments in quantum TGD during last years have led to a fusion of real and p-adic physics by using generalization of number concept, to the realization of the crucial role of hyper-finite factors of type II_1 for quantum TGD, to the generalization of the imbedding space implying hierarchy of quantized values of Planck constant, to so called zero energy ontology, and to the reduction of quantum TGD to parton level with parton understand as 2-D surface whose orbit is light-like 3-surface, and to the realization that quantum TGD can be formulated as almost topological quantum field theory using category theoretical framework.

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2 The new developments in quantum TGD

This section summarizes the developments in quantum TGD which have taken place during last few years.

2.1 Reduction of quantum TGD to parton level

It took surprisingly long time before the realization that quantum TGD can be reduced to parton level in the sense that fundamental objects are light-like 3-surfaces (of arbitrary size). This identification follows from 4-D general coordinate invariance. Light-likeness in turn implies effective 2-dimensionality of the fermionic dynamics. 4-D space-time sheets are identified as preferred extrema of Kähler action. A stronger form of holography is that modified Dirac action and Chern-Simons action for light-like partonic 3-surfaces defined the Kähler action as a logarithm of the fermionic determinant.

2.1.1 Magic properties of 3-D light-like surfaces and generalization of super-conformal symmetries

The very special conformal properties of both boundary $\delta M^4_{\pm}$ of 4-D light-cone and of light-like partonic 3-surfaces X^3 imply a generalization and extension of the super-conformal symmetries of super-string models to 3-D context [B2, B3, C1]. Both the Virasoro algebras associated with the light-like coordinate r and to the complex coordinate z transversal to it define super-conformal algebras so that the structure of conformal symmetries is much richer than in string models.

1. The canonical transformations of $\delta M^4_{\pm} \times CP_2$ give rise to an infinite-dimensional symplectic/canonical algebra having naturally a structure of Kac-Moody type algebra with respect to the light-like coordinate of $\delta M^4_{\pm} = S^2 \times R_+$ and with finite-dimensional Lie group G replaced with the canonical group. The conformal transformations of S^2 localized with respect to the light like coordinate act as conformal symmetries analogous to those of string models. The super-canonical algebra, call it SC, made local with respect to partonic 2-surface can be regarded as a Kac-Moody algebra associated with an infinite-dimensional Lie algebra.

2. The light-likeness of partonic 3-surfaces is respected by conformal transformations of H made local with respect to the partonic 3-surface and gives to a generalization of bosonic

Kac-Moody algebra, call it KM, Also now the longitudinal and transversal Virasoro algebras emerge. The commutator $[KM, SC]$ annihilates physical states.

3. Fermionic Kac-Moody algebras act as algebras of left and right handed spinor rotations in M^4 and CP_2 degrees of freedom. Also the modified Dirac operator allows super-conformal symmetries as gauge symmetries of its generalized eigen modes.

2.1.2 Quantum TGD as almost topological quantum field theory at parton level

The light-likeness of partonic 3-surfaces fixes the partonic quantum dynamics uniquely and Chern-Simons action for the induced Kähler gauge potential of CP_2 determines the classical dynamics of partonic 3-surfaces [B4]. For the extremals of C-S action the CP_2 projection of surface is at most 2-dimensional.

The modified Dirac action obtained as its super-symmetric counterpart fixes the dynamics of the second quantized free fermionic fields in terms of which configuration space gamma matrices and configuration space spinors can be constructed. The essential difference to the ordinary massless Dirac action is that induced gamma matrices are replaced by the contractions of the canonical momentum densities of Chern-Simons action with imbedding space gamma matrices so that modified Dirac action is consistent with the symmetries of Chern-Simonas action. Fermionic statistics is geometrized in terms of spinor geometry of WCW since gamma matrices are linear combinations of fermionic oscillator operators identifiable also as super-canonical generators [B4]. Only the light-likeness property involving the notion of induced metric breaks the topological QFT property of the theory so that the theory is as close to a physically trivial theory as it can be.

The resulting generalization of $N = 4$ super-conformal symmetry [27] involves super-canonical algebra (SC)and super Kac-Moody algebra (SKM) [C1] There are considerable differences as compared to string models.

1. Super generators carry fermion number, no sparticles are predicted (at least super Poincare invariance is not obtained), SKM algebra and corresponding Virasoro algebra associated with light-like coordinates of X^3 and $\delta M^4_{\pm}$ do not annihilate physical states which justifies p-adic thermodynamics used in p-adic mass calculations, four-momentum does not appear in Virasoro generators so that there are no problems with Lorentz invariance, and mass squared is p-adic thermal expectation of conformal weight.

2. The conformal weights and eigenvalues of modified Dirac operator are complex and the conjecture is that they are closely related to zeros of Riemann Zeta [B4, C2]. This means that positive energy particles propagating into geometric future are not equivalent with negative energy particles propagating in geometric past so that crossing symmetry is broken. Complex conjugation for the super-canonical conformal weights and eigenvalues of the modified Dirac operator would transform laser photons to their phase conjugates for which dissipation seems to occur in a reversed direction of geometric time. Hence irreversibility would be present already at elementary particle level.

2.2 Quantum measurement theory with finite measurement resolution

Infinite-dimensional Clifford algebra of CH can be regarded as a canonical example of a von Neumann algebra known as a hyper-finite factor of type II_1 [16, 18](shortly HFF) characterized by the defining condition that the trace of infinite-dimensional unit matrix equals to unity: $Tr(Id) = 1$. In TGD framework the most obvious implication is the absence of fermionic normal ordering infinities whereas the absence of bosonic divergences is guaranteed by the basic properties of the configuration space Kähler geometry, in particular the non-locality of the Kähler function as a functional of 3-surface.

The special properties of this algebra, which are very closely related to braid and knot invariants [17, 26], quantum groups [19, 18], non-commutative geometry [23], spin chains, integrable models [21], topological quantum field theories [22], conformal field theories, and at the level of concrete physics to anyons [20], generate several new insights and ideas about the structure of quantum TGD.

Jones inclusions $\mathcal{N} \subset \mathcal{M}$ [24, 18] of these algebras lead to quantum measurement theory with a finite measurement resolution characterized by $\mathcal{N}$ [C8, C9]. Quantum Clifford algebra $\mathcal{M}/\mathcal{N}$ interpreted as $\mathcal{N}$-module creates physical states modulo measurement resolution. Complex rays of the state space resulting in the ordinary state function reduction are replaced by $\mathcal{N}$-rays and the notions of unitarity, hermiticity, and eigenvalue generalize [C9, C2].

The notion of entanglement generalizes so that entanglement coefficients are N-valued. Generalized eigenvalues are in turn N-valued hermitian operators. S- and U-matrices become N valued and probabilities are obtained from N-valued probabilities as traces.

Non-commutative physics would be interpreted in terms of a finite measurement resolution rather than something emerging below Planck length scale. An important implication is that a finite measurement sequence can never completely reduce quantum entanglement so that entire universe would necessarily be an organic whole. Topologically condensed space-time sheets could be seen as correlates for sub-factors which correspond to degrees of freedom below measurement resolution. Topological condensation in turn corresponds to the inclusion $\mathcal{N} \subset \mathcal{M}$. This is however not the only possible interpretation.

2.3 Hierarchy of Planck constants

The idea about hierarchy of Planck constants relying on generalization of the imbedding space was inspired both by empirical input (Bohr quantization of planetary orbits) and by the mathematics of hyper-finite factors of type II_1 combined with the quantum classical correspondence.

2.3.1 The generalization of imbedding space concept and hierarchy of Planck constants

Quantum classical correspondence suggests that Jones inclusions [24] have space-time correlates [C8, C9]. There is a canonical hierarchy of Jones inclusions labelled by finite subgroups of SU(2)[18] This leads to a generalization of the imbedding space obtained by gluing an infinite number of copies of H regarded as singular bundles over $H/G_a \times G_b$, where $G_a \times G_b$ is a subgroup of $SU(2) \times SU(2) \subset SL(2,C) \times SU(3)$. Gluing occurs along a factor for which the group is same. The generalized imbedding space has clearly a book like structure with pages of books intersecting along 4-D sub-manifold $M^2 \times S^2$, S^2 a geodesic sphere of CP_2 characterizing the choice of quantization axies. Entire configuration space is union over "books" corresponding to various choices of this sub-manifold.

The groups in question define in a natural manner the direction of quantization axes for for various isometry charges and this hierarchy seems to be an essential element of quantum measurement theory. Ordinary Planck constant, as opposed to Planck constants $\hbar_a = n_a\hbar_0$ and $\hbar_b = n_b\hbar_0$ appearing in the commutation relations of symmetry algebras assignable to M^4 and CP_2, is naturally quantized as $\hbar = (n_a/n_b)\hbar_0$, where n_i is the order of maximal cyclic subgroup of G_i. The hierarchy of Planck constants is interpreted in terms of dark matter hierarchy [C9]. What is also important is that $(n_a/n_b)^2$ appear as a scaling factor of M^4 metric so that Kähler action via its dependence on induced metric codes for radiative corrections coming in powers of ordinary Planck constant: therefore quantum criticality and vanishing of radiative corrections to functional integral over WCW does not mean vanishing of radiative corrections.

G_a would correspond directly to the observed symmetries of visible matter induced by the underlying dark matter [C9]. For instance, in living matter molecules with 5- and 6-cycles could

directly reflect the fact that free electron pairs associated with these cycles correspond to $n_a = 5$ and $n_a = 6$ dark matter possibly responsible for anomalous conductivity of DNA [C9, J1] and recently reported strange properties of graphene [33]. Also the tedrahedral and icosahedral symmetries of water molecule clusters could have similar interpretation [35, F10].

A further fascinating possibility is that the observed indications for Bohr orbit quantization of planetary orbits [31] could have interpretation in terms of gigantic Planck constant for underlying dark matter [D6] so that macroscopic and -temporal quantum coherence would be possible in astrophysical length scales manifesting itself in many manners: say as preferred directions of quantization axis (perhaps related to the CMB anomaly) or as anomalously low dissipation rates.

Since the gravitational Planck constant is proportional to the product of the gravitational masses of interacting systems, it must be assigned to the field body of the two systems and characterizes the interaction between systems rather than systems themselves. This observation applies quite generally and each field body of the system (em, weak, color, gravitational) is characterized by its own Planck constant.

In the gravitational case the order of G_a is gigantic and at least GM_1m/v_0, $v_0 = 2^{-11}$ the favored value. The natural interpretation is as a discrete rotational symmetry of the gravitational field body of the system having both gravimagnetic and gravi-electric parts. The subgroups of G_a for which order is a divisor of the order of G_a define broken symmetries at the lower levels of dark matter hierarchy, in particular symmetries of visible matter.

The number theoretically simple ruler-and-compass integers having as factors only first powers of Fermat primes and power of 2 would define a physically preferred sub-hierarchy of quantum criticality for which subsequent levels would correspond to powers of 2: a connection with p-adic length scale hypothesis suggests itself. Ruler and compass hypothesis implies that besides p-adic length scales also their 3- and 5- multiples should be important. Note that in the structure of chromosomes p-adic length scale $L(151) \simeq 10$ characterizes beads-on-string structure of DNA whereas the length scale $3L(151)$ appears in the coiling of this structure.

2.3.2 Implications of dark matter hierarchy

The basic implication of dark matter hierarchy is hierarchy of macroscopic quantum coherent systems covering all length scales. The presence of this hierarchy is visible as exact discrete symmetries of field bodies reflecting at the level of visible matter as broken symmetries. In case of gravitational interaction these symmetries are highest and also the scale of quantum coherence is astrophysical. Together with ruler-and-compass hypothesis and p-adic length scale hypothesis this leads to very powerful predictions and p-adic length scale hypothesis might reduce to the ruler-and-compass hypothesis.

At the level of condensed matter one application is nuclear string model explaining also the selection rules of cold fusion and predicting that dark copy of weak physics with atomic scale defining the range of weak interaction is involved. Note that cold fusion has recently gained considerable support. High T_c super-conductivity is second application of dark matter hierarchy.

The 5- and 6-fold symmetries of the sugar backbone of DNA suggest that corresponding cyclic groups or cyclic groups having these groups as factors are symmetries of dark matter part of DNA presumably consisting of what is called as free electron pairs assignable to 5- and 6-cycles. The model allows to understand the observed high conductivity of DNA not consistent with the insulator property of DNA at the level of visible matter.

One also ends up with a speculative notion of N-atom providing a mechanism for the emergence of symbolic representations at the level of bio-molecules and a general mechanism of bio-catalysis.

2.3.3 Dark matter and bio-control

The hierarchy of dark matters provides rather concrete realization for the vision about living matter as quantum critical system. This vision will be discussed in more detail later.

The large Planck constants characterize various field bodies of physical system. This gives justification to the notion of (magnetic) field body which plays key role in TGD inspired model of living matter serving as intentional agent controlling the behavior of field body. For instance, the model of EEG relies and of bio-control relies on this notion. The large value of the Planck constant is absolutely essential since for a given low frequency it allows to have gauge boson energy above thermal threshold. Large value of Planck constant is essential for time mirror mechanism which is behind the models of metabolism, long term memory, and intentional action.

The huge values of gravitational Planck constant supports the vision of Penrose [38] about the special role of quantum gravitation in living matter. In TGD framework the proposal of Penrose and Hameroff for the emergence of consciousness known as Orch-Or (Orchestrated Objective Reduction [39]) is however too restricted since it gives a very special role to micro-tubules.

A reasonable guess - based on the hypothesis that transition to dark matter phase occurs when perturbation theory for standard value of Planck constant fails - is that $GMm > 1$ is the criterion for the transition to dark phase for the gravitational field body characterizing the interaction between the two masses so that Planck mass becomes the critical mass for this transition. For the density of water this means size scale of .1 mm, the size of large neuron.

2.4 Zero energy ontology

Zero energy ontology has roots in TGD inspired cosmology [D5]. The problem has been that the imbeddings of Robertson-Walker cosmologies have vanishing densities of Poincare momenta identified as inertial momenta whereas gravitational energy density is non-vanishing. This led to the conclusion that one must allow space-time sheets with both time orientations such that the signs of Poincare energies are different for them and total density of inertial energy vanishes. Gravitational momenta can be identified as difference of the Poincare momenta and need not be conserved.

2.4.1 Construction of S-matrix and zero energy ontology

The construction of S-matrix allows to formulate this picture more sharply. Zero energy states have positive and negative energy parts located in geometric past and future and S-matrix can be identified as time-like entanglement coefficients between these states. Positive energy ontology is a good approximation in time scales shorter than the temporal distance between positive and negative energy states. This picture leads also to a generalization of Feynman graphs obtained by gluing light-like partonic 3-surfaces together along their ends at vertices. These Feynman cobordisms become a basic element of quantum TGD having interpretation as almost topological QFT and category theoretical formulation of quantum TGD emerges.

2.4.2 Elementary particles and zero energy ontology

At the level of elementary particles zero energy ontology means that fermionic quantum numbers are located at the light-like throats of wormhole contacts connecting CP_2 type extremals with Euclidian signature of induced metric to space-time sheets with Minkowskian signature of induced metric. Gauge bosons in turn correspond to pieces of CP_2 type extremals connecting positive and negative energy space-time sheets with fermion and antifermion quantum numbers at the throats of the wormhole contact. Depending on the sign of net energy one has ordinary boson or its phase conjugate. Gravitons correspond to pairs of fermion or gauge boson pair with particle and antiparticle connected by flux tube. This string picture emerges automatically if one assumes

that the fermions of the conformal field theory associated with partonic 3-surface are free. It is also possible to have gauge bosons corresponding to single wormhole throat: these particles correspond to bosonic generators of super-canonical algebra and excitations which correspond to genuine configuration space degrees of freedom so that description in terms of quantum field theory in fixed background space-time need not work.

2.5 U- and S-matrices

In quite early stage physical arguments led to the conclusion that the universal U-matrix associated with quantum jump must be distinguished from the S-matrix characterizing the rates of particle reactions. The notion of zero energy ontology was however needed before it became possible to characterize the difference between these matrices in a more precise manner.

2.5.1 Some distinctions between U- and S-matrices

The distinctions between U- and S-matrices have become rather clearer.

1. U-matrix is the universal unitary matrix assignable to quantum jump between zero energy states whereas S-matrix can be identified as time-like entanglement coefficients between positive and negative energy parts of the zero energy state. Thus S-matrix characterizes zero energy states.

2. U-matrix is always between zero energy states and the corresponding state function reduction reduces entanglement between zero energy states. State function reduction for S-matrix elements reduces the entanglement between positive and negative energy parts of a given zero energy state and is completely analogous to ordinary quantum measurement reducing entanglement between systems having space-like separation.

3. U-matrix is unitary whereas S-matrix can be unitary only for HFFs of type II_1. In the most general case S-matrix can be regarded as a "square" root of the density matrix assignable to time like entanglement: this hypothesis would unify the notions of S-matrix and density matrix and one could regard quantum states as matrix analogs of Schrö;dinger amplitudes expressible as products of its modulus (square root of probability density replaced with square root of density matrix) and phase (possibly universal unitary S-matrix). Thermal S-matrices define an important special case and thermodynamics becomes an integral part of quantum theory in zero energy ontology.

4. U-matrix can have elements between different number fields. In this case one must however assume number theoretical universality meaning that U-matrix has rational or at most algebraic matrix elements. In the case of HFFs of type II_1 this might imply triviality. U-matrix between p-adic and real number fields would relate to intentional action and the almost triviality would be a blessing meaning that the realization of intentional action occurs in a very precise manner and is restricted only by cutoff due to the algebraic character of number theoretic braids.

S-matrix as time-like entanglement matric is diagonal with respect to number field and number theoretical universality is not absolutely essential for its definition.

2.5.2 Number theoretic universality and S-matrix

The fact that zero energy states are created by p-adic to-real transitions and must be number theoretically universal suggests strongly that the data about partonic 2-surfaces contributing to S-matrix elements come from the intersection of real partonic 2-surface and its p-adic counterpart

satisfying same algebraic equations. The intersection consists of algebraic points and contains as subset number theoretic braids central for the proposed construction of S-matrix.

The question is whether also states for which S-matrix receives data from non-algebraic points should be allowed or whether the data can come even from continuous string like structures at partonic 2-surfaces as standard conformal field theory picture would suggest. If also S-matrix is algebraic, one can wonder whether there is any difference between p-adic and real physics at all. The latter option would mean that intentional action is followed by a unitarity process U analogous to a dispersion of completely localized particle implied by Schröndinger equation.

The algebraic universality of S-matrix could mean that S-matrix is obtained as algebraic continuation of rational S-matrix by replacing incoming momenta and other continuous quantum numbers with real ones. Similar continuation should make sense in p-adic sector. S-matrix and U-matrix in a given algebraic extension of rationals or p-adics are not in general diagonalizable. Thus number theory would allows to avoid the paradoxical conclusion that S-matrix is always diagonal in a suitable basis.

2.6 Number theoretic ideas

p-Adic physics emerged roughly at the same time via p-adic mass calculations. The interpretation of p-adic physics as physics of cognition and intentionality emerged. The basic idea was that bosonic p-adic space-time sheets provide representations for intentions and the transformation of intention to action corresponds to a transformation of p-adic space-time sheet to a real one. Gauge bosons identified as pairs of wormhole throats carrying fermion and antifermion numbers so that a a more precise characterization of "bosonic" would be as "purely bosonic" meaning wormhole throat associated with CP_2 type extremal. These bosons would be exotic and correspond to states of super-canonical representations. If one accepts the hypothesis that fermionic Fock algebra represents Boolean cognition, one ends up the idea that fermions and their p-adic counterparts appear as pairs and that p-adic partonic 2-surface has interpretation as cognitive representation of fermion. This picture conforms nicely with interpretation in terms of infinite primes.

Cognition and intentionality would be present already at elementary particle level and p-adic fractality would be the experimental signature of it making itself visible in elementary particle mass spectrum among other things. The success of p-adic mass calculations provides strong siupport for the hypothesis.

This led gradually to the vision about physics as generalized number theory. It involves three separate aspects.

1. The p-adic approach led eventually to the program of fusing real physics and various p-adic physics to a single coherent whole by generalizing the number concept by gluing reals and various p-adics to a larger structure along common rationals and algebraics. This inspired the notion of algebraic universality stating that for instance S-matrix should result by algebraic continuation from rational or at most algebraic valued S-matrix.

   The notion of number theoretic braid belonging to the algebraic intersection of real and p-adic partonic 2-surface obeying same algebraic equations emerged also and gives a further connection with topological QFT:s. The perturbation theoretic definition of S-matrix is definitely excluded in this approach and TGD indeed leads to the understanding of coupling constant evolution at the level of "free" theory as a discrete p-adic coupling constant evolution so that radiative corrections are not needed for this purpose.

2. Also the classical number fields relate closely to TGD and the vision is that imbedding space M^4xCP_2 emerges from the physics based on hyper-octonionic 8-space with associativity as the fundamental dynamical principle both at classical and quantum level. Hyper-octonion space M^8 with space-time surface identified as hyper-quanternionic sub-manifolds or their

duals and M^4xCP_2 would provide in this framework dual manners to describe physics and this duality would provide TGD counterpart for compactication.

3. The construction of infinite primes is analogous to repeated second quantization of supersymmetric arithmetic quantum field theory. This notion implies a further generalization of real and p-adic numbers allowing space-time points to have infinitely complex number theoretic structure not visible at the level of real physics. The idea is that space-time points define the Platonia able to represent in its structure arbitrarily complex mathematical structures and that space-time points could be seen as evolving structures becoming quantum jump by quantum jump increasingly complex number theoretically. Even the world of classical worlds (light-like 3-surfaces) and quantum states of Universe might be represented in terms of the number theoretic anatomy of space-time points (number theoretic Brahman=Atman and algebraic holography).

2.6.1 S-matrix as a functor and the groupoid structure formed by S-matrices

In zero energy ontology S-matrix can be seen as a functor from the category of Feynman cobordisms to the category of operators. S-matrix can be identified as a "square root" of the positive energy density matrix $S = \rho_+^{1/2} S_0$, where S_0 is a unitary matrix and ρ_+ is the density matrix for positive energy part of the zero energy state. Obviously one has $SS^\dagger = \rho_+$. $S^\dagger S = \rho_-$ gives the density matrix for negative energy part of zero energy state. Clearly, S-matrix can be seen as matrix valued generalization of Schrödinger amplitude. Note that the "indices" of the S-matrices correspond to configuration space spinors (fermions and their bound states giving rise to gauge bosons and gravitons) and to configuration space degrees of freedom (world of classical worlds). For hyper-finite factor of II_1 it is not strictly speaking possible to speak about indices since the matrix elements are traces of the S-matrix multiplied by projection operators to infinite-dimensional subspaces from right and left.

The functor property of S-matrices implies that they form a multiplicative structure analogous but not identical to groupoid [30]. Recall that groupoid has associative product and there exist always right and left inverses and identity in the sense that ff^{-1} and $f^{-1}f$ are always defined but not identical and one has $fgg^{-1} = f$ and $f^{-1}fg = g$.

The reason for the groupoid like property is that S-matrix is a map between state spaces associated with initial and final sets of partonic surfaces and these state spaces are different so that inverse must be replaced with right and left inverse. The defining conditions for groupoid are replaced with more general ones. Also now associativity holds but the role of inverse is taken by hermitian conjugate. Thus one has the conditions $fgg^\dagger = f\rho_{g,+}$ and $f^\dagger fg = \rho_{f,-}g$, and the conditions $ff^\dagger = \rho_+$ and $f^\dagger f = \rho_-$ are satisfied. Here $\rho_\pm$ is density matrix associated with positive/negative energy parts of zero energy state. If the inverses of the density matrices exist, groupoid axioms hold true since $f_L^{-1} = f^\dagger \rho_{f,+}^{-1}$ satisfies $ff_L^{-1} = Id_+$ and $f_R^{-1} = \rho_{f,-}^{-1} f^\dagger$ satisfies $f_R^{-1} f = Id_-$.

There are good reasons to believe that also tensor product of its appropriate generalization to the analog of co-product makes sense with non-triviality characterizing the interaction between the systems of the tensor product. If so, the S-matrices would form very beautiful mathematical structure bringing in mind the corresponding structures for 2-tangles and N-tangles. Knowing how incredibly powerful the group like structures have been in physics, one has good reasons to hope that groupoid like structure might help to deduce a lot of information about the quantum dynamics of TGD.

A word about nomenclature is in order. S has strong associations to unitarity and it might be appropriate to replace S with some other letter. The interpretation of S-matrix as a generalized Schrödinger amplitude would suggest Ψ-matrix. Since the interaction with Kea's M-theory blog (with M denoting Monad or Motif in this context) was crucial for the realization of the the

connection with density matrix, also M-matrix might work. S-matrix as a functor from the category of Feynman cobordisms in turn suggests C or F. Or could just Matrix denoted by M in formulas be enough?

2.6.2 Number theoretic braids and braid replication

The notion of number theoretic braid is especially interesting from the point of view of quantum biology. Generalized Feynman diagrams obtained by gluing light-like partonic 3-surfaces (whose sizes can be arbitrarily large) along their ends and define what might be called Feynman cobordisms.

A key observation is that number theoretic braids replicate in annihilation vertices. This leads to a general interpretation of generalized Feynman diagrams. Incoming and outgoing "lines" give rise to topological quantum computations characterized by corresponding S-matrices, vertices give rise to replication of number theoretic braids analogous to DNA replication, and internal lines are analogous to quantum communications.

Number theoretic braids are associated with light-like 3-surfaces and can be said to have both dynamical and static characteristics. Partonic 2-surfaces as sub-manifolds of space-like 3-surface can also become linked and knotted and would naturally define space-like counterparts of tangles. Number theoretic braids could define dynamical topological quantum computation like operations whereas partonic 2-surfaces associated with say RNA could define as their space-like counterparts tangles and in special case braids analogous to printed quantum programs. An interesting question is how these two structures are transformed to each other: could this process correspond to a conscious reading like process and how closely DNA relates to language so that reading and writing would be fundamental processes appearing in all scales.

2.6.3 Dark matter hierarchy and hierarchy of quantum critical systems in modular degrees of freedom

Dark matter hierarchy corresponds to a hierarchy of conformal symmetries Z_n of partonic 2-surfaces with genus $g \geq 1$ such that factors of n define subgroups of conformal symmetries of Z_n. By the decomposition $Z_n = \prod_{p|n} Z_p$, where $p|n$ tells that p divides n, this hierarchy corresponds to an hierarchy of increasingly quantum critical systems in modular degrees of freedom. For a given prime p one has a sub-hierarchy Z_p, $Z_{p^2} = Z_p \times Z_p$, etc... such that the moduli at n+1:th level are contained by n:th level. In the similar manner the moduli of Z_n are sub-moduli for each prime factor of n. This mapping of integers to quantum critical systems conforms nicely with the general vision that biological evolution corresponds to the increase of quantum criticality as Planck constant increases. This hierarchy would also define a hierarchy of conscious entities and could relate directly to mathematical cognition.

The group of conformal symmetries could be also non-commutative discrete group having Z_n as a subgroup. This inspires a very short-lived conjecture that only the discrete subgroups of SU(2) allowed by Jones inclusions are possible as conformal symmetries of Riemann surfaces having $g \geq 1$. Besides Z_n one could have tedrahedral and icosahedral groups plus cyclic group Z_{2n} with reflection added but not Z_{2n+1} nor the symmetry group of cube. The conjecture is wrong. Consider the orbit of the subgroup of rotational group on standard sphere of E^3, put a handle at one of the orbits such that it is invariant under rotations around the axis going through the point, and apply the elements of subgroup. You obtain a Riemann surface having the subgroup as its isometries. Hence all discrete subgroups of SU(2) can act even as isometries for some value of g.

The number theoretically simple ruler-and-compass integers having as factors only first powers of Fermat primes and power of 2 would define a physically preferred sub-hierarchy of quantum criticality for which subsequent levels would correspond to powers of 2: a connection with p-adic length scale hypothesis suggests itself.

Spherical topology is exceptional since in this case the space of conformal moduli is trivial and conformal symmetries correspond to the entire $SL(2,C)$. This would suggest that only the fermions of lowest generation corresponding to the spherical topology are maximally quantum critical. This brings in mind Jones inclusions for which the defining subgroup equals to $SU(2)$ and Jones index equals to $\mathcal{M}/\mathcal{N} = 4$. In this case all discrete subgroups of $SU(2)$ label the inclusions. These inclusions would correspond to fiber space $CP_2 \to CP_2/U(2)$ consisting of geodesic spheres of CP_2. In this case the discrete subgroup might correspond to a selection of a subgroup of $SU(2) \subset SU(3)$ acting non-trivially on the geodesic sphere. Cosmic strings $X^2 \times Y^2 \subset M^4 \times CP_2$ having geodesic spheres of CP_2 as their ends could correspond to this phase dominating the very early cosmology.

3 TGD inspired theory of consciousness in the new conceptual framework

In this section basic implications of the new view about quantum TGD for TGD inspired theory of consciousness are summarized.

3.1 Basic notions and ideas

Quantum jump as moment of consciousness and self represent the fundamental notions of TGD inspired theory of consciousness.

3.1.1 Quantum jump as moment of consciousness and the notion of self

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

Intuitively self corresponds to a sequence of quantum jumps which somehow integrates to a larger unit much like many-particle bound state is formed from more elementary building blocks. It also seems natural to assume that self stays conscious as long as it can avoid bound state entanglement with the environment: everything is conscious and consciousness can be only lost. This view predicts infinite self hierarchy with the entire Universe at the top.

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

If one accepts the hierarchy of Planck constants [C9], it seems un-necessary to distinguish between self and quantum jump. The hierarchy of Planck constants interpreted in terms of dark matter hierarchy predicts a hierarchy of quantum jumps such that the size of space-time region contributing to the contents of conscious experience scales like $\hbar$. That sequence of sub-selves/sub-quantum jumps are experienced as separate mental images explains why we can distinguish between digits of phone number. The irreducible component of self (pure awareness) would correspond to the highest level in the "personal" hierarchy of quantum jumps and the sequence of lower level quantum jumps would be responsible for the experience of time flow. Entire life cycle would correspond to single quantum jump at the highest(?) level of the personal self hierarchy and pure awareness would prevail during sleep: this would make it possible to experience directly that I existed yesterday.

The standard dogma about consciousness is that it is completely private. It seems that this cannot be the case in TGD Universe. Von Neumann algebras known as hyper-finite factors of type II_1 (HFF) [C8, C9] provide the basic mathematical framework for quantum TGD and this suggests important modifications of the standard measurement theory besides those implied by the zero energy ontology predicting that all physical states have vanishing net quantum numbers and are creatable from vacuum. The notion of measurement resolution characterized in terms of Jones inclusions $\mathcal{N} \subset \mathcal{M}$ of HFFs implies that entanglement is defined always modulo some resolution characterized by infinite-dimensional sub-Clifford algebra $\mathcal{N}$ playing a role analogous to that of gauge algebra.

The finite resolution of quantum measurement in degrees of freedom corresponding to HFFs of type II_1 means also finite sensory and cognitive resolution. Fuzzy logic emerges naturally since ordinary spinors are replaced by quantum spinors for which the discrete spectrum of the eigenvalues of the moduli of its spinor components can be interpreted as probabilities that corresponding belief is true is universal [C8].

For ordinary quantum measurement theory separate selves are by definition unentangled and same applies to their sub-selves so that they cannot entangle and thus fuse and shared mental images are impossible: consciousness would be completely private. Space-time sheets as correlates for selves however suggests that space-time sheets topologically condensed on larger space-time sheets and serving as space-time correlates for mental images can be connected by join along boundaries bonds so that mental images could fuse and be shared.

HFFs allow to realize mathematically this intuitive picture. The entanglement in $\mathcal{N}$ degrees of freedom between selves corresponding to $\mathcal{M}$ is below the measurement resolution so that these selves can be regarded as separate conscious entities. They can be said to be unentangled although their sub-selves corresponding to $\mathcal{N}$ (mental images at upper level) can entangle. Fusion and sharing of mental images becomes possible. For instance, in stereo vision right and left visual fields would fuse together. More generally, a pool of shared stereo mental images might be fundamental for evolution of social structures and development of social and moral rules and language (shared mental images make possible common meaning for symbols of language). A concrete realization for this would be in terms of hyper-genome making possible collective gene expression [L2, L1].

The emergence of hierarchy of Planck constants inspired the question whether one could reduce the notion of self to that of fractal quantum jump containing quantum jumps within quantum jumps. It indeed seems that this reduction is possible and that both p-adic time scale hierarchy and hierarchy of Planck constants relate closely to the hierarchy of quantum jumps defining also hierarchy of selves. This reduction conforms with the basic intuitions motivating the original definition of self.

3.1.2 Qualia

Since physical states are labelled by quantum numbers, various qualia correspond naturally to the increments of quantum numbers in quantum jump which leads to a general classification of qualia in terms of the fundamental symmetries [K3]. One can speak also about geometric qualia assignable to the increments of zero modes which correspond to the classical variables in ordinary quantum measurement theory and non-quantum fluctuating degrees of freedom which do not contribute to the metric of world of classical worlds (WCW) in TGD framework. Dark matter hierarchy suggests that also qualia form a hierarchy with larger values of Planck constant identifiable as more refined qualia. Rather amusingly, visual colors would correspond to increments of color quantum numbers assignable to quarks and gluons in standard model physics. The term "color", originally introduced as an algebraic joke, would directly relate to visual color.

3.1.3 Self-referentiality of consciousness

Quantum classical correspondence is the basic guiding principle of quantum TGD. Thanks to the failure of a complete determinism of classical dynamics, space-time surface can provide symbolic representations not only for quantum states (as maximal deterministic regions) but also for quantum jump sequences (sequences of quantum states) and thus for the contents of consciousness. These representations are regenerated in each quantum jump, and make possible the self referentiality of consciousness: self can be conscious of what it *was* conscious of. The hierarchy of Planck constants and dark matter hierarchy provides a more concrete realization for this vision.

3.2 The interpretation of S- and U-matrices from the point of view of consciousness theory

The interpretation of U- and S-matrices from the point of view of consciousness theory is an interesting challenge.

1. There are arguments suggesting that U-matrix in the degrees of freedom characterizable using von Neumann algebra identifiable as a factor of type I (standard QM) would correspond to a so called factorizing S-matrix and be therefore almost trivial [C2]. If so, it would seem that state function reduction in these degrees of freedom does not affect standard model quantum numbers so that the resulting experience would be kind of "that which is" mystic experience and would explain why it seems to be possible to experience state rather than only the change of state. This conforms also with the fact that these state function reductions do not involve reduction of time-like entanglement so that these experiences would be characterized by a kind of "timelessness".

2. The presence of hyper-finite factors of type II_1 is an essentially new element. It is however not clear what one can say about U-matrix associated with HFFs. In [C3] I have considered the possibility that U-matrix could allow transitions in which entanglement between zero energy states restricted to sub-factor $\mathcal{N} \subset \mathcal{M}$ is replaced with entanglement in factor $\mathcal{M}$ so that unitary process in a well-defined sense could be seen as the reversal of the state function reduction of entanglement in the quantum space $\mathcal{M}/\mathcal{N}$. Since the inclusions define lattice like one-dimensional structure, U-process would be analogous to a dispersion in 1-D lattice.

3. The state function reduction for S-matrix corresponds to a measurement of time-like entanglement and a natural interpretation is in terms of memories. It is not clear whether all state function reductions actually correspond to the reduction of time like entanglement. If this were the case, one could understand the finding of Libet about passive aspects of sensory experience [37] implying that sensory percepts are actually memories corresponding to time scale of fraction of seconds.

4. Interesting questions relate to the interpretation of the complex square root of density matrix character of time like entanglement coefficients define by S-matrix ($\rho_+ = SS^\dagger$ and $\rho_- = S^\dagger S$). If time like entanglement probabilities for the factor of type I are rational or even algebraic numbers, number theoretic entropy is well-defined and negentropic time-like entanglement stable under state function reduction is possible. This kind of entanglement would correspond to memory in which sensory or cognitive mental image of the geometric past is shared. This experience would be analogous to experience of understanding assigned to the negentropic entanglement in general. The near death experiences are reported to involve experiencing of the entire life cycle in single flash: could these experiences correspond to time-like entanglement?

3.3 Negentropy Maximization Principle

Negentropy Maximization Principle (NMP [H2]) stating that the reduction of entanglement entropy is maximal in quantum jump is the basic variational principle for TGD inspired theory of consciousness and says that the information contents of conscious experience is maximal. Although this principle is diametrically opposite to the second law of thermodynamics it is structurally similar to the second law. NMP does not dictate the dynamics completely since in state function reduction any eigen state of the density matrix is allowed as final state. NMP need not be in contradiction with second law of thermodynamics which might relate more to the ageing of mental images rather than physical reality.

3.3.1 Number theoretic Shannon entropy as information

The notion of number theoretic entropy obtained by can be defined by replacing in Shannon entropy the logarithms of probabilities p_n by the logarithms of their p-adic norms $|p_n|_p$. This replacement makes sense for algebraic entanglement probabilities if appropriate algebraic extension of p-adic numbers is used. What is new that entanglement entropy can be negative, so that algebraic entanglement can carry information and NMP can force the generation of bound state entanglement so that evolution could lead to the generation of larger coherent bound states rather than only reducing entanglement. A possible interpretation for algebraic entanglement is in terms of experience of understanding.

Standard formalism of physics lacks a genuine notion of information and one can speak only about increase of information as a local reduction entropy. It seems strange that a system gaining wisdom should increase the entropy of the environment. Hence number theoretic information measures could have highly non-trivial applications also outside the theory consciousness. For instance these information measures allow to construct a model of genetic code [L3] as a mapping of 64 genetic codons to primes labelling aminoacids based on the condition that the prime associated with given codon corresponds to minimal number theoretic entropy.

3.3.2 Hyper-finite factors of type II_1 and NMP

Hyper-finite factors of type II_1 bring in additional delicacies to NMP. The basic implication of finite measurement resolution characterized by Jones inclusion is that state function reduction can never reduce entanglement completely so that entire universe can be regarded as an infinite living organism. It would seem that entanglement coefficients become $\mathcal{N}$ valued and same is true for eigen states of density matrix. For quantum spinors associated with $\mathcal{M}/\mathcal{N}$ entanglement probabilities must be defined as traces of the operators $\mathcal{N}$.

One of the open questions is whether one generalize the notion of algebraic entanglement to the case of HFFs of type II_1 so that one could have negative number theoretic entanglement entropy as is possible in the case of factors of type I. The density matrices in these degrees of freedom are of form $\sum p_n P_n$ and the question is whether the quantities $p_n Tr(P_n)$ can be assumed to be rationals or at most algebraic numbers.

3.4 About the arrow of psychological time and notion of self: a critical discussion

Quantum classical correspondence predicts that the arrow of subjective time is somehow mapped to that for the geometric time. The detailed mechanism for how the arrow of psychological time emerges has however remained open. Also the notion of self is problematic. I have proposed two alternative notions of self and have not been able to choose between them. A further question is what happens during sleep: do we lose consciousness or is it that we cannot remember anything

about this period? The work with the model of topological quantum computation [O4] has led to an overall view allowing to select the most plausible answer to these questions. But let us be cautious!

Quantum classical correspondence requires that the flow of subjective time identified as a sequence of quantum jumps should have the flow of geometric time as a space-time correlate. The understanding of the detailed relationship between these two times has however remained a long standing problem, and only the emergence of zero energy ontology allows an ad hoc free model for how the flow and arrow of geometric time emerge, and answers why the relationship between geometric past and future is so asymmetric and why sensory experience is about so narrow interval of geometric time. Also the notion of self reduces in well-defined sense to the notion of quantum jump with fractal structure.

3.4.1 Two times

The notion of quantum jump implies a new view about time. Experienced/subjective time corresponds to a sequence of sub-quantum jumps and cannot be identified with the geometric time defined as the fourth space-time coordinate. This is of course obvious for anyone: consider only the reversibility of geometric time contra irreversibility of experienced time, and the fact that both geometric past and future exist whereas only subjective past exists. The fact that the contents of conscious experience is about 4-D rather than 3-D space-time region, motivates the notions of 4-D brain, body, and even society. In particular, conscious existence continues after biological death since 4-D body and brain continue to exist.

3.4.2 Two earlier views about how the arrow of psychological time emerges

The basic question how the arrow of subjective time is mapped to that of geometric time. The common assumption of all models is that quantum jump sequence corresponds to evolution and that by quantum classical correspondence this evolution must have a correlate at space-time level so that each quantum jump replaces typical space-time surface with a more evolved one.

1. The earliest model assumes that the space-time sheet assignable to observer ("self") drifts along a larger space-time sheet towards geometric future quantum jump by quantum jump: this is like driving car in a landscape but in the direction of geometric time and seeing the changing landscape. There are several objections.

   i) Why this drifting?

   ii) If one has a large number of space-time sheets (the number is actually infinite) as one has in the hierarchy the drifting velocity of the smallest space-time sheet with respect to the largest one can be arbitrarily large (infinite).

   iii) It is alarming that the evolution of the background space-time sheet by quantum jumps, which must be the quintessence of quantum classical correspondence, is not needed at all in the model.

2. Second model relies on the idea that intentional action -understood as p-adic-to-real phase transition for space-time sheets and generating zero energy states and corresponding real space-time sheets - proceeds as a kind of wave front towards geometric future quantum jump by quantum jump. Also sensory input would be concentrated on this kind of wave front. The difficult problem is to understand why the contents of sensory input and intentional action are localized so strongly to this wave front and rather than coming from entire life cycle.

There are also other models but these two are the ones which represent basic types for them.

3.4.3 The third option

The third explanation for the arrow of psychological time - which I have considered earlier but only half-seriously - looks to me the most elegant at this moment. This option is actually favored by Occam's razor since it uses only the assumption that space-time sheets are replaced by more evolved ones in each quantum jump. Also the model of tqc favors it.

1. In standard picture the attention would gradually shift towards geometric future and space-time in 4-D sense would remain fixed. Now however the fact that quantum state is quantum superposition of space-time surfaces allows to assume that the attention of the conscious observer is directed to a fixed volume of 8-D imbedding space. Quantum classical correspondence is achieved if the evolution in a reasonable approximation means shifting of the space-time sheets and corresponding field patterns backwards backwards in geometric time by some amount per quantum jump so that the perceiver finds the geometric future in 4-D sense to enter to the perceptive field. This makes sense since the shift with respect to M^4 time coordinate is an exact symmetry of extremals of Kähler action. It is also an excellent approximate symmetry for the preferred extremals of Kähler action and thus for maxima of Kähler function spoiled only by the presence of light-cone boundaries. This shift occurs for both the space-time sheet that perceiver identifies itself and perceived space-time sheet representing external world: both perceiver and percept change.

2. Both the landscape and observer space-time sheet remain in the same position in imbedding space but both are modified by this shift in each quantum jump. The perceiver experiences this as a motion in 4-D landscape. Perceiver (Mohammed) would not drift to the geometric future (the mountain) but geometric future (the mountain) would effectively come to the perceiver (Mohammed)!

3. There is an obvious analogy with Turing machine: what is however new is that the tape effectively comes from the geometric future and Turing machine can modify the entire incoming tape by intentional action. This analogy might be more than accidental and could provide a model for quantum Turing machine operating in TGD Universe. This Turing machine would be able to change its own program as a whole by using the outcomes of the computation already performed.

4. The concentration of the sensory input and the effects of conscious motor action to a narrow interval of time (.1 seconds typically, secondary p-adic time scale associated with the largest Mersenne M_{127} defining p-adic length scale which is not completely super-astronomical) can be understood as a concentration of sensory/motor attention to an interval with this duration: the space-time sheet representing sensory "me" would have this temporal length and "me" definitely corresponds to a zero energy state.

5. The fractal view about topological quantum computation strongly suggests an ensemble of almost copies of sensory "me" scattered along my entire life cycle and each of them experiencing my life as a separate almost copy.

6. The model of geometric and subjective memories would not be modified in an essential manner: memories would result when "me" is connected with my almost copy in the geometric past by braid strands or massless extremals (MEs) or their combinations (ME parallel to magnetic flux tube is the analog of Alfwen wave in TGD).

This argument leaves many questions open. What is the precise definition for the volume of attention? Is the attention of self doomed to be directed to a fixed volume or can quantum jumps change the volume of attention? What distinguishes between geometric future and past as far

as contents of conscious experience are considered? How this picture relates to p-adic and dark matter hierarchies? Does this framework allow to formulate more precisely the notion of self? Zero energy ontology allows to give tentative answers to these questions.

3.5 Questions related to the notion of self

I have proposed two alternative notions of self and have not been able to choose between them. A further question is what happens during sleep: do we lose consciousness or is it that we cannot remember anything about this period? The work with the model of topological quantum computation has led to an overall view allowing to select the most plausible answer to these questions. But let us be cautious!

3.5.1 Can one choose between the two variants for the notion of self or are they equivalent?

I have considered two different notions of "self" and it is interesting to see whether the new view about time might allow to choose between them or to show that they are actually equivalent.

1. In the original variant of the theory "self" corresponds to a sequence of quantum jumps. "Self" would result through a binding of quantum jumps to single "string" in close analogy and actually in a concrete correspondence with the formation of bound states. Each quantum jump has a fractal structure: unitary process is followed by a sequence of state function reductions and preparations proceeding from long to short scales. Selves can have sub-selves and one has self hierarchy. The questionable assumption is that self remains conscious only as long as it is able to avoid entanglement with environment.

   Even slightest entanglement would destroy self unless on introduces the notion of finite measurement resolution applying also to entanglement. This notion is indeed central for entire quantum TGD also leads to the notion of sharing of mental images: selves unentangled in the given measurement resolution can experience shared mental images resulting as fusion of sub-selves by entanglement not visible in the resolution used.

2. According to the newer variant of theory, quantum jump has a fractal structure so that there are quantum jumps within quantum jumps: this hierarchy of quantum jumps within quantum jumps would correspond to the hierarchy of dark matters labeled by the values of Planck constant. Each fractal structure of this kind would have highest level (largest Planck constant) and this level would corresponds to the self. What might be called irreducible self would corresponds to a quantum jump without any sub-quantum jumps (no mental images). The quantum jump sequence for lower levels of dark matter hierarchy would create the experience of flow of subjective time.

It would be nice to reduce the original notion of self hierarchy to the hierarchy defined by quantum jumps. There are some objections against this idea. One can argue that fractality is a purely geometric notion and since subjective experience does not reduce to the geometry it might be that the notion of fractal quantum jump does not make sense. It is also not quite clear whether the reasonable looking idea about the role of entanglement as destroyer of self can be kept in the fractal picture.

These objections fail if one can construct a well-defined mathematical scheme allowing to understand what fractality of quantum jump at the level of space-time correlates means and showing that the two views about self are equivalent. The following argument represents such a proposal. Let us start from the causal diamond model as a lowest approximation for a model of zero energy states and for the space-time region defining the contents of sensory experience.

Let us make the following assumptions.

1. Assume the hierarchy of causal diamonds within causal diamonds in a sense to be specified more precisely below. Causal diamonds would represent the volumes of attention. Assume that the highest level in this hierarchy defines the quantum jump containing sequences of lower level quantum jumps in some sense to be specified. Assume that these quantum jumps integrate to single continuous stream of consciousness as long as the sub...-sub-self in question remains unentangled and that entangling means loss of consciousness or at least that it is not possible to remember anything about contents of consciousness during entangled state.

2. Assume that the contents of conscious experience come from the interior of the causal diamond. A stronger condition would be that the contents come from the boundaries of the two light-cones involved since physical states are defined at these in the simplest picture. In this case one could identify the lower light-cone boundary as giving rise to memory.

3. The time span characterizing the contents of conscious experience associated with a given quantum jump would correspond to the temporal distance T between the tips of the causal diamond. T would also characterize the average and approximate shift of the superposition of space-time surfaces backwards in geometric time in single quantum jump at a given level of hierarchy. This time scale naturally scales as $T_n = 2^n T_{CP_2}$ so that p-adic length scale hypothesis follows as a consequence. T would be essentially the secondary p-adic time scale $T_{2,p} = \sqrt{p}T_p$ for $p \simeq 2^k$. This assumption - absolutely essential for the hierarchy of quantum jumps within quantum jumps - would differentiate the model from the model in which T corresponds to either CP_2 time scale or p-adic time scale T_p. One would have hierarchy of quantum jumps with increasingly longer time span for memory and with increasing duration of geometric chronon at the highest level of fractal quantum jump. Without additional restrictions, the quantum jump at n^{th} level would contain 2^n quantum jumps at the lowest level of hierarchy. Note that in the case of sub-self - and without further assumptions which will be discussed next - one would have just two quantum jumps: mental image appears, disappears or exists all the time. At the level of sub-sub-selves 4 quantum jumps and so on. Maybe this kind of simple predictions might be testable.

4. We know that that the contents of sensory experience comes from a rather narrow time interval of duration about .1 seconds, which corresponds to the time scale T_{127} associated with electron. We also know that there is asymmetry between positive and negative energy parts of zero energy states both physically and at the level of conscious experience. This asymmetry must have some space-time correlate. The simplest correlate for the asymmetry between positive and negative energy states would be that the upper light-like boundaries in the structure formed by light-cones within light-cones intersect along light-like radial geodesic. No condition of this kind would be posed on lower light-cone boundaries. The scaling invariance of this condition makes it attractive mathematically and would mean that arbitrarily long time scales T_n can be present in the fractal hierarchy of light cones. At all levels of the hierarchy all contribution from upper boundary of the causal diamond to the conscious experience would come from boundary of same past directed light-cone so that the conscious experience would be sharply localized in time in the manner as we know it to be. The new element would be that content of conscious experience would come from arbitrarily large region of Universe and seing Milky Way would mean direct sensory contact with it.

5. These assumptions relate the hierarchy of quantum jumps to p-adic hierarchy. One can also include also dark matter hierarchy into the picture. For dark matter hierarchy the time scale hierarchy $\{T_n\}$ is scaled by the factor $r = \hbar/\hbar_0$ which can be also rational number. For $r = 2^k$ the hierarchy of causal diamonds generalizes without difficulty and there is a kind of resonance involved which might relate to the fact that the model of EEG favors the values of $k = 11n$, where $k = 11$ also corresponds in good approximation to proton-electron

mass ratio. For more general values of $\hbar/\hbar_0$ the generalization is possible assuming that the position of the upper tip of causal diamond is chosen in such a manner that their positions are always the same whereas the position of the lower light-cone boundary would correspond to $\{rT_n\}$ for given value of Planck constant. Geometrically this picture generalizes the original idea about fractal hierarchy of quantum jumps so that it contains both p-adic hierarchy and hierarchy of Planck constants.

The contributions from lower the boundaries identifiable in terms of memories would correspond to different time scales and for a given value of time scale T the net contribution to conscious experience would be much weaker than the sensory input in general. The asymmetry between geometric now and geometric past would be present for all contributions to conscious experience, not only sensory ones. What is nice that the contents of conscious experience would rather literally come from the boundary of the past directed light-cone along which the classical signals arrive. Hence the mystic feeling about telepathic connection with a distant object at distance of billions of light years expressed by an astrophysicist, whose name I have unfortunately forgotten, would not be romantic self deception.

This framework explains also the sharp distinction between geometric future and past (not surprisingly since energy and time are dual): this distinction has also been a long standing problem of TGD inspired theory of consciousness. Precognition is not possible unless one assumes that communications and sharing of mental images between selves inside disjoint causal diamonds is possible. Physically there seems to be no good reason to exclude the interaction between zero energy states associated with disjoint causal diamonds.

The mathematical formulation of this intuition is however a non-trivial challenge and can be used to articulate more precisely the views about what configuration space and configurations space spinor fields actually are mathematically.

1. Suppose that the causal diamonds with tips at different points of $H = M^4 \times CP_2$ and characterized by distance between tips T define sectors CH_i of the full configuration space CH ("world of classical worlds"). Precognition would represent an interaction between zero energy states associated with different sectors CH_i in this scheme and tensor factor description is required.

2. Inside given sector CH_i it is not possible to speak about second quantization since every quantum state correspond to a single mode of a classical spinor field defined in that sector.

3. The question is thus whether the Clifford algebras and zero energy states associated with different sectors CH_i combine to form a tensor product so that these zero energy states can interact. Tensor product is required by the vision about zero energy insertions assignable to CH_i which correspond to causal diamonds inside causal diamonds. Also the assumption that zero energy states form an ensemble in 4-D sense - crucial for the deduction of scattering rates from M-matrix - requires tensor product.

4. The argument unifying the two definitions of self requires that the tensor product is restricted when CH_i correspond to causal diamonds inside each other. The tensor factors in shorter time scales are restricted to the causal diamonds hanging from a light-like radial ray at the upper end of the common past directed light-cone. If the causal diamonds are disjoint there is no obvious restriction to be posed, and this would mean the possibility of also precognition and sharing of mental images.

This scenario allows also to answers the questions related to a more precise definition of volume of attention. Causal diamond - or rather - the associated light-like boundaries containing positive and negative energy states define the primitive volume of attention. The obvious question whether

the attention of a given self is doomed to be fixed to a fixed volume can be also answered. This is not the case. Selves can delocalize in the sense that there is a wave function associated with the position of the causal diamond and quantum jumps changing this position are possible. Also many-particle states assignable to a union of several causal diamonds are possible. Note that the identification of magnetic flux tubes as space-time correlates of directed attention in TGD inspired quantum biology makes sense if these flux tubes connect different causal diamonds. The directedness of attention in this sense should be also understood: it could be induced from the ordering of p-adic primes and Planck constant: directed attention would be always from longer to shorter scale.

3.5.2 Does entanglement mean loss of consciousness?

The ability to avoid entanglement with environment would be essential for the original notion of self and incase of sub-selves it would explain the finite life-time of mental images. One can of however ask whether the assumption about the loss of consciousness in entanglement - that is during sleep - is really necessary. One could however argue that if consciousness is really lost during sleep, we could not have the deep conviction that we existed yesterday. Furthermore, during topological quantum computation entanglement is absent and thus this state should correspond to conscious experience. Night time is however the best time for tqc since sensory input and motor action do not take metabolic resources and we certainly do problem solving during sleep. Thus we should be conscious at some level during sleep and perform quite a long tqc. Perhaps we are!

Could it be that we do not remember anything about the period of sleep because our attention is directed elsewhere and memory recall uses only copies of "me" assignable to brain manufacturing standardized mental images? Perhaps the communication link to the mental images during sleep experienced at dark levels of existence is lacking or sensory input and motor activities of busy westeners do not allow to use metabolic energy to build up this kind of communications. Hence one can seriously ask, whether self is actually eternal with respect to the subjective time and whether entangling with some system means only diving into the ocean of consciousness as someone has expressed it. We would be Gods as also quantum classical correspondence in the reverse direction requires (p-adic cognitive space-time sheets have literally infinite size in both temporal and spatial directions). This would be the most optimistic view that one can imagine.

3.5.3 What after biological death?

Could the new option allow to speculate about the course of events at the moment of death? Certainly this particular sensory "me" would effectively meet the geometro-temporal boundary of the biological body: sensory input would cease and there would be no biological body to use anymore. "Me" might lose its consciousness (if it can!). "Me" has also other mental images than sensory ones and these could begin to dominate the consciousness and "me" could direct its attention to space-time sheets corresponding to much longer time scale, perhaps even to that of life cycle, giving a summary about the life.

What after that? The Tibetan Book of Dead gives some inspiration. A western "me" might hope (and even try use its intentional powers to guarantee) that quantum Turing tape sooner later brings into the volume of attention (which might also change) a living organism, be it human or cat or dog or at least some little bug. If this "me" is lucky, it could direct its attention to it and become one of the very many sensory "me's" populating this particular 4-D biological body. There would be room for a newcomer unlike in the alternative models. A "me" with Eastern/New-Ageish traits could however direct its attention permanently to the dark space-time sheets and achieve what she might call enlightment.

3.6 Time, memory, and realization of intentional action

3.6.1 What distinguishes between geometric future and past?

One must of course understand why geometric and experienced time correspond to each other so closely that they have been identified. Why geometric future and past are so different?: this might be the core question. If geometric future contains intentional resources (p-adic space-time sheets) transformed to actions in the phase transition propagating to the geometric future and if geometric future is in a quantum critical state transformed to a non-critical state in this process (a process analogous to freezing or melting critical state of water-ice mixture), one could assign the experienced time with the geometric time characterizing the position of the phase transition front (assignable to sub-selves/mental images).

Also the almost triviality of U-matrix for ordinary transitions might be relevant for the stability of the geometric past. This could also resolve the problem posed by the fact that the contents of conscious experience is only about changes: the state could be represented as changes of internal quantum numbers not related directly to the external world but related to the internal state. For p-adic-to-real transitions representing transformations of intentions to actions almost-triviality does not have meaning.

3.6.2 Do declarative memories and intentional action involve communications with geometric past?

Communications with geometric past using time mirror mechanism in which phase conjugate photons propagating to the geometric past are reflected back as ordinary photons (typically dark photons with energies above thermal threshold) make possible realization of declarative memories in the brain of the geometric past [H6].

This mechanism makes also possible realization of intentional actions as a process proceeding from longer to shorter time scales and inducing the desired action already in geometric past. This kind of realization would make living systems extremely flexible and able to react instantaneously to the changes in the environment. This model explains Libet's puzzling finding that neural activity seems to precede volition [36].

Also a mechanism of remote metabolism ("quantum credit card") based on sending of negative energy signals to geometric past becomes possible [K6]: this signal could also serve as a mere control signal inducing much larger positive energy flow from the geometric past. For instance, population inverted system in the geometric past could allow this kind of mechanism. Remote metabolism could also have technological implications.

3.6.3 Episodal memories as time-like entanglement

Time-like entanglement explains episodal memories as sharing of mental images with the brain of geometric past [H6]. An essential element is the notion of magnetic body which serves as an intentional agent "looking" the brain of geometric past by allowing phase conjugate dark photons with negative energies to reflect from it as ordinary photons. The findings of Libet about time delays related to the passive aspects of consciousness [37] support the view that the part of the magnetic body corresponding to EEG time scale has same size scale as Earth's magnetosphere. The unavoidable conclusion would be that our field/magnetic bodies contain layers with astrophysical sizes.

p-Adic length scale hierarchy and number theoretically preferred hierarchy of values of Planck constants, when combined with the condition that the frequencies f of photons involved with the communications in time scale T satisfy the condition $f \sim 1/T$ and have energies above thermal energy, lead to rather stringent predictions for the time scales of long term memory. The model for the hierarchy of EEGs relies on the assumption that these time scales come as powers $n = 2^{11k}$,

$k = 0, 1, 2,$, and predicts that the time scale corresponding to the duration of human life cycle is ~ 50 years and corresponds to $k = 7$ (amusingly, this corresponds to the highest level in chakra hierarchy).

3.6.4 Zero energy ontology and time mirror mechanism

Zero energy ontology gives a justification for the notion of time mirror mechanism essential for the models of remote metabolism, intentional action and long term memory. Negative energy gauge bosons, in particular phase conjugate photons, make possible signals propagating to the direction of geometric past. A second essential element is large value of Planck constant making possible low frequency quanta having energy above the thermal energy.

1. Remote metabolism provides extremely flexible mechanism of metabolism allowing an instantaneous gain of metabolic energy by sending negative energy to some system able to provide the energy. Population inverted laser or "many-sheeted laser" for which dropping of particles to larger space-time sheet provides zero point kinetic energy as usable energy would define simplest energy storage.

2. The mechanism of intentional action involves sending of negative energy signal from magnetic field body to the brain of the geometric past where it initiates the neural activities giving rise to the desired action. Suppose that one takes seriously the hypothesis that fermions appear as pairs of real fermion and its p-adic counterpart providing a cognitive representation of real fermion and that p-adic bosons represent intentions and their real counterparts actions. If so then the bosons assignable to intentions would not be ordinary gauge bosons but bosonic generators of super-canonical algebra and negative energy signals would be exotic bosons with vanishing electro-weak quantum numbers. This is perhaps too strong a constraint since it would exclude the model of intentional action based on dark $W^{\pm}$ bosons inducing charge density gradients and in this manner neuronal activities such as nerve pulse patterns.

3. There are two mechanisms of long term memory. First mechanism corresponds to episodal or sensory memories in which memories are realized as sharing of mental images by time-like entanglement. Second mechanism would correspond to declarative memories having digital representation. Memory recall would correspond to a pattern of negative energy signals from magnetic body to the brain of the geometric past where it generates the answer as a pattern of positive energy signals. For instance, a code consisting of binary digits is possible to realize in this manner. '1' would correspond to population inverted laser and '0' to same system in ground state. Negative energy signal would drop '1' to '0' and induce positive energy signal and '0' would not generate any signal. Hence the net positive energy signal would tell what the bit sequence in the geometric past is.

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