Self and Binding: Part I

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February 14, 2018

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Abstract

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

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

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

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

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

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

1   Introduction

The conflict between the non-determinism of state function reduction and determinism of time evolution of Schrödinger equation is serious enough a problem to motivate the attempt to extend physics to a theory of consciousness by raising the observer from an outsider to a key notion also at the level of physical theory by bringing in the notion of self. Further motivations come from the failure of the materialistic and reductionistic dogmas in attempts to understand consciousness in neuroscience context. There are reasons to doubt that standard quantum physics could be enough to achieve this goal and the new physics predicted by TGD is indeed central in the proposed theory.

1.1   Zero Energy Ontology

Zero Energy Ontology (ZEO) was forced by the interpretational problems created by the vacuum extremal property of Robertson-Walker cosmologies imbedded as 4-surfaces in $M^4 \times CP_2$ meaning that the density of inertial mass (but not gravitational mass) for these cosmologies was vanishing meaning a conflict with Equivalence Principle. In ZEO physical states are replaced by pairs of positive and negative energy states assigned to the past *resp.* future boundaries of causal diamonds

(CDs) defined as intersections of future and past directed light-cones ($\delta M_\pm^4 \times CP_2$). The net values of all conserved quantum numbers of zero energy states vanish. Zero energy states are interpreted as pairs of initial and final states of a physical event such as particle scattering so that only events appear in the new ontology.

ZEO combined with the notion of quantum jump resolves several problems. For instance, the troublesome questions about the initial state of universe and about the values of conserved quantum numbers of the Universe can be avoided since everything is in principle creatable from vacuum. Communication with the geometric past using negative energy signals and time-like entanglement are crucial for the TGD inspired quantum model of memory and both make sense in ZEO. ZEO leads to a precise mathematical characterization of the finite resolution of both quantum measurement and sensory and cognitive representations in terms of inclusions of von Neumann algebras known as hyperfinite factors of type II_1. The space-time correlate for the finite resolution is discretization which appears also in the formulation of quantum TGD.

ZEO (ZEO) means that one must distinguish between M-matrix and U-matrix. M-matrix characterizes the time like entanglement between positive and negative energy parts of zero energy state and is measured in particle scattering experiments. M-matrix need not be unitary and can be identified as a "complex" square root of density matrix representable as a product of its real and positive square root and of unitary S-matrix so that thermodynamics becomes part of quantum theory with thermodynamical ensemble being replaced with a zero energy state. The unitary U-matrix describes quantum transitions between zero energy states and is therefore something genuinely new. It is natural to assign the statistical description of intentional action with U-matrix since quantum jump occurs between zero energy states.

Quantum measurement theory based on ZEO can be said to imply the notion of self and to explaining basic aspects of consciousness when one includes also the hierarchy of Planck constants characterizing hierarchy of quantum criticalities. At the imbedding space-level CD is the correlate of self whereas space-time sheets having their ends at the light-like boundaries of CD are the correlates at the level of 4-D space-time. The hierarchy of CDs within CDs corresponds to the hierarchy of selves. Zero energy ontology leads also an argument explaining why the arrow of subjective time induces an apparent arrow of geometric time as a result if intentional action and why the contents of sensory consciousness is restricted to such a narrow time interval (located near the future boundary of CD).

1.2 Hierarchy Of Planck Constants

The hierarchy of Planck constants corresponds to a hierarchy $h_{eff} = n \times h$ [K6, **?**, K22]. The original hypothesis was that it corresponds to a hierarchy of singular coverings of imbedding space $M^4 \times CP_2$- or rather - given causal diamond (CD).

The recent view is that there is a hierarchy of quantum criticalities such that the sub-algebra of super-symplectic algebra for which conformal weights are n-ples of those for the entire algebra acts as conformal gauge symmetries at given level. Due to the resulting non-determinism the space-time surfaces connecting 3-surfaces at the opposite boundaries of CD are gauge degenerate and there are n conformal equivalence classes analogous to sheets of Riemann surface of $z^{1/n}$. This view has far reaching consequences. The hierarchy of quantum criticalities has an interpretation as that for macroscopic quantum phases and the phase transitions increasing n to its multiple occur spontaneously and generate also negentropy if NMP is assumed. Hence evolution can be seen as a gradual reduction of criticality occurring unavoidably.

An alternative formulation [K19, **?**, K22, K21] emerged in terms of gravitational Planck constant $h_{gr} = GMm/v_0$, where v_0 is characteristic velocity in the system consisting of two masses involved, introduced originally by Nottale [**?**] h_{gr} would be associated with the flux tubes connecting the two masses. Later it became clear that the identification $h_{eff} = h_{gr}$ leads to considerable insights in biology: in particular bio-photons can be identified as ordinary photons resulting from dark cyclotron photons with a universal energy spectrum.

The book metaphor inspired by the original view about hierarchy of Planck constants is however very useful. The value of the Planck constant characterizes partially given page and arbitrary large values of $\hbar$ are predicted so that macroscopic quantum phases are possible since the fundamental quantum scales scale like $\hbar$. All particles in the vertices of Feynman diagrams have the same value of Planck constant so that particles at different pages cannot have local interactions. Thus one can

speak about relative darkness in the sense that only the interactions mediated by the exchange of particles and by classical fields are possible between different pages. Dark matter in this sense can be observed, say through the classical gravitational and electromagnetic interactions. It is in principle possible to photograph dark matter by the exchange of photons which leak to another page of book, reflect, and leak back. This leakage corresponds to $\hbar$ changing phase transition occurring at quantum criticality and living matter is expected carry out these phase transitions routinely in bio-control. This picture leads to no obvious contradictions with what is really known about dark matter and to my opinion the basic difficulty in understanding of dark matter (and living matter) is the blind belief in standard quantum theory.

1.3   P-Adic Physics As Physics Of Cognition

p-Adic mass calculations relying on p-adic length scale hypothesis led to an understanding of elementary particle masses using only super-conformal symmetries and p-adic thermodynamics. The need to fuse real physics and various p-adic physics to single coherent whole led to a generalization of the notion of number obtained by gluing together reals and p-adics together along common rationals and algebraics (see fig. `http://tgdtheory.fi/appfigures/book.jpg`, which is also in the appendix of this `http://tgdtheory.fi/appfigures/book.jpg`). The interpretation of p-adic space-time sheets is as correlates for cognition. p-Adic and real space-time sheets intersect along common rationals and algebraics and the subset of these points could be called intersection of realities.

In fact, the intersection can be interpreted in more abstract sense at the level of WCW as surfaces for which parameters (WCW coordinates) are such that the interpretation both as real and p-adic surface is possible. In this manner one avoids discretization at space-time level. It has turned out that string world sheets and partonic 2-surfaces with defining parameters in an extension of rationals define naturally the intersection and strong form of holography allows the continuation of these 2-surfaces to space-time surfaces.

The outcome is a vision about hierarchy extensions of rational numbers defining an evolutionary hierarchy. So called ramified primes associated with the extension define preferred primes identifiable as p-adic primes and weak form NMP allows to understand p-adic length scale hypothesis and its generalization stating that primes near powers of primes are favored by NMP.

There exists an infinite hierarchy of number theoretical entropies making sense for rational or even algebraic entanglement probabilities. In this case the entanglement negentropy can be negative so that NMP favors the generation of negentropic entanglement, which need not be bound state entanglement in standard sense. Negentropic entanglement might serve as a correlate for emotions like love and experience of understanding. The reduction of ordinary entanglement entropy to random final state implies second law at the level of ensemble. The generation of NE as the outcome of the reduction is not totally random process: the prediction is that second law need not universal truth holding true in all scales. To avoid making wrong conclusions about NMP, one must keep in mind that entanglement entropy is two-particle property whereas thermodynamical entropy is single partcle property.

Quantum measurement theory allows only final states, which have density matrices which are projectors so that the rational entanglement probabilities $p = 1/n$ are identical in this case. If the prime p divides n, one obtains negative entanglement entropy and one can say that entanglement is negentropic. Negentropy is largest for the largest power of prime dividing n and one could define entanglement entropy as that associated with this prime.

1.4   NMP

One obtains standard quantum measurement theory by assuming that the density matrix of the sub-system is the universal observable. In state function reduction this observable is measured and the system goes to an eigenstate of it. It can however happen that the eigenvalues are degenerate and in this case one can ask whether the reduction leads only to an eigen space so that entanglement characterized by a n-dimensional projection operator remains.

If p divides n, one obtains negative entanglement entropy and one can say that entanglement is negentropic. Negentropy is largest for the largest power of prime dividing n.

Negentropy Maximization Principle (NMP) [K12] codes for the dynamics of standard state function reduction and states that the state function reduction process following U-process gives rise to maximal reduction of entanglement entropy - or equivalently - gain of entanglement negentropy- at each step. In the generic case this implies decomposition of the system to unique unentangled systems and the process repeats itself for these systems. The process stops when the resulting subsystem cannot be decomposed to a pair of free systems since energy conservation makes the reduction of entanglement kinematically impossible in the case of bound states.

The interpretation is that NMP favors generation of negentropic entanglement (NE). One can of course argue that the generation of this kind of entanglement is extremely improbable. The hierarchy of Planck constants involving quantum criticality could however provide the manner to generate it.

TGD inspired theory of consciousness forces to challenge the hypothesis that NMP always forces the state function reduction to the sub-space defined by the projector with maximal dimension appearing in the decomposition of the density matrix. NMP would not allow the self to make choices, which are bad deeds in the sense that they do not increase maximally the negentropic resources of the Universe. We would live in the best possible Universe becoming better all the time. This is obviously too good to be true.

The weak form of NMP allows the choice leading to maximal negentropy gain but allows also those choices for which the reduction occurs to a sub-space of the space defined by projector. When this sub-space is 1-dimensional standard quantum measurement results and the self is isolated from the target of observations. Negentropic entanglement has interpretation as attention with positively colored contents of consciousness. Experience of love would be one attribute of this kind of state. Weak form of NMP would be like God allowing the sinner to choose between Good and Evil.

Weak form of NMP turns out to have surprisingly strong consequences. For instance, by choosing the sub-space to have dimension given by power of prime, the state function reduction can yield a larger negentropy gain than otherwise. Primes near powers of prime as dimensions of final state projector are optimal from the point of view of evolution since they give a large negentropy gain and generate large p p-adicity, which means higher evolutionary level in number theoretical sense: this result is nothing but a generalization of p-adic length scale hypothesis.

NMP generalizes also so that it applies to hyper-finite factors of type II_1 and also in this case it is possible to define negentropic entanglement. In this case entanglement negentropy is positive because the projector for the sub-space as dimension smaller than one as the inverse of the index of inclusion. The interpretation is that the degrees of freedom below measurement resolution carry NE characterized by the projector to the sub-space.

1.5   The Notion Of Self

The quantum notion of self solved several key problems of TGD inspired theory of consciousness but the precise definition of self has remained a long standing problem and I have been even ready to identify self with quantum jump. Zero energy ontology allows what looks a final solution of the problem. Self indeed corresponds to a sequence of quantum jumps integrating to single unit, but these quantum jumps correspond to state function reductions to a fixed boundary of CD leaving the corresponding parts of zero energy states invariant. In positive energy ontology these repeated state function reductions would have no effect on the state but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and gives rise to self. The first quantum jump to the opposite boundary corresponds to the act of free will or wake-up of self.

p-Adic physics as correlate for cognition leads to the notion of negentropic entanglement possible in the intersection of real and p-adic worlds involves experience about expansion of consciousness. Consistency with standard quantum measurement theory forces negentropic entanglement to correspond to density matrix proportional to unit matrix. Unitary entanglement typical for quantum computing systems gives rise to unitary entanglement. A natural conjecture is that the the integer n in $h_{eff} = n \times h$ corresponds to the dimension of the unit matrix associated with negentropic entanglement. Also a connection with quantum criticality made possible by non-determinism of Kähler action and extended conformal invariance emerges so that there is high conceptual coherence between the new concepts inspired by TGD.

The identification of the imbedding space correlate of self as causal diamond (CD) of the imbedding space combined with the identification of space-time correlates as space-time sheets inside CD solved the problems concerning the relationship between geometric and subjective time.

Subjective memory is assumed to correspond to an average of conscious experiences of quantum jumps occurred after the last wake-up of self (the first one in the sequence of state function reduction at same boundary of CD). This leads to the identification of qualia as averages of the increments of quantum numbers and zero modes in the ensemble of quantum jumps defining self. Summation hypothesis states that self X experiences the experiences of its subselves as abstracted experiences, averages X_{ij} about sub-subselves X_{ij}. Subselves of un-entangled selves can entangle (this is due to the many-sheeted sub-system concept) and this allows fusion and sharing of mental images.

Quantum entanglement provides a mechanism leading to the formation of irreducible wholes at the level of mental images. Entanglement can be entropic bound state entanglement or negentropic entanglement, which need not involve binding energy. The latter is possible only in the intersection of real and p-adic worlds where life can be said to reside and quantum criticality of TGD Universe accompanied by the hierarchy of Planck constants is essential for it. Quantum entanglement is possible also in time direction in zero energy ontology. It is tempting to assign negatively colored emotions to the entropic entanglement and positive emotions to the negentropic one. In TGD framework the standard vision about brain based on reductionistic-holistic dichotomy must be replaced with a trinity in which negentropic entanglement corresponds to a mode of cognition, which does not allow linguistic expression and episodal memories, and various mental feats of synesthetes and idiot savants could be seen as a manifestation of negentropic entanglement. Also meditative consciousness would be negentropic.

Selves are called irreducible if they possess no subselves, otherwise reducible. Subselves correspond to mental images so that irreducible subselves possess no mental images and are in a state of pure self-awareness: it is not clear whether this kind of states are possible in practice. When the subselves of self fuse to single negentropic subself, a state of "one-ness" results in somewhat different sense. This mode of consciousness can be identified as "whole-body" consciousness and differs from ordinary consciousness during which self has large number of mental images. These modes could naturally explain emotional/holistic and rational modes of mind. These two modes could make it possible to understand various dichotomies like brain/left brain, emotional/analytic, religous/rational, Eastern/Western,... One could understand linear cognitive processes like thinking and language as self cascades in which self decomposes into subselves, which in turn decompose into subselves, which ... and self hierarchy implies connection with computationalism.

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

In TGD framework it is not at all obvious that the highest levels of our personal self hierarchy should correspond to the size of the physical body. Various empirical facts, in particular the observations related to the special effects of excitations of geomagnetic fields and ELF em fields in EEG frequency range on brain, inspire the hypothesis that our selves correspond to topological field quanta of em fields associated with EEG frequencies and thus by Uncertainty Principle have size scale of Earth. This leads to a rather radical modification of the brain centered views about consciousness, and one can quite seriously consider the questions like what physical death means from the point of view of consciousness: it could be that electromagnetic part of self hierarchy could survive after the physical death as a "soul".

This chapter is devoted to the theoretical aspects related to the definition of self. In second chapter applications of the notion of self are discussed. The plan of this chapter is as follows.

1. In the first section the notion of self is defined and various aspects related to it are discussed. This includes discussion about the flow and arrow of time, qualia, quantum model for intelligent systems, emotional representation of Boolean logic, the origins of ethics and

moral as NMP allows to understand them, and self referentiality. Also the general structure of conscious experience is considered: self has sub-selves experienced as mental images and sharing and fusion of mental images is possible in many-sheeted space-time. Various aspects of binding are discussed in terms of negentropic entanglement. The basic prediction is entire self hierarchy and also the aspects related to this hierarchy are discussed.

2. Second section is devoted to a critical question: is NE experienced directly or does it only define a model of self and is it necessary to have a mechanism allow to make the information in question conscious. Although the most elegant assumption is that sequence of repeated state function reductions makes NE conscious, the possibility that interaction free measurement might be needed to achieve this, is discussed.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [?].

2   Quantum Self

The section introduces the definition of self, discusses the role of entanglement in binding, introduces the basic assumptions about the structure of conscious experience of self and some of their consequences.

The necessary conceptual background includes ZEO, hierarchy of Planck constants, fusion of real physics and p-adic physics to single coherent whole - adelic physics, the notion notion of negentropic entanglement, and weak form of NMP. These building bricks are discussed in the introduction.

2.1   Quantum Jump As Moment Of Consciousness

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

Quantum jump has a complex anatomy since it must include state preparation, state function reduction, and also unitary process characterized by U-matrix.

It took quite a long time to realize that state repeated state function reductions which do not change state at all in standard quantum measurement theory are quite essential for the notion of self and that the first state function reduction at the opposite boundary of CD corresponds to the state function reduction assigned with quantum measurement.

In ZEO the repeated state function reduction leave the passive boundary and the parts of the zero energy states at the passive boundary invariant whereas the active boundary and parts of states at it change. In other worlds, one has state function in the moduli space charactering the position of the active boundary (discrete Lorentz boosts leaving passive boundary invariant and discrete translations in the proper time distance between the tips of CD). Each repeated state function reduction corresponds to a unitary process inducing de-localization in these degrees of freedom and localization so that fixed CD results.

2.2   Definition Of Self In ZEO

Intuitively self corresponds to a sequence of quantum jumps which somehow integrates to a larger unit much like many-particle bound state is formed from more elementary building blocks. It also seems natural to assume that self stays conscious as long as it can avoid bound state entanglement with the environment in which case the reduction of entanglement is energetically impossible. One could say that everything is conscious and consciousness can be only lost when the system forms

bound state entanglement with environment. Second intuitive view is that self is a subsystem able to remain un-entangled with the environment. This view can be subjected to criticism.

The precise definition of self has remained a long standing problem and I have been even ready to identify self with quantum jump. ZEO allows the most feasible candidate for the solution of the problem found hitherto.

In ZEO self indeed corresponds to a sequence of quantum jumps integrating to single unit, but these quantum jumps correspond state function reductions to a fixed boundary of CD leaving the corresponding parts of zero energy states invariant. In positive energy ontology these repeated state function reductions would have no effect on the state but in TGD framework there occurs a change for the second boundary and gives rise to the experienced flow of time and its arrow and also to self. One can also identify the age of self as the increase of the distance between the tips of CD. The first quantum jump to the opposite boundary corresponds to the act of free will or death of self and re-incarnation of self at the opposite boundary of CD.

The part of zero energy state at the fixed boundary is stable so that it indeed represents a system able to remain un-entangled. All entanglement associated with the passive boundary is either negentropic or bound state entanglement since state function reduction produced it destroys non-negentropic entanglement unless it is bound state entanglement.

Since number theoretic entropies are natural in the intersection of real and p-adic worlds, this suggests that life resides in this intersection identifiable in terms of string world sheets and partonic 2-surfaces. A natural assumption is that self experiences expansion of consciousness as it entangles negentropically. Quite generally, an infinite self hierarchy with the entire Universe at the top is predicted.

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

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

Dark matter hierarchy and p-adic length scale hierarchy would provide a quantitative formulation for the self hierarchy. To a given p-adic length scale one can assign a secondary p-adic time scale as the temporal distance between the tips of the causal diamond (pair of future and past directed light-cones in $H = M^4 \times CP_2$). For electron this time scale is.1 second, the fundamental biorhythm. For a given p-adic length scale dark matter hierarchy gives rise to additional time scales coming as $\hbar/\hbar_0$ multiples of this time scale.

2.3 Two Variants For The Notion Of Self

I have considered two basic notions of "self".

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

   Even slightest entanglement would destroy self unless on introduces the notion of finite measurement resolution applying also to entanglement. This notion is indeed central for entire quantum TGD also leads to the notion of sharing of mental images: selves unentangled in

the given measurement resolution can experience shared mental images resulting as fusion of sub-selves by entanglement not visible in the resolution used.

ZEO solves this problem. The sequence of quantum jumps defining self consist of only those for which state function reduction takes place on fixed boundary of CD! In ordinary quantum measurement theory these state function reductions would have no effect on state. Now however the wave function characterizing the position of the second boundary of CD disperses towards "geometric future" of the fixed boundary. Geometric time corresponds to the proper time distance between the tips of CD whose quantum average value increases. Self corresponds to this sequence of quantum jumps and indeed remains unentangled at the fixed boundary and also experiences flow of geometric time with definite arrow.

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

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

The first view about self, which I believe is nearer to the correct one, does not exclude the hierarchy of selves, and one should be also in this case able to construct a well-defined mathematical scheme allowing to understand what fractality of quantum jumps and selves at the level of space-time correlates could mean. The following argument represents such a proposal.

Let us start from the CD model as a lowest approximation for a model of zero energy states and for the space-time region defining the contents of sensory experience and allow wave function in the moduli space of CDs essential for the new view about arrow of time and self.

Let us make the following assumptions.

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

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

3. The time span characterizing the contents of conscious experience associated with a given quantum jump would correspond to average temporal distance T between the tips of the CD in the wave function in space of CDs. The lifetime of self corresponds to the quantum average for the increase ΔT during the sequence of state function reductions to a fixed boundary of CD. A reasonable guess is that ΔT is of same order as T.

4. We know that that the contents of sensory experience comes from a rather narrow time interval of duration about .1 seconds, which corresponds to the time scale T_{127} associated with electron. We also know that there is asymmetry between positive and negative energy

parts of zero energy states both physically and at the level of conscious experience. This asymmetry must have some space-time correlate. The simplest correlate for the asymmetry between positive and negative energy states would be that the upper light-like boundaries in the structure formed by light-cones within light-cones intersect along light-like radial geodesic. No condition of this kind would be posed on lower light-cone boundaries. The scaling invariance of this condition makes it attractive mathematically and would mean that arbitrarily long time scales T_n can be present in the fractal hierarchy of light cones. At all levels of the hierarchy all contribution from upper boundary of the CD to the conscious experience would come from boundary of same past directed light-cone so that the conscious experience would be sharply localized in time in the manner as we know it to be. The new element would be that content of conscious experience would come from arbitrarily large region of Universe and seing Milky Way would mean direct sensory contact with it.

5. These assumptions relate the hierarchy of quantum jumps to p-adic hierarchy. One can also include also dark matter hierarchy into the picture. For dark matter hierarchy the time scale hierarchy $\{T_n\}$ is scaled by the factor $r = \hbar/\hbar_0$ which can be also rational number. For $r = 2^k$ the hierarchy of CDs generalizes without difficulty and there is a kind of resonance involved which might relate to the fact that the model of EEG favors the values of $k = 11n$, where $k = 11$ also corresponds in good approximation to proton-electron mass ratio. For more general values of $\hbar/\hbar_0$ the generalization is possible assuming that the position of the upper tip of CD is chosen in such a 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 classically the contents of conscious experience would rather literally come from the boundary of the past directed light-cone along which the classical signals arrive (not however that this boundary disperses to future). Hence the mystic feeling about telepathic connection with a distant object at distance of billions of light years expressed by an astrophysicist, whose name I have unfortunately forgotten, would not be romantic self deception.

This framework explains also the sharp distinction between geometric future and past (not surprisingly since energy and time are dual): this distinction has also been a long standing problem of TGD inspired theory of consciousness. Precognition is not possible unless one assumes that communications and sharing of mental images between selves inside disjoint CDs is possible. Physically there seems to be no good reason to exclude the interaction between zero energy states associated with disjoint CDs (see **Fig. http://tgdtheory.fi/appfigures/sharing.jpg** or **Fig. ??** in the appendix of this book).

This scenario allows also to answers the questions related to a more precise definition of volume of attention. Causal diamond - or rather - the associated light-like boundaries containing positive and negative energy states define the primitive volume of attention. The obvious question whether the attention of a given self is doomed to be fixed to a fixed volume can be also answered. This is not the case. Selves can de-localize in the sense that there is a wave function associated with the position of the CD and quantum jumps changing this position are possible. Also many-particle states assignable to a union of several CDs are possible. Note that the identification of magnetic flux tubes as space-time correlates of directed attention in TGD inspired quantum biology makes sense if these flux tubes connect different CDs. The directedness of attention in this sense should be also understood: it could be induced from the ordering of p-adic primes and Planck constant: directed attention would be always from a longer to shorter scale.

2.4 Basic Consequences Of The Definition Of Self

Summation hypothesis, when combined with the mechanism for the formation of abstractions and mechanism of subjective memory, has rather nontrivial consequences.

2.4.1   Self, psychological time and its arrow

There are many difficult questions related to the relationship between subjective and geometric time. How the arrow of subjective time is mapped to the arrow of geometric time? How to understand the sharp distinction between geometric future and past at the level of conscious experience? What is the average interval of geometric time assignable to quantum jump and how it depends on the p-adic prime p characterizing system and on the value of Planck constant? Can one assign to quantum jumps space-time region about which the contents of conscious experience are, and how the temporal and spatial scales of this region depend on p and the value of Planck constant?

The emergence of ZEO and hierarchy of Planck constants provides to my opinion the most convincing partial answers to these questions found hitherto. the answers are not final however as the considerations of last section demonstrate.

1. Zero energy state is identifiable in positive energy ontology as a physical event, say elementary particle scattering such that positive and negative energy parts of the state correspond to the initial and final states of the event. The geometric correlate is a CD formed by a pair of future and past directed light-cones of M^4 and corresponds to a region of the imbedding space rather than that of space-time.

2. The temporal distance T between the tips of the CD brings to physics a new time scale and simple argument predicts p-adic length scale hypothesis (favored primes p satisfy $p \simeq 2^k$, k prime), and that the minimal value of T for elementary particles corresponds to secondary p-adic time scale $T_{2,p} = \sqrt{p}T_p$. For nonstandard values of $\hbar$ T scales like $\hbar/\hbar_0$. In the case of zero energy state describing electron this time scale is .1 seconds and corresponds to the 10 Hz frequency defining the fundamental biorhythm, and the duration of moment of sensory experience.

3. The simplest explanation for the arrow of geometric time relies on the view about self as a sequence of repeated reductions at fixed boundary of CD. The sequence involves unitary evolution in the moduli space of the active boundary and is essentially dispersion. Each reduction means localization in the moduli space of CDs and by purely geometric argument the distance beween the tips of CD tends to increases. This distance defines the age of self and the arrow of phychological times means its average increase. In the first state function reduction to the opposite boundary of CD the arrow of geometric time changes but the distance between the tips increases also in this reduction.

4. There is a strong analogy with cosmic time and a natural proposal is that the quantum counterpart for cosmic time correspond to this kind of parameter for a very large CD. The relative positions of the of tips define part of the moduli space of CD and this space is discrete by number theoretical universality and correspond to a tesselations assignable to cosmic time constant hyperboloid having discrete algebraic subgroup of Lorentz group as isometry group. The hierarchy of tesselations is expected to relate to the hierarchy of algebraic extensions of rationals defining an evolutionary hierarchy. This would predict quantization of redshifts in cosmology.

2.4.2   Qualia

Since physical states are labeled by quantum numbers, various qualia correspond naturally to the increments of quantum numbers in quantum jump which leads to a general classification of qualia in terms of the fundamental symmetries [K8]. One can speak also about geometric qualia assignable to the increments of zero modes which correspond to the classical variables in ordinary quantum measurement theory and non-quantum fluctuating degrees of freedom which do not contribute to the metric of world of classical worlds (WCW) in TGD framework. Dark matter hierarchy suggests that also qualia form a hierarchy with larger values of Planck constant identifiable as more refined qualia. Rather amusingly, visual colors would correspond to increments of color quantum numbers assignable to quarks and gluons in standard model physics. The term "color", originally introduced as an algebraic joke, would directly relate to visual color.

NMP demands that self generates NE. One manner to achieve this is by performing a state function reduction to opposite boundary of CD meaning death and re-incarnation of self. The more pleasant option is to become an NE gatherer so that negentropic mental images are created: selves try to eat other selves to get negentropic sub-selves. This is nothing but metabolism with metabolites identifiable as negentropic carriers of quantum numbers. Fundamental qualia would correspond to quantum numbers for metabolites.

2.4.3 Quantum model for intelligent system

The concept of self provides justification for the assumptions behind the quantum model for intelligent systems [K3]. One can understand at very general level the mechanism for how universe forms abstractions about itself. Even the basic hierarchical structures of language could be identified in terms of Russian doll like structure formed by selves with phonemes possibly representing the lowest level selves in case of language. The possibility of NE possible in the intersection of real and p-adic worlds is perhaps the most important new element and makes possible the identification of quantum correlates of rules and abstractions. The intersection is number theoretically universal so that the number field assigned with it is some extension of rationals depending on the evolutionary level. NE in the intersection defines symbolic (real) and cognitive representations (p-adic) accompanying each other. Time-like negentropic entanglement between boundaries of CD in fermionic degrees of freedom is in principle also possible and would provide a natural representation for a Boolean rule $A \rightarrow B$ with paired instances of A and B represented by state pairs.

The close connection with the computationalistic approach to psychology and consciousness is obvious. The hierarchy of selves is analogous to a hierarchy of higher level computer languages. Note also the analogy with the hierarchy of the modules of a computer program. Selves could be interpreted as symbolic representations for the objects of external (and internal) world and cascades of selves generating selves inside selves provide a model for sensory experience and cognition. This model provides also a possible representation for logical implication sequences as temporally ordered sequences generating sub-selves. NE between selves is a good candidate for representing how wholes are formed from parts consciously as also for the formation of associations. Abstraction process emerges naturally as a formation of quantum average selves about the sub-sub-selves of self. Zero energy ontology is ideal for construction of hierarchies as negentropically entangled states formed from zero energy states formed from....

NE and also quantum statistical determinism makes possible reliable thinking and sensory experiencing at the level of self and one could in principle model brain and sensory organs as ensembles of sub-sub-systems for which quantum measurement of certain observables occurs in quantum jump leading to the thought or sensory experience [K3]. For negentropic entanglement the outcome of the state function reduction is rather deterministic but U process can generate ensemble since one can obtain from a given negentropically entangled state new ones by permuting the entangled state pairs. This kind of transformation makes possible to realize quantum computations using negentropic qubits formed by entangled positive and negative energy parts of the state [K12]. Biological quantum computation could be rely on this kind of fuzzy qubits and the model of DNA as a topological quantum computer [K5] can be formulated in terms of negentropic qubits. What is especially nice is that temporal statistical averages become possible since mind-like space-time sheets can have also time-like distance: thus individual can learn form experience if temporal ensemble of cognitive space-time sheets is available.

2.4.4 Do positively colored emotions allow a representation of Boolean logic?

Weak form of NMP allows the state function reduction to occur in $2^n - 1$ manners corresponding to subspaces of the sub-space defined by n-dimensional projector if the density matrix is n-dimensional projector (the outcome corresponding to 0-dimensional subspace and is excluded). If the probability for the outcome of state function reduction is same for all values of the dimension $1 \leq m \leq n$, the probability distribution for outcome is given by binomial distribution $B(n,p)$ for $p = 1/2$ (head and tail are equally probable) and given by $p(m) = b(n,m) \times 2^{-n} = (n!/m!(n-m)!) \times 2^{-n}$. This gives for the average dimesion $E(m) = n/2$ so that the negentropy would increase on the average. The world would become gradually better. Note that one assumes that there is some preferred basis for the states and these numbers apply when this basis is given.

One cannot avoid the idea that these different degrees of negentropic entanglement could actually give a realization of Boolean algebra in terms of conscious experiences.

1. There should be a mapping of k-dimensional subspaces of n-dimensional space to the fermionic representation of Boolean algebra

2. Could one speak about a hierarchies of codes of cognition based on the assignment of different degrees of "feeling good" to the Boolean statements? If one assumes that the n:th bit is always 1, all independent statements except one correspond at least two non-vanishing bits and corresponds to negentropic entanglement. Only of statement (only last bit equal to 1) would correspond 1 bit and to state function reduction reducing the entanglement completely (brings in mind the fruit in the tree of Good and Bad Knowlege!).

3. A given hierarchy of breakings of super-symplectic symmetry corresponds to a hierarchy of integers $n_{i+1} = \prod_{k \leq i} m_k$. The codons of the first code would consist of sequences of m_1 bits. The codons of the second code consists of m_2 codons of the first code and so on. One would have a hierarchy in which codons of previous level become the letters of the code words at the next level of the hierarchy.

In fact, I ended up with almost Boolean algebra for decades ago when considering the hierarchy of genetic codes suggested by the hierarchy of Mersenne primes $M(n+1) = M_{M(n)}$, $M_n = 2^n - 1$.

1. The hierarchy starting from $M_2 = 3$ contains the Mersenne primes $3, 7, 127, 2^{127} - 1$ and Hilbert conjectured that all these integers are primes. These numbers are almost dimensions of Boolean algebras with $n = 2, 3, 7, 127$ bits. The maximal Boolean sub-algebras have $m = n - 1 = 1, 2, 6, 126$ bits.

2. The observation that $m = 6$ gives 64 elements led to the proposal that it corresponds to a Boolean algebraic assignable to genetic code and that the sub-algebra represents maximal number of independent statements defining analogs of axioms. The remaining elements would correspond to negations of these statements. I also proposed that the Boolean algebra with $m = 126 = 6 \times 21$ bits (21 pieces consisting of 6 bits) corresponds to what I called memetic code obviously realizable as sequences of 21 DNA codons with stop codons included. Emotions and information are closely related and peptides are regarded as both information molecules and molecules of emotion.

3. This hierarchy of codes would have the additional property that the Boolean algebra at $n + 1$:th level can be regarded as the set of statements about statements of the previous level. One would have a hierarchy representing thoughts about thoughts about.... It should be emphasized that there is no need to assume that the Hilbert's conjecture is true.

   One can obtain this kind of hierarchies as hierarchies with dimensions $m, 2^m, 2^{2^m}, ...$ that is $n(i+1) = 2^{n(i)}$. The conditions that $n(i)$ divides $n(i+1)$ is non-trivial only for at the lowest step and implies that m is power of 2 so that the hierarchies starting from $m = 2^k$. This is natural since Boolean algebras are involved. If n corresponds to the size scale of CD, it would come as a power of 2.

   p-Adic length scale hypothesis has also led to this conjecture. A related conjecture is that the sizes of CDs correspond to secondary p-adic length scales which indeed come as powers of two. In case of electron this predicts that the minimal size of CD associated with electron corresponds to time scale $T = .1$ seconds, the fundamental time scale in living matter (10 Hz is the fundamental biorhythm). It seems that the basic hypothesis of TGD inspired partly by the study of elementary particle mass spectrum and basic bio-scales (there are 4 p-adic length scales defined by Gaussian Mersenne primes in the range between cell membrane thickness 10 nmandsize 2.5 μm of cell nucleus!) follow from the proposed connection between emotions and Boolean cognition.

Hilbert's conjecture relates in interesting manner to space-time dimension. Suppose that Hilbert's conjecture fails and only the four lowest Mersenne integers in the hierarchy are Mersenne primes that is $3, 7, 127, 2^{127} - 1$. In TGD one has hierarchy of dimensions associated with space-time surface coming as 0, 1, 2, 4 plus imbedding space dimension 8. The abstraction hierarchy

associated with space-time dimensions would correspond discretization of partonic 2-surfaces as point set, discretization of 3-surfaces as a set of strings connecting partonic 2-surfaces character-ized by discrete parameters, discretization of space-time surfaces as a collection of string world sheet with discretized parameters, and maybe - discretization of imbedding space by a collection of space-time surfaces. Discretization means that the parameters in question are algebraic numbers in an extension of rationals associated with p-adic numbers.

In TGD framework it is clear why imbedding space cannot be higher-dimensional and why the hierarchy does not continue. Could there be a deeper connection between these two hierarchies. For instance, could it be that higher dimensional manifolds of dimension $2 \times n$ can be represented physically only as unions of say n 2-D partonic 2-surfaces (just like $3 \times N$ dimensional space can be represented as configuration space of N point-like particles)? Also infinite primes define a hierarchy of abstractions. Could it be that one has also now similar restriction so that the hierarchy would have only finite number of levels, say four. Note that the notion of n-group and n-algebra involves an analogous abstraction hierarchy.

2.4.5   How memories are represented and recalled?

Formation of memories and memory recall are key elements in the vision proposed by Hawkins [J4]. The question is what memories and memory recall are. If quantum jump is the fundamental process, it should automatically give rise to memories and memory recall.

1. Memories in given scale would naturally correspond to sequences of mental images defined by negentropically entangled sub-CDs of CD in given scale. According to earlier view the sequences of moments of consciousness bind to form higher level moments of consciousness, selves. Somewhat different view is that formation of selves means formation of sequence of negentropically entangled sub-CDs stable against NMP and preserved in quantum jump and even increasing in size. Thus self would correspond to a property of state and consciousness would be associated with the replacement of state with a new one.

2. The hierarchical structure of memories would emerge naturally. Conscious memory recall would correspond to a generation of negentropic entanglement between the new mental im-ages emerging in the state function reduction (recall that the sizes of CDs increase and new sub-CDs emerge) and already existing negentropically entangled mental images. Genera-tion of negentropic entanglement would give rise to the experience of recognition of the new mental images.

3. The natural guess is that negentropic entanglement (see **Fig. http://tgdtheory.fi/appfigures/cat.jpg** or **Fig. ??** in the appendix of this book) is generated if the new sensory input is "consistent" with older mental images. The addition of new tensor factor would mean a more abstract representation so that the sequence of quantum jumps would mean accumulation of experience. Consistency with older mental images could mean that the mental images have same "name". The name could correspond to p-adic cognitive representation. The physical correlate could be a collection of resonance frequencies. The names would be same if the frequencies for older mental images and new one are same, so that resonant interactions becomes possible. The generation of negentropic entanglement would be like finding a radio station.

For this proposal memory recall and memory formation are actually more or less the same thing. Only the completely new memories claimed to be formed in hippocampus would not involve memory recall. The new memory would correspond to a new sub-CD or ensemble of sub-CDs representing the associated negentropically entangled mental images. Neuronal loop could make possible to build copies about the new memory and thinking about it would create copies of corresponding p-adic cognitive representations which in turn could be transformed via state function reduction to an opposite boundary of CD to actions. In TGD framework the 4-D hierarchy of memories could continue from hippocampus to the magnetic body: this would explain the correlation of EEG with memory and also with various other brain functions.

2.4.6 Self as a moral agent

There are many manners to interpret evolution in TGD Universe.

1. p-Adic evolution would mean a gradual increase of the infinite p-adic prime characterizing the entire universe implying the gradual increase of p-adic primes characterizing individual partonic 2-surfaces and therefore their size. Infinite primes at the n:th level of hierarchy defining the analogs of bound states of multiply second quantized arithmetic quantum field theory can be mapped to irreducible polynomials of n variables and for $n = 1$ they define irreducible extensions of rationals. Infinite integers in turn define polynomials giving rise to reducible extensions of rationals. Hence infinite primes having interpretation in terms of bound states define levels of the hierarchy of algebraic extensions defining evolutionary hierarchy.

2. The hierarchy of Planck constants suggests evolution as the gradual increase of the Planck constant characterizing p-adic space-time sheet (or partonic 2-surface for the minimal option). This evolution could be seen as a migration to the pages of the book like structure defined by the generalized imbedding space and has therefore quite concrete geometric meaning. It implies longer time scales of long term memory and planned action and macroscopic quantum coherence in longer scales.

3. The vision about life as something in the intersection of real and p-adic words allows to see evolution information theoretically as the increase of number entanglement negentropy implying entanglement in increasing length scales. This option is consistent with the first one if the effective p-adic topology characterizes the real partonic 2-surfaces in the intersection of p-adic and real worlds. The singular coverings of CD s and CP_2 are characterized by an Abelian group Z_n permuting the sheets of the covering and corresponds naturally to powers of the (quantum) phase $q = exp(i2\pi/n)$ allowing to define the notion of angle in p-adic context but only with a finite resolution since only finite number of angles are represented as phases for a given value of n. The increase of the integers n could be interpreted as the emergence of higher algebraic extensions of p-adic numbers in the intersection of the real and p-adic worlds. These observations suggest that all three views about evolution are closely related.

The third kind of evolution would mean also the evolution of spiritual consciousness if the proposed interpretation is correct. In each quantum jump U-process generates a superposition of states in which any sub-system can have both real and algebraic entanglement with the external world. If state function redution process involves also the choice of the type of entanglement it could be interpreted as a choice between good and evil. The hedonistic complete freedom resulting as the entanglement entropy is reduced to zero on one hand, and the algebraic bound state entanglement implying correlations with the external world and meaning giving up the maximal freedom on the other hand. The selfish option has the risk of leading to non-algebraic bound state entanglement implying a loss of consciousness: death as the prize of sin. The second option means expansion of consciousness - a fusion to the ocean of consciousness as described by spiritual practices.

In this framework one could therefore understand the physics correlates of ethics and moral. The ethics is simple: evolution of consciousness to higher levels is a good thing. Anything which tends to reduce consciousness represents violence and is a bad thing. Moral rules are related to the relationship between individual and society and presumably develop via self-organization process and are by no means unique. Moral rules however tend to optimize evolution. As blind normative rules they can however become a source of violence identified as any action which reduces the level of consciousness.

Weak form of NMP indeed allows the self to choose between good and evil since the reduction need not take place to the maximal dimension n_{max} defined by the projector in question but also to sub-spaces. This in fact allows to have larger negentropy gains as strong form of NMP: when n_{max} is product of primes it can happen that some smaller integer has larger power of prime as a factor so that negentropy gain is larger. The choice $n = 1$ means vanishing negentropy gain and implies isolation of self. Weak form of NMP makes also possible realization of Boolean algebra in terms of the lattice of sub-spaces of the n_{max}-dimensional space: only that $n = 0$ case is excluded

so that one has $2^{n_{max}} - 1$ choices. In set theoretic representation of Boolean algebra this option corresponds to empty set.

There is an entire hierarchy of selves and every self has the selfish desire to survive and moral rules develop as a kind of compromise and evolve all the time. The need to satisfy the needs of NMP without dying (this in general means increase of negentropy) has led to the discovery of metabolism as the fundamental form of crime! Self can eat other selves and in this manner gain the NE of sub-selves and live longer. This has the positive outcome that self makes possible for its sub-selves (mental images) to evolve via repeated death and re-incarnations. Replication of magnetic bodies having concrete counterpart as splitting of 3-surfaces analogous to 3-particle vertex of Feynman diagram is another discovery making it possible for selves to replicate.

The newest progress in this evolution is brought by the cosmology of consciousness, which forces to extend the concept of society to four-dimensional society! The decisions of "me now" affect both my past and future and time like quantum entanglement makes possible conscious communication in time direction by sharing conscious experiences. One can therefore speak of genuinely four-dimensional society. Besides my next-door neighbors I had better to take into account also my nearest neighbors in past and future (the nearest ones being perhaps copies of me!). If I make wrong decisions those copies of me in future and past will suffer the most. Perhaps my personal hell and paradise are here and are created mostly by me.

Selves can make plans since they have 4-dimensional geometric memory (conscious experience contains information about a *four-dimensional* space-time region, rather than only time=constant snapshot, and gives rise to a "prophecy", a prediction for the future and past, which would be reliable if the world were completely classical). As a matter fact, it is p-adic space-time sheets which correspond to intentions and plans and act of volition transforms p-adic space-time sheet to a real one. Selves can make decisions and select between various classical macroscopic time developments. Selves are able to remember their choices since they have subjective memories about the previous quantum jumps. Thus selves are genuine moral agents.

2.4.7 Self-referentiality of consciousness and evolution

Quantum classical correspondence is the basic guiding principle of quantum TGD. Thanks to the failure of a complete determinism of classical dynamics, space-time surface can provide symbolic representations not only for quantum states (as maximal deterministic regions) but also for quantum jump sequences (sequences of quantum states) and thus for the contents of consciousness. These representations are regenerated in each quantum jump, and make possible the self referentiality of consciousness: self can be conscious of what it *was* conscious of. This allows to avoid infinite regress and replaced it with endless evolution.

Evolution in turn involves several aspects. The increase of the complexity of the algebraic extension of rationals in the intersection of reality and p-adicities and by strong form of holography identifiables as string world sheets and partonic 2-surfaces whose parameters (WCW coordinates essentially) are in the extension. The ramified primes in the extension define the preferred primes.

In strong form of holography p-adic continuations of 2-surfaces to preferred extrmals identifiable as imaginations would be easy due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K13]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes.

NMP leads to a generalizations of p-adic length scale hypothesis stating that primes near powers of prime are favoured. Generation of NE defining Akashic records is a one aspect of evolution. Increase of Planck constant $h_{eff} = n \times h$ and thus size scale of macroscopic quantum systems and CDs serving as correlates of selves is second aspect of evolution.

2.5 General Structure Of Conscious Experience

Combining summation hypothesis and the hypothesis about subjective memory one can understand quite a lot about the phenomenology of consciousness.

2.5.1 Summation hypothesis

Binding of selves by entanglement and summation hypothesis are the basic assumptions about the structure of contents of consciousness of self. Unentangled sub-system X possessing self behaves essentially as a separate sub-Universe with respect to NMP. This means that unentangled sub-systems X_i of X, in particular sub-selves, participate in each quantum jump. If one postulates that the conscious experiences of sub-systems X_i of unentangled sub-system X integrate with the self experience of X to form single experience, one obtains a filtered hierarchy of conscious experiences with increasingly richer contents. The integrated experience cannot a simple sum of individual experiences of sub-selves (we do not experience the conscious experiences of neurons separately). Rather, the experience of X is most naturally sum of abstractions about experiences of X_i. A natural hypothesis is that X forms kind of abstraction or average $\langle X_{ij} \rangle$ about the experiences of sub-selves X_{ij} of X_i representing what it is to be average X_{ij}, that is average over the mental images of X_i.

This kind of mechanism would explain why we do not experience the experiences of individual neurons, microtubules, DNA: s, etc... as a huge multitude of separate experiences and do note get drowned to useless information. Combining summation hypothesis with the hypothesis about subjective memory (described in previous section), one can understand self as an object having genuine extension in subjective time. In particular, it is possible to identify short term memory as a subjective memory. Also temporal average in geometric sense is possible since mind-like space-time sheets can have also time-like separation.

A challenge for the hypothesis of self and summation hypothesis is provided by split brain patients [J1]. It seems that in most serious cases either right or left half dominates the behavior of the split brain patient and communication between brain hemispheres is lacking. It is known that brain hemispheres learn to communicate indirectly. Is the hypothesis about summation of the right and left selves to form mental images of a higher self ireally consistent with the behaviour of split brain patients?

1. The dominance of either hemisphere is highly analogous to the dominance of a person over another one. The sudden changes of personality can be understood as result of different cognitive specializations of the two hemispheres. The lacking information transfer between hemispheres explains why right and left brain behave so differently (to the extend that they can have different future plans!). It is well known that in early childhood hemispheres behave as separate personalities and certain period in the learning of language seems to involve communication between brain hemispheres: left hemisphere comments what right hemisphere is doing. This kind of direct communication usually ceases, when the direct physical connection between brain hemispheres has developed.

2. One must of course ask what "dominance" really means. A possible definition is based on the notion of self hierarchy and magnetic body as intentional agent. Magnetic body could direct its attention in normal circumstances to either left hemisphere or right hemisphere or both if they are entangled (entropically or negentropically). The unattended hemisphere could be conscious but would not contribute to the conscious experience of the magnetic body representing us. Corpus callosum- the axon bundle connecting right and left hemisphere- would serve as a natural correlate for their entanglement, which should be negentropic in the normal situation. Quite generally, axons would serve as correlates for the entanglement so that also sensory receptors would be in this sense part of the brain. Note that this would make possible macroscopic quantum coherence between distance parts of body and brain and the regions of quantum coherence would be highly irregular.

3. The alternating hemisphere dominance characterizes also healthy persons and could provide magnetic body with three different views about world corresponding to hawks and doves and those between. Problems begin when either hemisphere dominates for too long time. For instance, for schizophrenics the time of dominance is longer than normally. For split brain patients the absence of physical connection between hemispheres makes impossible quantum entanglement binding the hemispheres together to form single coherent whole and the body of the patient is inhabited by two persons. The length of time-interval during which given hemisphere contributes to our conscious experience could be rather short. Interestingly, in

the case of dolphins and some birds the second hemisphere sleeps. Is this for metabolic reasons or is the second hemisphere entangled with the collective consciousness of the dolphin horde? The theory of bicameral mind assumes that human consciousness before the evolution of language was dominated by another hemisphere entangled with collective level of consciousness. I have discussed a model of bicamerality in the earlier formulation of TGD inspired theory of consciousness in [K17, K18]. One can of course whether that dolphins could represent a modern example about bi-cameral consciousness.

2.5.2   Sharing and fusion of mental images

The standard dogma about consciousness is that it is completely private. It seems that this cannot be the case in TGD Universe. Von Neumann algebras known as hyper-finite factors of type II_1 (HFF) [K20, K6] provide the basic mathematical framework for quantum TGD and this suggests important modifications of the standard measurement theory besides those implied by the zero energy ontology predicting that all physical states have vanishing net quantum numbers and are creatable from vacuum. The notion of measurement resolution characterized in terms of Jones inclusions $\mathcal{N} \subset \mathcal{M}$ of HFFs implies that entanglement is defined always modulo some resolution characterized by infinite-dimensional sub-Clifford algebra $\mathcal{N}$ playing a role analogous to that of gauge algebra.

This modification has also important implications for consciousness. For ordinary quantum measurement theory separate selves are by definition unentangled and the same applies to their sub-selves so that they cannot entangle and thus fuse and shared mental images are impossible: consciousness would be completely private.

Space-time sheets as correlates for selves however suggests that space-time sheets topologically condensed at larger space-time sheets and serving as space-time correlates for mental images can be connected by flux tubes so that mental images could fuse and be shared.

HFFs allow to realize mathematically this intuitive picture. The entanglement in $\mathcal{N}$ degrees of freedom between selves corresponding to $\mathcal{M}$ is below the measurement resolution so that these selves can be regarded as separate conscious entities. These selves can be said to be unentangled although their sub-selves corresponding to $\mathcal{N}$ (mental images at upper level) can entangle. Fusion and sharing of mental images becomes possible. For instance, in stereo vision right and left visual fields would fuse together. More generally, a pool of shared stereo mental images might be fundamental for evolution of social structures and development of social and moral rules and language (shared mental images make possible common meaning for symbols of language). A concrete realization for this would be in terms of hyper-genome making possible collective gene expression [K9, K11].

2.5.3   Self as a statistical ensemble, emotions, and qualia

The sequence of quantum jumps defining self defines also a sequence of completely unentangled quantum states resulting in the state reduction process governed by NMP. This set of states, which grows in size quantum jump by quantum jump, defines in a natural manner a statistical ensemble identifiable as the fundamental realization of the otherwise fictive notion of statistical ensemble fundamental in the formulation of statistical physics. As far as conscious experience is involved, it seems that it is the increments of quantum numbers and zero modes which are the relevant statistical variables.

This observation anchors the theory of conscious experience to statistical physics [K8]. For instance, the increments of zero modes resp. quantum numbers are responsible for geometric resp. non-geometric qualia. More precisely, the gradients with respect to subjective time for the zero modes and for the net quantum numbers associated with selves correspond to qualia. One can classify non-geometric qualia to kinesthetic qualia (sense of pressure and force and, more generally, gradient of any conserved (with respect to geometric time) quantity associated with self with respect to subjective time); and generalized chemical qualia (rates for the changes of numbers of particles with various quantum numbers). Various entropies associated with self and sub-selves in turn characterize the sharpness of the mental images, and one can relate concepts like attentiveness, alertness and the level of arousal to these variables.

Statistical aspect could be involved with sensory experiences also in the sense of ensemble averaging. For instance, various cones of retina are sensitive to different wavelength regions (red, green, blue) and their experiences must correspond to different colors. Therefore our color experience, which corresponds to average color, should be abstraction about experiences of a small group of retinal cells. Ensemble averaging could be present in case of sense such as temperature and pressure sense. Also temporal averaging with respect to *geometric* time would be made possible by mind-like space-time sheets and could be present.

The original proposal was that emotions some kind of qualia since also ordinary qualia have the characteristic black-white dichotomies. What is clear that emotions relate very closely to information. For instance, peptides are both informational molecules and molecules of emotion [J2]. This suggests that positive-negative dichotomy for emotions correlates directly with negentropic-entropic dichotomy for entanglement. For instance, the neurotransmitters producing positive (negative) emotions would generate negentropic (entropic) entanglement. The fate of the right amygdala would be a specialization to experience negative emotions by entangling mostly by bound state entanglement whereas left amygdala specialized to positive emotions would enjoy the negentropic entanglement.

In positive energy ontology it seems impossible to have quantum coherence in human time scales. The occurrence of 10^{39} quantum jumps per second probably means that at the lowest level of self hierarchy corresponding to time scale which is 10^4 Planck times statistical averaging thermalizes sub-selves completely so that mental images would contain no information. Decoherence is the physical counterpart of this process. In zero energy ontology the situation changes. The time scale assignable to CDassumed to be an octave of CP_2 time represents a completely new time scale which is macroscopic even for elementary particles. This time scale provides a simple estimate for the average increment of psychological time per quantum jump. For electron and quarks the time scales are.1 seconds and 1 millisecond and correspond to basic time scales of nervous system. The hierarchy of Planck constants allows to scale up these time scales and makes possible communication using photons with arbitrarily low wave lengths since large enough Planck constant implies that the energy of photon is above the thermal threshold. Negentropic entanglement makes possible the formation of completely new kind of macroscopic quantum systems. Time-like entanglement makes possible fusion of quantum jumps to longer quantum jumps and thus macrotemporal quantum coherence.

The feed of metabolic energy could destroy entropic entanglement and feed negentropic entanglement as such: for a simple model see [K7]. Interestingly, there is a well-documented disease in which the patient can live for decades in single frozen moment of consciousness. Is negentropic entanglement with abnormally large value of Planck constant in question? Or is entropic entanglement with abnormally large binding energy and therefore not possible to destroy by the feed of standard metabolic energy quanta in question?

2.5.4 Reducible and irreducible selves

Sub-selves correspond to mental images of self. Irreducible selves do not posses sub-selves and have thus no mental images. The interpretation of this kind of experience -if possible in practice- would be as a pure awareness without content. Whether this kind of states are really possible is not obvious since any space-time sheet contains smaller space-time sheets. When all sub-selves of self fuse (negentropically) together to yield a kind of stereo-consciousness (fusion of left and right visual fields gives rise to 3-D stereo vision), something exceptional results also. One might interpret this kind of state as whole-body consciousness, a state of oneness in very literal sense. Synchronous neuronal firing could be a signature of this kind of states at neuronal level. Reducible selves have several sub-selves experienced as mental images. One can model conscious processing as cascades leading to creation of sub-selves of sub-selves of...: selves are interpretable as symbolic representations of objects of sensory experience and a close parallelism with computationalism and connectivism emerges. In zero energy ontology negentropically entangled zero energy states form this kind of hierarchy.

2.6 Binding And Quantum Entanglement

How different components of conscious experiences, such as various sensory qualia and the active components of conscious experience involving thoughts, conscious selections and volition, integrate to single experience, is known as binding problem. In the original approach I distinguished between binding of conscious experiences and binding of conscious experiencers. Since mental images define experiences and are itself experiencers at a lower level of hierarchy, there seems however to be no need for this kind of distinction.

2.6.1 Negentropic entanglement as a mechanism of binding

Quantum entanglement provides a mechanism of binding of selves to larger selves. If the entanglement is negentropic, selves would experience an expansion of consciousness in the fusion. I have considered also the possibility of bound states entanglement and suggested that this leads to a loss of consciousness. Certainly bound state entanglement in the generic case cannot correspond to NE for which density matrix is projector. Whether conscious is lost in the formation of bound state entanglement and whether the higher level system is conscious remain open questions.

At the level of mental images (sub-selves) NE corresponds to the integration of parts to wholes. NE could create mental images representing rules as a collection of instances of rule as pairs of quantum states. Negentropically entangled Schrödinger cat would know that it is better to not open the bottle.

The successes of p-adic physics suggest that it should be possible to label also real selves/space-time sheets by p-adic primes. NMP and adelic view give strong support for this view. Algebraic extensions of rationals define a hierarchy and the parameters characterizing string world sheets and partonic 2-surfaces in the intersection of real and p-adic worlds belong to these algebraic extensions. By strong form of holography these surfaces carry the information about both space-time surfaces and quantum states and define cognitive representations. Boolean cognition (fermions) and cognitive representations reside in the intersection.

p-Adic primes would naturally correspond to so called ramified primes of extension. In strong form of holography p-adic continuations of 2-surfaces to preferred extrmals identifiable as imaginations would be easy due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K13]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes.

NMP leads to a generalization of p-adic length scale hypothesis so that also primes powers of general prime rather than only $p = 2$ are allowe. Hence also real selves would form a p-adic hierarchy. Sensory experience corresponds to the space-time surfaces and to the classical correlates of quantum states. Both p-adic length scale hierarchy and its generalizations and the hierarchy of Planck constants reduce to the hierarchy of algebraic extensions of rationals.

The fusion of selves to a larger self by bound state entanglement means a formation of a bound state and the binding energy could be liberated as a usable energy. Thus quantum metabolism could accompany the negentropic binding of the mental images. In the case of NE the possibility that the binding energy is effectively negative would also make possible liberation of energy, and I have proposed that this might take place in ATP→ADP+P$_i$ defining the fundamental step of metabolism in which the high energy phosphate bond is believed to liberate metabolic energy quantum [K7]. High energy phosphate bond could correspond to a magnetic flux tube carrying NE. Jail and love are good metaphors for the two kinds of correlations represented by bound state entanglement and NE. The recent view is that metabolites are NE carriers and that NE is transferred to the used in metabolism. This applies to all forms of metabolism, not only energy metabolism.

Different components of sensory experience, even sensory qualia, naturally correspond to separate sub-selves, whose individual experiences are separate but combine to form various qualia in our experience. In TGD framework they could correspond to sensory pathways or parts of them and perhaps containing also primary sensory organs: this option looks at this moment the most convincing one. Quite generally, it seems that the reliability of the sensory experiences and the

absence of experienced volition is guaranteed by the hypothesis about subjective memory.

In accordance with this, the experienced volition is most naturally related to the first state function at the opposite boundary of CD and means death and re-incarnation of corresponding self producing in typical case negentropy by NMP. Sensory perception in turn can be assigned to the sequence of state function reductions at fixed boundary of CD defining sensory mental images as sub-self.

For instance, synchronous neuronal firing could be understood as a consequence of almost simultaneous wake-up of neuronal sub-selves near criticality for phase transition changing the local topology of the space-time sheets associated with sub-self. 40 Hz neural synchrony to be discussed later has a nice interpretation in terms of the generation of NE.

If neurons have sub-selves, also subneuronal quantum jumps are possible and this could eventually make synchronous assembly and de-assembly of microtubules and even synchronously occurring biochemical reactions possible. Primary sensory experiences could occur in part of the sensory pathway containing also primary sensory organ and nerve pulse activity could be regarded as resulting from the creation or wake-up of sensory sub-self by quantum jump leading to state able to remain unentangled. It came as a surprise that in TGD universe our sensory representations (an entire hierarchy is involved) could be realized at the magnetic sensory canvas associated with the electromagnetic body accompanying the physical body and having size much larger than the physical body [K10].

A possible example of the bound state entanglement of sub-selves could be the binding of right and left visual fields to single visual field. The visual fields can sometimes fail to bind: this should result from the failure of the corresponding sub-selves to generate mutual entanglement with sufficient rate or at all (the connection between brain hemispheres is lacking).

Bio-feedback is a well-established phenomenon in which person receives feedback from the behaviour of, say, single neuron and learns to control voluntarily its behaviour. A possible mechanism of bio-feedback is based on quantum entanglement generated between the (sub)self of the person and the self of neuron. Socio-feedback at the level of entire society could be important mechanism making possible to establish moral and behavioural rules of the society: this socio-feedback is perhaps the basic function of sleep.

2.6.2   Binding geometrically

Quantum-classical correspondence suggests that the concept of binding should have a counterpart at the level of space-time geometry. The gluing of the space-time sheets by topological sum to larger space-time sheets creates nested hierarchical structures. This suggests that the summation of mental images to a collection of mental images experienced by a given self corresponds geometrically to the gluing of the material space-time sheets of sub-selves to the material space-time sheet of self by topological sum operation involving the formation of "wormhole contacts" (having physical identification as bosons and their super partners).

The binding of experiences (or experiencers) in turn would naturally correspond to the glueing of 3-surfaces together along their boundaries by join along boundaries bonds (topological sum for boundaries). Magnetic flux tubes is the more recent term meaning essentially same as join along boundaries bond. Magnetic flux tubes define a correlate for both kinds of entanglement.

The geometric counterpart of self defines a geometric representation for the subjective history of the self. For instance, larger mind-like space-time sheets at the higher level of the hierarchy could contain or generate holes making possible for smaller mind-like space-time sheets to form magnetic flux tubes. This mechanism would provide a concrete geometric realization for the communication between different levels of the hierarchy of selves. For instance, long term memories could become conscious through this kind of mechanism.

There are several arguments supporting the importance of flux tubes.

1. The dynamical realization of the self hierarchy as a master-slave hierarchy of various kinds of super conductors [K14, K15] relies on the identification of the magnetic flux tubes between the space-time sheets belonging to various levels of hierarchy as Josephson junctions. The "biofeedback" made possible by the magnetic flux tube makes it possible for the selves at higher levels of the hierarchy to experience what it is to be lower level self. In particular, our immediate sub-selves are represented by topological field quanta of ELF em fields

associated with EEG frequencies and thus have size of order Earth's circumference by Uncertainty Principle, whereas sensory experiences involve in essential manner entanglement with sub..sub-selves with size scale of neuronal circuits.

2. Magnetic flux tubes are perhaps the most interesting magnetic flux tubes in the TGD based quantum model of biology. Wormhole magnetic flux tubes consisting of a pair of space-time sheets with opposite time orientations, carrying magnetic fluxes with opposite directions, and containing also dark matter with large value of Planck constant are especially interesting. They play a key role in TGD inspired view about bio-chemistry and in the model of DNA as topological quantum computer [K5].

Cognitive entanglement between real and p-adic variants of the partonic 2-surface should be probable only for preferred primes. The successful applications of p-adic physics give good reasons to believe that real partonic 2-surfaces and also space-time regions can be a labelled by p-adic primes characterizing their effective p-adic topology. This should make sense at least in the intersection of real and p-adic worlds. The most natural entanglement is between partonic 2-surface and its p-adic counterpart and has maximum for a unique prime. One expects that this negentropy is expressible solely in terms of rational and common algebraic points of real and p-adic surfaces and thus using only the data about real partonic surface. If this entanglement negentropy has a space-time correlate, one could expect that it is maximum for the same prime and that the geometry of the partonic 2-surface and perhaps also of corresponding light-like 3-surface and even of a 4-D space-time region reflects this p-adic topology. This prime could characterize the local p-adic topology to which the real region can be transformed easily (, that is criticality against this kind of transition). This easiness could be measured by the total number of rational and common algebraic points of the partonic 2-surface if the transition amplitude is expressible in terms of the information coming from the common points.

It has become clear that the effective p-adic topology most naturally manifests itself rather abstractly at the level of WCW and by strong form of holography for the parameters of string world sheets and partonic 2-surfaces belonging to an algebraic extension of rationals defining also the extension of p-adic numbers. It is of course quite possible that these parameters have interpretation in terms of space-time geometry and topology. Good example is provide by the conformal moduli characterizing the conformal equivalence classes of partonic 2-surfaces and string world sheets. They have rather concrete geometric interpretation (say as positions for punctures). p-Adic variants of Teichmueller parameters indeed emerged first in p-adic mass calculations [K4]. What is nice is that these parameters are general coordinate invariants so that one avoids the problems with General Goordinate Invariance resulting if space-time coordinates are p-adicized and one wants to map real and p-adic space-time surfaces to each other.

2.6.3 Wholes and parts

The basic feature of higher level cognition is the formation of wholes from parts. NE between selves representing parts provides an attractive model for this process. NE is indeed highly suggestive in the case of cognition. One can wonder whether positive-negative dichotomy for emotions could reflect the negentropic-entropic dichotomy for entanglements. This would conform with the idea that the transformation of NE to bound state entanglement liberates metabolic energy and information and transforms nutrient to entropic waste. Therefore emotions would not reduce to special kind of qualia. The association of negatively colored emotions with bound state entanglement need not be the correct thing to do. Rather, the color of emotion tells how large negentropy gain is in state function reduction for sub-self. It it vanishes, the emotion is maximally negative.

Sub-selves represent symbolically the components of conscious experience, say letters of the word: in absence of NE between these "letter" selves the sum experience is set of letters whereas higher level experiences is about average letter. If sub-selves get entangled, there are no sub-self-experiences and sum-experience is about the word as is also the higher level experience. Understood word or written language could correspond to NE between the mental images representing letters. This entanglement could be also time like and by light-like 3-surfaces connecting a temporal sequence of CDs.

Entanglement might be be also time-like in zero energy ontology and this could relate closely to the differences between right and left hemispheres. For right brain hemisphere time-like (and

also space-like) NE could occur in longer time scales than for the left one as the saying right brain sings-left brain talks and the fact that spatial thinking is associated with the right hemisphere suggests.

This overall picture will be applied to the modelling of music experience later. The hypothesis will be also applied to explain paradoxical result of certain experiment testing right-left brain differences.

2.6.4   Entanglement and directed attention

Directed attention is one of the basic processes of consciousness occurring continually. Directed attention seems to involve free choice but focusing of attention could also occur spontaneously. One can approach the problem of identifying the physical correlates of directed attention from several angles.

1. The possibility to interpret self as a statistical ensemble suggests that the entropy of the mental image regarded as ensemble of sub-sub-selves of self measures its fuzziness. The negentropy of the mental image is maximal if sub-sub-selves are negentropically entangled to form a single coherent whole. Both attentiveness, alertness and level of arousal should relate very closely to the negentropy and thermal entropy of the mental image.

   Attention entangles it with the self attending it and creates negentropic system and in this manner prevents NMP to force the death of the mental image. Attention should bring in NE and this requires the feed of metabolites carrying NE.

   7 ± 2 rule of cognitive science suggests that the maximum number of our cognitive sub-selves, which can be awake simultaneously, is rather limited. The rule might be based on the metabolic limitations: sub-selves can have high energy NE content only in the presence of an external negentropy feed and metabolism must provide the needed negentropy feed. Note however that the needed metabolic energy might be extremely low. One could interpret the focused of attention as a wake-up of sub-self and keeping it in wake-up state and hence in short term memory. This could occur at the expense of the other sub-selves, which would be in wake-up state for only short times.

   Negentropic fusion of mental images would be alternative strategy to keep them alive: note however that this requires state function reduction at opposite boundary of the CD involve with them so that the re-incarnated mental images would be fused.

2. One can imagine that sub-sub-self inside sub-self representing mental image (say "monitor screen" as average over subs-ub-selves representing the visual objects) somehow pops up one level higher in the self hierarchy so that it becomes mental image. Geometrically this could correspond to the re-gluing of the corresponding space-time sheet to the space-time sheet of self instead of that of sub-self. Negentropic entanglement could be in question.

3. Self is assumed to experience the sub-systems immediately below it in the hierarchy or perhaps to the entire collection of mental images. This might however not be what attention is basically. Rather, attention seems to select one particular mental image and put other mental images to background and feed NE to this mental image as its mental images. It seems possible to direct attention to lower levels of the self hierarchy than the one immediately below. For instance, I can direct my attention to the entire sentence, which I am writing here or to some word of this sentence or to individual letters of this word. The phenomenon of bio-feedback demonstrates that it is possible to learn to direct the attention to even single neuron. This suggests that selves are able to modify the hierarchy of selves by raising some sub...sub-self to the role of sub-self temporarily and thus experience the former sub...sub-self as a direct mental image.

4. The formation of the flux tubes between mind-like space-time sheets belonging to different levels of the self hierarchy provides a candidate for the geometric correlate of directed attention. A formation of flux tube connecting partonic 2-surface assignable to self with a partonic 2-surface assignable to sub-self would be in question. Both the directed character of attention and the selection of a particular mental image would have clear geometric correlates. The attention to an object of perceptive field would separate the corresponding mental

image from the fusion of mental images. In the case of bound state entanglement this would require the feed of metabolic energy. In the case of negentropic fusion carrying energy it could liberate metabolic energy.

Anyone can do a simple but thought provoking experiment suggesting the presence of the macroscopic quantum entanglement at the level of brain and a change of the level of sub-self in the self hierarchy. Look at a mirror, direct your attention at your left eye, and redirect the gaze to the right eye. What you find that it is impossible to perceive the change in the direction of the eye gaze.

1. Consider first what probably happens when we perceive a moving object. A negentropic binding of the mental images of the visual field to single mental image implies that both the parts and the whole can be experienced so that the motion is perceived. If the direction of the gaze is stationary, the object moves relative to the background, and if the direction of the gaze follows the object the background moves with respect to the direction of gaze. In both cases the motion can be perceived.

2. If the eye follows its own rotating mirror image, neither of these options is realized if the environment to which the attention is directed is restricted to be the eye itself. The direction of the gaze should remain the same in order to perceive the change of the direction of the gaze but this is impossible.

3. The perceptive field however contains also other objects and one could argue that if the attention is directed also to these simultaneneously, it should be possible to perceive the changing direction of gaze as they move relative to the changing direction of gaze. Does the very act of directing attention to the mirror image of eye separate it from the NE with the other mental images so that the conscious comparison with them is not possible anymore? Or is the visual mental image representing eye at a different level of hierarchy from the very beginning and cannot negentropically entangle with the other visual mental images? Eye cannot perceive itself! Not even in mirror.

4. This argument raises the question whether it is possible to perceive the the motion of object if the attention is permanently directed to it? Is it necessarily to direct the attention only temporarily to the object and whether the saccadic motion of eyes could relate to this? There are almost incredible sounding experiments demonstrating that the attention directed intensely to a fixed object makes it impossible to become aware what happens in environment.

2.6.5   Entanglement and altered states of consciousness

NE might provide the Royal Road to the understanding of altered states of consciousness. Entanglement can take place both at the level of self and sub-selves, In the latter case one can consider the possibility that self can choose in state function reduction whether the mental images are entangled entropically or negentropically. Weak form of NMP indeed predicts this.

For self the NE would be kind of moment of mercy by higher level self. Both space-like and time-like entanglement are possible and this can lead to transpersonal experiences and memories extending past the own life time. Also the increases of p-adic prime or Planck constant could be be involved with these experiences. Clearly, a wide repertoire of expanded states of consciousness is predicted. This picture conforms with the view that a certain kind of personal moral and intellectual evolution is a prerequisite for enlightenment experiences.

Examples of altered states of consciousness are transpersonal experiences and enlightenment experiences in which one identifies with some larger consciousness. For instance, prenatal experiences could result from a time-like NE of a sub-self with self having a temporal extension of order lifetime or longer and having kind of abstracted experience about the period of life before birth. Experiences like "sharing the sorrow of all mothers of dead soldiers" could involve the entanglement of sub-self with a collective mental image resulting in the entanglement with a collective mental images having quite concretely as mental images of mothers. If the notion of field body having size at least of order Earth size makes sense, this idea does not look so implausible anymore.

2.6.6 Direct eye contact as an example of quantum entanglement between experiencers?

Direct eye contact is fundamental in the communication between living creatures. The naive intuitive picture of cartoon drawings about direct eye contact is is as rays connecting the eyes of persons involved. TGD suggests that this naive picture actually represents fundamental mechanism for the temporal fusion of selves to form larger selves. What could happen is that magnetic flux tubes are formed between eyes, and, if the neural window hypothesis holds true, also between brains and eventually between sensory canvases.

MEs are optimal for this purpose. The coherent photons associated with them would be the required macroscopic quantum phase associated with the entire higher level self. Thus it is perhaps not accident that extended states of consciousness are so often described as experiences about radiance of light. A weaker hypothesis is that eye contact involves only the formation of magnetic flux tubes along which classical communication based on propagation of classical signals occurs. Also for this option MEs are optimal candidates for magnetic flux tubes.

The reader has possibly noticed that these arguments open up the possibility that our visual field in some sense corresponds to the actual visual field rather than only its cognitive representation provide by the visual pathways. The photons arriving along MEs connecting our brain with the objects of the perceptive field could provide the join along boundaries bonds extending our sensory self to contain part of the external world. Our visual field would still be determined by the light entering to our eyes so that no contradictions with well established empirical facts about vision are encountered. This kind of extension of visual self could however provide completely new manners for brain to compute the distances to the objects of the perceptive field since the basic information would not be mere two-dimensional picture in retina. The most plausible option seems to be however the one in which ultimate sensory representations are realized outside brain at the sensory canvas provided by the magnetic flux tube structures which can be even of the order of Earth size. This option is discussed in [K16].

2.6.7 Semitrance mechanism

The notion of semitrance allows to understand how higher level selves can communicate to and control and coordinate the behaviour of lower levels selves. If individual contains at least part of time at least single sub-self, this sub-self can entangle with higher level self and in this trance state can communicate with the self and possible sub-selves and transmit commands, advices or messages. Communication is here quite generally understood as a generation of mental images, waking-up of sub-selves, these sub-selves could be p-adic sub-selves of real selves in accordance with the idea that communication is part of cognition. The wake-up process initiates self-organization leading to a final state pattern representing the message. Final state pattern depends only weakly on the stimulus serving as message: this is as it should be.

The NE of the right or left brain hemisphere (or some part of it, perhaps the linguistic regions with respect to which human brain has highest asymmetry) with a collective self could be the basic mechanism making it possible to communicate the commands of the collective self to left and/or right hemisphere as "hallucinations". This leads to a TGD variant of the vision of Jaynes about bicamerals and schizophrenics as persons who differ from the average modern man in that they are able to receive commands and advice from collective levels of consciousness as hallucinations [J5]. The notion of semitrance leads to very general views about how various societies (cells as societies of proteins, organisms as societies of cells, societies of various animals) develop and allows also to understand various altered states of consciousness [K17, K18].

The semitrance mechanism involves the generation of NE and liberation of metabolic energy if the liberation of metabolic energy always accompanies transfer of NE to the receiver. This non-metabolic energy might have something to do with the miraculous architectural feats of the ancient bicameral cultures (consider only pyramides) and the unusual physical strength of schizophrenics discussed in [J5].

2.6.8 Entanglement and sleep

What happens for our self during sleep? One can imagine several alternative answers to the question.

1. We really lose consciousness during sleep. This means that our self entangles negentropically with some other self. One can however ask why NE should not be possible and whether it could be the reason for healing effects of sleep. ZEO implies that the self representing our wake-up consciousness dies and re-incarnates at opposite boundary of CD. An interesting question is whether we can remember anything about this period of consciousness and whether memories about dreams are this kind of memories.

2. Long term memory representations are not constructed during sleep so that we do not remember anything about sleep time consciousness except when we wake up from REM sleep: note that in this case the memories fade rapidly in accordance with the idea that long term memories are not constructed. Synchronous hippocampal theta is indeed absent during sleep and synchronous firing would be a natural candidate for both the communications of mental images to magnetic body and for the generation of memory representations as negentropic fusions of mental images. If these memory representations are nor formed there is nothing to remember.

3. We are able to remember what happened during sleep only if we are asleep. Perhaps synchronous theta and delta oscillations are involved with the construction of negentropic memory representations experienced only during sleep just as theta synchrony is essential for memories about daytime experiences. The mirror mechanism of long term memories might allow this kind of possibility. These memory representations would be incomprehensible from the point of day-time consciousness. The strange mental images experienced just at the verge of falling asleep or waking up, which have meaning before transition but lose it during the transition, might reflect this.

Irrespective of whether the entanglement is bound state entanglement or NE, an important function of sleep could be the formation of larger collective selves. During sleep our selves could entangle to form a kind of a stereo consciousness representing human condition. This process could involve either phase transition changing local topology or a formation of magnetic flux tubes with much larger space-time sheets characterized by the same local topology. This mechanism could make possible subconscious communication between the members of society and also establish conscience and moral. The topological field quanta associated with photons generated by EEG during sleep have frequency smaller than 7 Hz [K9]. This suggests that the higher level selves in question correspond to these topological field quanta and thus have a wake-up time of order .5 seconds during delta wave sleep. Mental images would not disappear but would become more abstract during sleep.

2.7   Self Hierarchy

The basic outcome of the definition of self is the prediction that infinite hierarchy of selves exists. This prediction clearly distinguishes TGD from brain centered theories of consciousness.

2.7.1   Infinite hierarchy of selves with God at the top

A rather dramatic prediction is a Russian doll like hierarchy of conscious experiencers having the entire Universe, God, at the top. The necessary localization in zero modes making the Universe of conscious experience classical together with the proposed concept of self allows to understand both active and passive aspects of consciousness and a general classification of various types of conscious experiences becomes possible. Summation hypothesis, sharing of mental images and "enlightenment" by the generation of negentropic entanglement hypothesis provide a general framework for interpreting various transpersonal experiences and altered states of consciousness as resulting from entanglement with larger units of consciousness.

2.7.2   Self, evolution and, self-organization

Quantum jumps between quantum histories make also possible genuine quantum self-organization. The concept of self-organization gets quite new additional meaning in TGD framework. Self-organization means also evolution of self-hierarchies. Self-organization by quantum jumps can be

regarded as a hopping in the zero modes characterizing the macroscopic aspects of the space-time surface. Each self is a dissipative system which ends up to some asymptotic self-organization pattern in the presence of the external energy feed (and even without it). Dissipation is the ultimate Darwinian selector picking up the winning selves as favored self organization patterns. Since sub-selves correspond to mental images, the immediate implication is that also memes are subject to similar selection. For instance, the formation of long term memories and habits could be understood as a formation of surviving sub-selves.

The time evolution by quantum jumps has many facets. One of them relates to effective p-adic topology and is expected to be of speciall importance if live resides in the intersection of real and p-adic worlds. Simple arguments leads to the conclusion that evolution for a given space-time sheet must correspond to a sequence of p-adic primes increasing in a statistical sense. This means that the concept of nearness defining the effective topology becomes gradually more refined, the complexity of the universe increases, and the maximal information contents of the conscious experience increase in the long run (like $p \times log(p)$ or at least as $log(p)$ as a function of p-adic prime characterizing the system). This is nothing but evolution. NMP, which states that entanglement negentropy gain maximal for allowed quantum jumps, enhances this tendency.

The TGD based realization of the quantum criticality, besides making macroscopic quantum systems possible, in a well-defined sense maximizes the intelligence and complexity of the universe [K3]. In biosystems a concrete realization of quantum criticality is in terms of magnetic flux tube structures and electret type space-time sheets representing solutions of field equations dual to each other and having opposite signs of Kähler action density.

TGD universe is quantum spin glass and this adds additional aspect to the self-organization process. For instance, the energy landscape of the spin glass is fractal like structure containing valleys inside valleys and provides an ideal dynamical memory mechanism. Spin glass degeneracy also provides a mechanism increasing the lifetimes of the bound states formed by join along boundaries/flux tube condensates and thus could allow macrotemporally quantum coherent states able to perform quantum computation like activities. The impossibility of macrotemporal quantum coherence is indeed the main objection against quantum theories of consciousness.

This looks nice but one can ask whether the framework of standard quantum theory is all that is needed to formulate quantum TGD and the notion of quantum criticality. The original motivations for introducing the hierarchy of Planck constants and the generalization of the imbedding space to a book like structure having as pages the almost copies of the imbedding space were purely physical. Now it seems that this generalization is required by a need to have a proper formulation of quantum criticality of TGD Universe. The hierarchy of Planck constants leads to a whole bundle of ideas about quantum biology and evolution of consciousness and also to a detailed model for how living matter can perform topological quantum computation like activities [K2, K5, K7, K1].

State function reduction reducing entanglement is a random process unlike that producing negentropic entanglement and implies quantum de-coherence. Therefore the unentangled sub-selves of self define a statistical ensemble in a natural manner and dissipation is naturally related to the ageing of self since the statistical ensemble in question grows quantum jump by quantum jump. The averaging over quantum jumps means that the contents of consciousness of self thermalize with mental images becoming more and more fuzzy.

Haken's classical theory of self-organization applies almost as such if only entropic entanglement is considered since time development by quantum jumps means hopping around the space of zero modes characterizing the size and shape and induced Kähler fields associated with the space-time surface $X^4(X^3)$. Negentropic entanglement of mental images changes however the situation in time scale which could be the time scale assignable to the CDs associated with the entangled selves.

Self-organization involves Darwinian selection performed by dissipation inside each self. Dissipation selects also surviving sub-selves having interpretation as mental images. Hence the selection of memes is also in question.

Subjective ageing results from dissipation and is the price paid for having autonomous self separated from environment. Very concretely, the mental image of self represented by sub-self gets more and more entropic during ageing. One can also formulate questions about what happens in death in terms of physical concepts. Does only the bodily sub-self (mental image about body) cease to exist in the physical death so that only the field body consisting of magnetic flux tube structures and massless extremals (MEs, topological counterparts of light rays) remains? Can one identify the field body as the counterpart of what is called soul? Could the field body get interested of

some new biological body and use it as sensory and motor organ (re-incarnation)? Is entanglement with some larger self generated after death (and during sleep)?

2.7.3   Space-time as a 4-dimensional living being

The new concept of the psychological time means a dramatic generalization of the standard view about subjective existence. mind-like space-time sheets are distributed everywhere around material space-time sheets of infinite time duration and all of them can participate in a given quantum jump. Therefore one can say that the entire space-time is a conscious, living being. Civilizations of the geometric past and future exist simultaneously with us. We are members of a four-dimensional society in the sense that our actions affect the life of selves of both geometric past and future since each quantum jump performed by us changes the macroscopic space-time in both past and future.

Everyday experience suggest that the geometric past is relatively rigid. Although changes in a given time scale can occur below some length scale, changes in larger scales are probably rare. Sensory representations could however change and this could explain the instability of long term memories. Turning point decisions are probably not possible for the me of my geometric past: otherwise dramatic quantum jump changing completely my personal identity would occur.

The notion of the four-dimensional body (both material and field bodies) becomes natural and only the concentration of consciousness to the psychological now during the physical life creates the illusion that the reality corresponds to the time=constant snapshot of the time evolution. Near death experiences indeed support the view that life is experienced as a temporal whole when the dominating contribution from the sensory input and motor actions is absent. 4-dimensional body is not static but changes quantum jump by quantum jump which suggests that life is like a four-dimensional sculpture which is gradually refined. We in our youth now experience in slightly more deeper manner and live in a society having slightly higher level of moral. Note that the newest view about arrow of time means that the creation of this 4-D sculpture can be also seen as classical time evolution in the first approximation.

3   Self And Model Of Self

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

The original proposal was that self is conscious entity.

1. Self corresponds to a subsystem able to remain un-entangled under the sequential informational "time evolutions" U. Exactly vanishing entanglement is practically impossible in ordinary quantum mechanics and it might be that "vanishing entanglement" in the condition for self-property should be replaced with "subcritical entanglement". If space-time decomposes into p-adic and real regions, and if entanglement between regions representing physics in different number fields vanishes, space-time indeed decomposes into selves in a natural manner. Causal diamonds would form natural imbedding space correlates for selves and their hierarchy would correspond to self hierarchy.

2. The intuitive idea inspired by the formation of bound states of particles from particles was that self corresponds somehow to an integration of quantum jumps to single coherent whole. Later I gave up this idea since it was difficult to understand how the integration could take place.

3. The next suggestion was that quantum jumps as such correspond to selves. It was however difficult to assign to selves identified in this manner a definite geometric time duration. It is an empirical fact that this kind duration can be assigned to mental images (identified as subselves).

4. Concerning the notion of self the notion of negentropic entanglement (NE) (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) is central. NMP implies that Universe is like a library with new books emerging continually at its shelves. It turned out that NE - "Akashic records" must be experienced directly and defines

what might be called permanent self - self as understood in the framework of meditation practices.

The original wrong idea was that so called interaction free measurement could give information about NE at the same time leaving it invariant. It turned out that interaction free measurement does not allow to read the "Akashic records" but makes possible to read memories relying on bit representations (not qubits). These representations could give rise to self model and often referred to as ego in meditative practices.

5. The approach which seems the most convincing relies on the following observation. In ordinary positive energy ontology repeated state function reductions leave the state invariant. In ZEO this is not the case. There is wave function in moduli space of causal diamonds (CDs) and all sizes of CD characterized by the proper time distance between the tips of CD and all Lorentz boosts of CD are allowed. State function reduction localizes this wave function so that the other boundary of CD is at fixed light-cone boundary but other remains delocalized.

   The sequences of ordinary state function reductions leaving state unchanged are replaced with sequences for which the part of the zero energy state associated with a fixed boundary of CD remains unchanged in state function reduction whereas the state at the other end of CD changes. This is something new and explains the arrow of time and its flow and self could be understood as a sequence of quantum jumps at fixed boundary of CD (with the average location of second boundary shifted towards geometric future like in dispersion). Amusingly, this is in accordance with the original proposal except that state function reductions take place on same boundary of CD as long as self exists. For this option NE is directly experienced and at the passive boundary of CD gives rise to the unchanging part of self. There is no need to read the Akashic records by any mechanism.

   This view is extremely attractive since it implies that the act of free will interpreted as genuine state function reduction must mean reversal for the direction of geometric time at some level of hierarchy of selves. The proposal has indeed been that sensory perception and motor action are time reversals of each other and that motor action involves sending of negative energy signals to the geometric past.

3.1   NE And Self

NE provides a model for associations as rules in which superposition of tensor product states defines rule with entanglement pairs defining its various instances. This generalizes to N-fold tensor products. Associations would be realized as N-neuron NE stable against NMP. One could also think of realizing associative areas in terms of neurons, whose inputs form entangled tensor product and when sensory inputs are received they form analogous tensor product in representative degrees of freedom.

Thus NE is necessary for mental images (having sub-CDs as correlates) to mental images representing spatial patterns. NE in time direction for these patterns (zero energy states) is in turn necessary to bind them to sequences of mental images representing abstract memories as sequences of mental images. Negentropically entangled sequence would be a quantal counterpart for the original association sequence introduced as purely geometric concept.

If one accepts the identification of self as a sequence of state function reductions to a fixed boundary of CD then the identification of NE at the passive boundary of CD as a building brick of self is natural. One must distinguish from self the self model (one might speak of ego) which would rely on memory representations at the active boundary of CD.

By definition NE tends to be preserved in quantum jumps also at the active boundary of CD so that it represents information as approximate invariant: this conforms with the idea of invariant representation and quite generally with the idea that invariants represent the useful information. Self as opposed to self model be determined by NE at the passive boundary of CD.

Self model would be based on the properties of state at the active boundary of CD: also here NE is possible but is not absolutely stable. If the notion of interaction free measurement makes sense also in TGD based quantum measurement theory, the models of self and external world can be defined in terms of representations (sensory -, memory -, cognitive -) and their time reversals and correspond to the reflective level of consciousness as opposed to the phenomenal consciousness

to which sensory qualia contribute mostly. Self representations are not exact invariants although there seems to be no end for experience of consciousness: sleep in this framework can be interpreted as a period about which there are no memories accessible in wake-up state. If the contribution of the magnetic body dominates during sleep, this can be understood.

The picture about repeated state function reductions suggest the following view about self. The passive part of zero energy state is not changed during its life cycle and negentropic entanglement associated with it is preserved. Self at given level of hierarchy is in wake up state during period of fixed direction of geometric time. When the reductions begin to occur at the opposite boundary of CD self "falls asleep": symmetry suggests that new self living in opposite direction of geometric time is generated. Also in biological the change of time direction at some level of hierarchy might take place.

3.2   Is Interaction Free Measurement Needed To Deduce Information About Self Model?

The assumption that self model is a negentropically entangled system which does not change in state function reduction, leads to a problem. If the conscious information about this kind of sub-self corresponds to change of negentropy in quantum jump, it seems impossible to get this information. Quite generally, if moment of consciousness corresponds to quantum jump and thus change, how it is possible to carry conscious information about quantum state? The following proposal for non-destructive reading of memories and future plans allows to resolve this problem.

The objection is that the repeated state function reductions make the NE at the passive boundary of CD a part of the conscious experience defining the static background representing the experiencer as the background whereas the contribution to the experience from the changing active boundary of CD would define the figure.

This interpretation seems reasonable and actually the only possible one in the recent formulation of the theory. One can however consider the possibility that interaction free quantum measurement could allow to "read" memory representations realized in terms of bits. These representations would define self model localizable to the changing boundary of CD as opposed to the permanent self.

3.2.1   Bomb testing problem as a model for interaction free measurement

One can consider a generalization of so called interaction free measurement as a manner to deduce information about self model. This information would be obtained as sequences of bits and might be correspond to declarative, verbal memories rather than direct sensory experiences.

1. The bomb testing problem of Elitzur and Vaidman gives a nice concrete description of what happens in interaction free measurement [**?**] for an illustration of the system considered (see `http://tinyurl.com/kx2jsyu`).

   The challenge is to find whether the bomb is dud or not. Bomb explodes if it receives photon with given energy. The simplest test would explode all bombs. Interaction free measurement allows to make test by destroying only small number of bombs and at idealized limit no bombs are destroyed.

   The system involves four lenses arranged in square and two detectors C and D at the upper right corner of the square. In the first lens at the lower left corner the incoming photon beam splits to reflected and transmitted beams: the path travelled by transmitted beam contains the bomb.

   (a) The bomb absorbs photon with a probability which tells the fraction of photon beam going to the path at which bomb is (is transmitted through the lens). The other possibility is that this measurement process creates a state in which photon travels along the other path (is reflected). This photon goes through a lens and ends up to detector C or D through lens.

   (b) If the bomb is dud, the photon travels through both paths and interference at the lens leads the photon to detector D. If C detects photon we know that the bomb was not a dud without exploding it. If D detects the photon, it was either dud or not and we can

repeat the experiment as long as bomb explodes, or C detects photon and stop if the detector continues to be D (dud). This arrangement can be refined so that at the ideal limit no explosions take place and all.

2. The measurement of bomb property is interaction free experiment in the sense that state function reduction performed by absorber/bomb can eliminate the interaction in the sense that photon travels along the path not containing the bomb. One might say that state function reduction is an interaction which can eliminates the usual interaction with photon beam. State function reduction performed by bomb can change the history of photon so it travels along the path not containing the bomb.

This picture is only metaphorical representation of something much more general.

1. Bomb could be of course replaced with any two-state system absorbing photons in one state but not in the other state, say atom. Now one would test in which state the atom is gaining one bit of information in the optimal situation. Two-state atom could thus represent bit and one could in principle read the bit sequence formed by atoms (say in row) by this method without any photon absorption so that the row of atoms would remain in the original state.

2. Two-state system could be replaced with N-state system. In this case the testing selects at first step one state as analogs of bomb intact and the remaining states as analogs of dud. If the answer was "dud" in the first step, the next step selects one preferred state from $N-1$ states and regards the remaining states as "dud". The process continues until the state of the system is measured.

3. In TGD framework the photon paths branching at lenses correspond to branching 3-surfaces analogous to branching strings in string model and photon wave splits to sum of waves travelling along the two paths.

3.2.2 Memory recall as an interaction free measurement

One can imagine several applications if the information to be read in interaction free manner can be interpreted as bit sequences represented as states of two-state system. Lasers in ground states and its excited state would be analogous many particle quantum system. In TGD framework the analog of laser consisting of two space-time sheets with different sizes and different zero point kinetic energies would be the analogous system.

For instance, a model of memory recall with memories realized as negentropically entangled states such that each state represents a bit can be considered. The model applies also to the reading of future plans (memories on reversed time direction).

1. Reading of a particular bit of memory means sending of negative energy photon signal to the past, which can be absorbed in the reading process. The problem is however that the memory representation is changed in this process since two state system returns to the ground state. This could be seen as analog of no-cloning theorem (the read thoughts define the clone). Interaction free measurement could help to overcome the problem partially. Memory would not be affected at all at the limit so that no-cloning theorem would be circumvented at this limit. Memory bit to be read would be mathematically analogous to bomb in the Elizur-Weizman bomb tester thought experiment in which one tries to determine whether bomb is active (bit 1) and can therefore explode or passive (bit 0) and cannot explode.

2. A possible problem is that the analogs of detectors C and D for a given qubit are in geometric past and one must be able to decide whether it was C or D that absorbed the negative energy photon! Direct conscious experience should tell whether the detector C or D fired: could this experience correspond to visual quale black/white and more generally to a pair of complementary colors?

3. ZEO means that zero energy states appear have both imbedding space arrows of time and these arrows appear alternately during periods of repeated state functions having no effect at the other boundary of CD. This dichotomy would correspond to sensory representation-motor action dichotomy and would suggest that there is no fundamental difference between

memory recall and future prediction by self model and they different only the direction of the signal.

4. Since photon absorption is the basic process, the conscious experience about the bit pattern could be visual sensation or even some other kind of sensory qualia induced by the absorption of photons. The model for the lipids of cell membrane as pixels of a sensory screen suggests that neuronal/cell membranes could serve defined digital self model at the length scale of neurons.

 Some comments are in order.

1. To avoid misunderstandings it should be emphasized that TGD based view about memory is not the same as the standard view. In ZEO brain is four-dimensional and in principle memories can be negentropically entanglement memories in geometric past. It is possible to build copies of memories by memory recall, and learning would correspond to a generation of large enough number of copies of the memory mental image. Memory recall could be seen as a negative energy signal inducing the interaction free measurement of memory qubits. Dark photons with EEG frequencies (say in theta band characterizing hippocompus) but having energies of visible photons could be involved with the memory recall. Correlation between EEG and bio-photons supports this view.

2. If the systems taking the role of the detectors C and D in interaction free measurement are analogous to population reversed lasers, their return to the ground state could automatically generate virtual sensory input propagating to the sensory organs and allowing to check whether it is consistent with the actual sensory input. The generation of the feedback signal takes some time expected however to be much shorter than that for a typical neuronal activity.

   Since the signals would propagate with light velocity, the virtual sensory input could travel practically instantaneously from the brain to sensory organs and possibly also vice versa. Libet's experiments on passive aspects of consciousness [J3] in fact demonstrate a time delay which is fraction of second having interpretation in terms of time to propagate to a layer of magnetic body of size scale of Earth and back: these delays are consistent with the fact that the chronon of sensory experience is about.1 seconds. The propagation of photon signals in both directions would make possible construction of sensory representation in time scale much shorter than that of neural activity. This mechanism could also explain generation of after images.

3. Photons can be replaced with phonons or quanta of any other wave motion with constant propagation velocity (no dispersion of signal) in a given reference frame. This suggests that imagination and internal speech correspond to the two reading mechanisms of memories.

One could also introduce self as a subsystem, which is only potentially conscious and here the notion of NE (see **Fig. `http://tgdtheory.fi/appfigures/cat.jpg`** or **Fig. ??** in the appendix of this book) suggests an approach based on interaction free measurement. NMP implies that Universe is like a library with new books emerging continually at its shelves. It turned out that negentropic entanglement - "Akashic records" must be experienced directly and would define what might be called permanent self. Interaction free measurement does not allow to read the "Akashic records" but makes possible to read memories relying on bit representations (not qubits). These representations could give rise to self model.

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