

Time, Space-Time, and Consciousness

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Abstract

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

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

The most recent proposal involves no ad hoc assumptions and relies on the recent formulation of quantum TGD using zero energy ontology. The correlate of self is now so called causal diamond (pair of future and past directed light-cones) which is 8-D sub-manifold of the imbedding space rather than space-time sheet. The flow of geometric time is apparent and due the change of quantum state in quantum jump which in the first approximation means a shift of the quantum superposition of space-time surfaces to the direction of the geometric past of the imbedding space. This proposal allows to understand the asymmetry between geometric future and past at the level of conscious experience and makes also precise quantitative predictions. Also a unification of the definition of self identifying it as a sequence of quantum jumps and of the definition based on the reduction of self hierarchy to a fractal hierarchy of quantum jumps within quantum jumps becomes possible.

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

"Ontogeny recapitulates phylogeny" principle suggests that the structure of the many-sheeted space-time represents the structure of the cosmology of consciousness. This heuristic principle together with the concept of self, the hypothesis that also infinite primes are present in the topological condensate and association sequence concept, leads to a Grand Scenario for the cosmology of consciousness. There is no need to assume that different irreducible sub-experiences associated with given moment of consciousness correspond to a common value of the psychological time.

Most naturally, the values of psychological time extending from zero to strictly infinite values of time and beyond(!) are present. This means that cosmology of consciousness has fractal like structure: there are sub-cosmologies which know nothing about each other's existence except in quantum jumps involving entanglement with larger space-time sheets: in this case the conscious experience could be regarded as a religious or mystic experience. Both future and past civilizations participate in each quantum jump. The allowance of infinite primes suggested strongly by various arguments, means that conscious intelligences which are God like as compared to us, participate in each quantum jump.

An especially important general consequence is the paradigm of 4-dimensional brain.

a) This paradigm trivializes the problem of long term memory. The desire to remember would be quantum communicated from the geometric now to the geometric past by sharing of mental images made possible by time-like quantum entanglement of sub-selves. In the case of episodal memories the sharing of mental images gives already rise to the memory. For non-episodal memories the memory is communicated classically to the geometric future. An essential element of the mechanism are negative energy MEs ("massless extremals") which are ideal for generating time-like quantum entanglement with the geometric past. Positive energy MEs are in turn involved with classical communications.

b) Second consequence is a model of cognition relying on the concept of cognitive neutrino pair: cognitive neutrino pair has almost vanishing total energy and consists of neutrino and antineutrino residing at different space-time sheets. The cornerstone of the model is the negative energy of the condensed matter neutrinos deriving from the classical Z^0 interaction with nuclear Z^0 charges. Thus one can say that TGD predicts that $k = 169$ space-time sheet ($L(169) \simeq 5$ microns) is the length scale in which cognitive consciousness emerges.

Quantum jumps between quantum histories concept explains the peculiar time delays of consciousness revealed in the experiments relating to active and passive roles of consciousness [54, 45] and the causal anomalies revealed by the experiments of Radin and Bierman [46]. TGD predicts "tribar effect" as a general signature for the quantum jump between quantum histories concept.

1 Introduction

In this chapter I will discuss TGD based view about time and space-time. The discussion of the many-sheeted space-time concept explaining the basic notions once again is included because I feel that this is in order since the understanding of "topological light rays" (massless extremals, briefly MEs), and of magnetic and electric flux quanta has developed vigorously since the articles published in the last issue of JNLRMI [25]. I have not even attempted to include all essential aspects since this would simply lead both me and the reader to despair. I consider those aspect that I feel especially relevant just now. To be honest, the act of writing the article generated a lot of new insights and ideas so that

the boring duty to summarize something already done transformed once again to an active process of thinking and identifying weak points in the existing scenario and trying to see the idea landscape from a more general perspective. The 8 online books [10, 8, 9, 13, 11, 12, 14, 15] at my home page provide a comprehensive unavoidably out of date summary TGD inspired theory of consciousness.

A brief summary of what might be called basic principles is in order to facilitate the reader to assimilate the basic tools and rules of intuitive thinking involved.

1.1 Quantum-classical correspondence

The fundamental metalevel guiding principle is quantum-classical correspondence (classical physics is an exact part of quantum TGD). The principle states that all quantum aspects of the theory, which means also various aspects of consciousness such as volition, cognition, and intentionality, should have space-time correlates. Real space-time sheets provide kind of symbolic representations whereas p-adic space-time sheets provide correlates for cognition and intentions. All that we can symbolically communicate about conscious experience relies on quantal space-time engineering to build these representations.

1.2 Classical physics as exact part of quantum theory

Classical physics corresponds to the dynamics of space-time surfaces determined by the absolute minimization of so called Kähler action. This dynamics have several unconventional features basically due to the possibility to interpret the Kähler action as a Maxwell action expressible in terms of the induced metric defining classical gravitational field and induced Kähler form defining a non-linear Maxwell field not as such identifiable as electromagnetic field however.

1.2.1 Classical electroweak and color fields as signature for a fractal hierarchy of copies standard model physics

The geometrization of classical fields means that various classical fields are expressible in terms of imbedding space-coordinates and are thus not primary dynamical variables. This predicts the presence of long range weak fields, in particular Z^0 fields, and color (gluon) fields not possible in standard physics context. It took 26 years to end up with a convincing interpretation for this puzzling prediction.

What seems to be the correct interpretation is in terms of an infinite fractal hierarchy of copies of standard models physics with appropriately scaled down mass spectra for quarks, leptons, and gauge bosons. Both p-adic length scales and the values of Planck constant predicted by TGD [C7] label various physics in this hierarchy. Also other quantum numbers are predicted as labels. This means that universe would be analogous to an inverted Mandelbrot fractal with

each bird's eye of view revealing new long length scale structures serving also as correlates for higher levels of self hierarchy.

Exotic dark weak forces and their dark variants are consistent with the experimental widths for ordinary weak gauge bosons since the particles belonging to different levels of the hierarchy do not have direct couplings at Feynman diagram level although they have indirect classical interactions and also the de-coherence reducing the value of \hbar is possible. Classical long ranged weak fields play a key role in quantum control and communications in living matter [M3, L4]. Long ranged classical color force in turn is the backbone in the model of color vision [K3]: colors correspond to the increments of color quantum numbers in this model. The increments of weak isospin in turn could define the basic color like quale associated with hearing (black-white \leftrightarrow to silence-sound [K3, M5, M6]).

1.2.2 Topological field quantization and the notion of many-sheeted space-time

The compactness of CP_2 implies the notions of many-sheeted space-time and field quantization. Topological field quantization means that various classical field configurations decompose into topological field quanta. One can see space-time as a gigantic Feynman diagram with lines thickened to 4-surfaces. Absolute minimization of Kähler action implies that only selected field configurations analogous to Bohr's orbits are realized physically so that quantum-classical correspondence becomes very predictive. An interpretation as a 4-D quantum hologram is a further very useful picture [K2] but will not be discussed in this chapter in any detail.

Topological field quantization implies that the field patterns associated with material objects form extremely complex topological structures which can be said to belong to the material objects. The notion of field body, in particular magnetic body, typically much larger than the material system, differentiates between TGD and Maxwell's electrodynamics, and has turned out to be of fundamental importance in the TGD inspired theory of consciousness. One can say that field body provides an abstract representation of the material body.

One implication of many-sheetedness is the possibility of macroscopic quantum coherence. By quantum classical correspondence large space-time sheets as quantum coherence regions are macroscopic quantum systems and therefore ideal sites of the quantum control in living matter.

1. The original argument was that each space-time sheet carrying matter has a temperature determined by its size and the mass of the particles residing at it via de Broglie wave length $\lambda_{dB} = \sqrt{2mE}$ assumed to define the p-adic length scale by the condition $L(k) < \lambda_{dB} < L(k_>)$. This would give very low temperatures when the size of the space-time sheet becomes large enough. The original belief indeed was that the large space-time sheets can be very cold because they are not in thermal equilibrium with the smaller space-time sheets at higher temperature.

2. The assumption about thermal isolation is not needed if one accepts the possibility that Planck constant is dynamical and quantized and that dark matter corresponds to a hierarchy of phases characterized by increasing values of Planck constant [C7, J6]. From $E = hf$ relationship it is clear that arbitrarily low frequency dark photons (say EEG photons) can have energies above thermal energy which would explain the correlation of EEG with consciousness. This vision allows to formulate more precisely the basic notions of TGD inspired theory of consciousness and leads to a model of living matter giving precise quantitative predictions. Also the ability of this vision to generate new insights to quantum biology provides strong support for it [M3].

Many-sheeted space-time predicts also fundamental mechanisms of metabolism based on the dropping of particles between space-time sheets with an ensuing liberation of the quantized zero point kinetic energy. Also the notion of many-sheeted laser follows naturally and population inverted many-sheeted lasers serve as storages of metabolic energy [K6].

Space-time sheets topologically condense to larger space-time sheets by worm-hole contacts which have Euclidian signature of metric. This implies causal horizon at which the signature of the induced metric changes from Minkowskian to Euclidian. This forces to modify the notion of subsystem. What is new is that two systems represented by space-time sheets can be unentangled although their subsystems bound state entangle with the mediation of the join along boundaries bonds connecting the boundaries of sub-system space-time sheets. This is not allowed by the notion of subsystem in ordinary quantum mechanics. This notion in turn implies the central concept of fusion and sharing of mental images by entanglement.

1.2.3 The possibility of negative energies

A further prediction derives from the fact that space-time is 4-surface rather than an abstract manifold. Energy momentum tensor of general relativity is replaced by a collection of conserved energy and momentum currents, which are 4-vector fields. This makes the notions of energy and momentum precisely defined but also implies that the sign of energy and momentum depend on the time-orientation of the space-time sheet. Negative energies become therefore possible somewhat like in the lines of a Feynman diagram. Negative energy topological light rays have phase conjugate laser waves [28] as the most plausible standard physics counterparts, and play a fundamental role in quantum metabolism as a kind of quantum credit card [K6]. They generate also time like entanglement which corresponds to a formation of new kind of bound states.

Negative energies might be possible even for ordinary particles and could mean dramatic deviation from the standard quantum theory. The roles of annihilation and creation operators have changed for negative energy space-time sheets. This would mean that operator combinations involving both annihilation and creation operators would generate states involving positive and nega-

tive energy space-time sheets. One can even imagine that a intentional action could create states with vanishing net quantum numbers and that positive and negative energy particles could be separated from each other.

1.2.4 TGD Universe is quantum spin glass

Since Kähler action is Maxwell action with Maxwell field and induced metric expressed in terms of $M_+^4 \times CP_2$ coordinates, the gauge invariance of Maxwell action as a symmetry of the vacuum extremals (this implies is a gigantic vacuum degeneracy) but not of non-vacuum extremals. Gauge symmetry related space-time surfaces are not physically equivalent and gauge degeneracy transforms to a huge spin glass degeneracy. Spin glass degeneracy provides a universal mechanism of macro-temporal quantum coherence and predicts degrees of freedom called zero modes not possible in quantum field theories describing particles as point-like objects. Zero modes are identifiable as effectively classical variables characterizing the size and shape of the 3-surface as well as the induced Kähler field.

1.2.5 Classical and p-adic non-determinism

The vacuum degeneracy of Kähler action implies classical non-determinism, which means that space-like 3-surface is not enough to fix the space-time surface associated with it uniquely as an absolute minimum of action, and one must generalize the notion of 3-surface by allowing sequences of 3-surfaces with time like separations to achieve determinism in a generalized sense. These "association sequences" can be seen as symbolic representations for the sequences of quantum jumps defining selves and thus for contents of consciousness. Not only speech and written language define symbolic representations but all real space-time sheets of the space-time surfaces can be seen in a very general sense as symbolic representations of not only quantum states but also of quantum jump sequences. An important implication of the non-determinism is the possibility to have conscious experiences with contents localized with respect to geometric time. Without this non-determinism conscious experience would have no correlates localized at space-time surface, and there would be no psychological time.

p-Adic non-determinism follows from inherent non-determinism of p-adic differential equations for any action principle and is due to the fact that integration constants, which by definition are functions with vanishing derivatives, are not constants but functions of the binary cutoffs x_N defined as $x = \sum_k x_k p^k \rightarrow x_N = \sum_{k < N} x_k p^k$ of the arguments of the function (see Fig. 9.4). In p-adic topology one can therefore fix the behavior of the space-time surface at discrete set of space-time points *above* some length scale defined by p-adic concept of nearness by fixing the integration constants. In the real context this corresponds to the fixing the behavior *below* some time/length scales since points p-adically near to each other are in real sense faraway. This is a natural correlate for the possibility to plan the behavior and p-adic non-determinism is assumed to be

a classical correlate for the non-determinism of intentionality, and perhaps also imagination and cognition.

These two non-determinisms allow to understand the self-referentiality of consciousness at a very general level. In a given quantum jump a space-time surface can be created with the property that it represents symbolically or cognitively something about the contents of consciousness before the quantum jump. Thus it becomes possible to become conscious about being conscious of something. This is very much like mathematician expressing her thoughts as symbol sequences which provides feedback to go the next abstraction level.

Classical and p-adic non-determinisms force also the generalization of the notion of entanglement. Time-like entanglement, crucial for understanding long term memory and precognition becomes possible. The notion of many-sheeted space-time forces also to modify the notion of subsystem, which implies that unentangled systems can have entangled subsystems. One can partially understand this in terms of length scale dependent notion of entanglement (the entanglement of subsystems is not seen in the length scale resolution defined by the size of unentangled systems) but only partially. The formation of join along boundaries bonds between subsystem space-time sheets and the fact that topologically condensed space-time sheets are separated by "elementary particle horizons" from larger space-time sheets, provide the deeper topological motivation for the generalization of subsystem concept.

1.2.6 p-Adic fractality of life and consciousness

p-Adic fractality of biology and consciousness has become an increasingly important guide line in the construction of the theory. This notion allows to relate phenomena occurring in the molecular level to phenomena like remote viewing and psychokinesis and it leads also to the view that topological field quanta of various fields of astrophysical size are crucial for the functioning of bio-systems. If one accepts p-adic fractality, the theory can be tested in unexpected manners, in particular in molecular and cellular length scales where the systems are much simpler. Sensory perception, long term memory, remote mental interactions, metabolism: all these phenomena rely on the same basic mechanisms. p-Adic length scale hypothesis allows to quantify the hypothesis with testable quantitative predictions.

1.2.7 Double slit experiment and classical non-determinism

Bohr's complementarity principle is the basic element of Copenhagen interpretation and at the same time one of the most poorly defined aspects of this interpretation. If the possibility of macroscopic quantum entanglement between measurement instrument and quantum system is accepted, complementary principle becomes un-necessary. This is however not all that is needed. If classical non-determinism makes it possible to represent quantum jump sequences at space-time level, a revision of space-time description of quantum measurement is necessary. This sounds very logical but to be honest, I write these lines only

after having learned about the remarkable experiment done by Shahriar Afshar [29].

The variant of double slit experiment by Shahriar Afshar seems to contradict the Copenhagen interpretation which states that the particle and field aspects are complementary and thus mutually exclusive. In the case of double slit experiment complementarity predicts that the measurement of whether the photon came to the detector through slit 1 or 2 should destroy the interference pattern of electromagnetic fields in the region behind the screen.

The experimental arrangement of Afshar differs from the standard double slit experiment in that a lens was added behind the screen. The lens transmitted the photons coming from slits 1 and 2 via mirrors to detectors A and B so that in particle picture a photon detected by A (B) could be regarded as coming from slit 1 (2). In the first step both slits were open and the detectors represented interference patterns representing diffraction through single slit. The other slit was then closed and metal wires at the positions of dark interference rings were added. These wires degraded somewhat the image in the second detector. After this the second slit was opened again. Surprisingly, the resulting interference pattern was the original one.

The measurement certainly measures the particle aspect of photons. On the other hand, the preservation of the detected patterns means that no photons did enter in the regions containing the wires so that also interference pattern is there. Hence wave and particle aspects seem to be mutually consistent.

This finding is difficult to understand in Copenhagen interpretation and also in the many-worlds interpretation of quantum mechanics. Afshar himself suggest that the very notion of photon must be questioned. It is however difficult to accept this view since the photon absorption quite concretely corresponds to a click in the detector and also because the mathematical formalism of second quantization works so fantastically.

The conclusion can be criticized. What is primarily measured is not basically through which slit the photons came but whether the direction of the momentum of the photon emerging from the lens was in the angle range characterizing the detector or not. One can however argue that in deterministic physics for fields the two measurements are equivalent so that the problem remains.

In TGD framework the classical physics is not completely deterministic and this has led to a generalization of the notion of quantum classical correspondence. Space-time surface provides a classical (unfaithful) representation not only for quantum states but for quantum jump sequences or equivalently, for sequences of quantum states. The most obvious identification for the quantum states is as the maximal non-deterministic regions of a given space-time sheet.

In the recent context this would mean that the fields in the region between the screen and lens represent the state before the state function reduction and thus the interference pattern, whereas the fields in the region between lens and detectors represent the situation after the state function reduction. The interaction with lens involves classical non-determinism.

This picture conforms also with the notion of topological field quantization. The space-time decomposes into space-time sheets interpreted, topological field

quanta (topological light rays containing photons, flux quanta of magnetic field, etc.). Topological field quanta correspond to the coherence regions for classical fields with spinor fields included. De-coherence corresponds to the splitting of space-time sheet to smaller, possibly parallel space-time sheets. Topological field quantum carries classical fields inside it but behaves as a whole like particle. Hence particle and wave aspects are consistent in the sense that below the size scale L of the topological field quantum (say the thickness of a magnetic flux tube or topological light ray) the description as a wave applies and above L particle description makes sense. In the recent case the coherence is lost at the lens space-time sheet where the space-time sheet representing interference pattern decomposes to two sheets representing photon beams going to the two detectors.

1.3 Some basic ideas of TGD inspired theory of consciousness and quantum biology

The following ideas of TGD inspired theory of consciousness and of quantum biology are the most relevant ones for what will follow.

1. "Everything is conscious and consciousness can be only lost" is the briefest manner to summarize TGD inspired theory of consciousness. Quantum jump as moment of consciousness and the notion of self are key concepts of the theory. Self is a system able to avoid bound state entanglement with environment and can be formally seen as an ensemble of quantum jumps. The contents of consciousness of self are defined by the averaged increments of quantum numbers and zero modes (sensory and geometric qualia). Moments of consciousness can be said to be the counterparts of elementary particles and selves the counterparts of many-particle states, both bound and free. The selves formed by macro-temporal quantum coherence are in turn the counterparts of atoms, molecules and larger structures. Macro-temporal quantum coherence effectively binds a sequence of quantum jumps to a single quantum jump as far as conscious experience is considered. The idea that conscious experience is about changes amplified to macroscopic quantum phase transitions, is the key philosophical guideline in the construction of various models, such as the model of qualia, the capacitor model of sensory receptor, the model of cognitive representations, and declarative memories.
2. Macro-temporal quantum coherence is a second consequence of the spin glass degeneracy [K2]. It is essentially due to the formation of bound states and has as a topological correlate the formation of join along boundaries bonds connecting the boundaries of the component systems. During macro-temporal coherence quantum jumps integrate effectively to single long-lasting quantum jump and one can say that system is in a state of oneness, eternal now, outside time. Macro-temporal quantum coherence makes possible stable non-entropic mental images. Negative energy MEs

are one particular mechanism making possible macro-temporal quantum coherence via the formation of bound states, and remote metabolism and sharing of mental images are other facets of this mechanism. The real understanding of the origin of macroscopic quantum coherence requires the generalization of quantum theory allowing dynamical and quantized Planck constant [J6, M3].

3. p-Adic physics as physics of intentionality and possibly also of cognition is a further key idea of TGD inspired theory of consciousness. p-Adic space-time sheets as correlates for intentions and p-adic-to-real transformations of them as correlates for the transformation of intentions to actions allow deeper understanding of also psychological time as a front of p-adic-to-real transition propagating to the direction of the geometric future. Negative energy MEs are absolutely essential for the understanding of how precisely targeted intentionality is realized.

In this chapter various aspects related TGD based notion of time are discussed. The original motivation for writing this chapter was to have a chapter completely free of mammoth bones. I would be happy to tell that the treatment is completely logical top-down discussion starting from the basic postulates but I must confess that there are internal inconsistencies. I have not had time to make all necessary updates and I hope that reader could forgive this. The last section of the chapter represents the latest (June 2008) vision about the relationship between geometric time and subjective time and also about the notion of self relying on the notion of zero energy ontology, hierarchy of Planck constants, and the improved understanding of p-adic length scale hypothesis not available when I wrote this chapter for the first time.

2 Many-sheeted space-time, magnetic flux quanta, electrets and MEs

TGD inspired theory of consciousness and of living matter relies on space-time sheets carrying ordinary matter, topological light rays (massless extremals, MEs), and magnetic and electric flux quanta. There are some new results which motivate a separate discussion of them.

2.1 Dynamical quantized Planck constant and dark matter hierarchy

By quantum classical correspondence space-time sheets can be identified as quantum coherence regions. Hence the fact that they have all possible size scales more or less unavoidably implies that Planck constant must be quantized and have arbitrarily large values. If one accepts this then also the idea about dark matter as a macroscopic quantum phase characterized by an arbitrarily large value of Planck constant emerges naturally as does also the interpretation

for the long ranged classical electro-weak and color fields predicted by TGD. Rather seldom the evolution of ideas follows simple linear logic, and this was the case also now. In any case, this vision represents the fifth, relatively new thread in the evolution of TGD and the ideas involved are still evolving.

2.1.1 Dark matter as large \hbar phase

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

Nottale and Da Rocha believe that their Schrödinger equation results from a fractal hydrodynamics. Many-sheeted space-time however suggests astrophysical systems are not only quantum systems at larger space-time sheets but correspond to a gigantic value of gravitational Planck constant. The gravitational (ordinary) Schrödinger equation would provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [D6].

2.1.2 Dark matter as a source of long ranged weak and color fields

Long ranged classical electro-weak and color gauge fields are unavoidable in TGD framework. The smallness of the parity breaking effects in hadronic, nuclear, and atomic length scales does not however seem to allow long ranged electro-weak gauge fields. The problem disappears if long range classical electro-weak gauge fields are identified as space-time correlates for massless gauge fields created by dark matter. Also scaled up variants of ordinary electro-weak particle spectra are possible. The identification explains chiral selection in living matter and unbroken $U(2)_{ew}$ invariance and free color in bio length scales become characteristics of living matter and of bio-chemistry and bio-nuclear physics. An attractive solution of the matter antimatter asymmetry is based on the identification of also antimatter as dark matter.

2.1.3 Dark matter hierarchy and consciousness

The emergence of the vision about dark matter hierarchy has meant a revolution in TGD inspired theory of consciousness. Dark matter hierarchy means also a hierarchy of long term memories with the span of the memory identifiable as a typical geometric duration of moment of consciousness at the highest level of dark matter hierarchy associated with given self so that even human life cycle represents at this highest level single moment of consciousness.

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [M3]. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar(k) = \lambda^k(p)\hbar_0$, $\lambda \simeq 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, \dots$ [M3]. Also integer valued sub-harmonics and integer valued sub-harmonics of λ might be possible. Each p-adic length scale corresponds to this kind of hierarchy and number theoretical arguments suggest a general formula for the allowed values of Planck constant λ depending logarithmically on p-adic prime [C7]. Also the value of \hbar_0 has spectrum characterized by Beraha numbers $B_n = 4\cos^2(\pi/n)$, $n \geq 3$, varying by a factor in the range $n > 3$ [C7].

The general prediction is that Universe is a kind of inverted Mandelbrot fractal for which each bird's eye of view reveals new structures in long length and time scales representing scaled down copies of standard physics and their dark variants. These structures would correspond to higher levels in self hierarchy. This prediction is consistent with the belief that 75 per cent of matter in the universe is dark.

1. *Living matter and dark matter*

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG [M3]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [L2, M3]. A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [M3].

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of \hbar at all. Secondly, the failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom due to spin glass degeneracy. Thirdly, the phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

2. *Dark matter hierarchy and the notion of self*

The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [J6, M3]. The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T(k) \propto \lambda^k$ of the quantum jump.

Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to

ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

2.2 p-Adic length scale hypothesis and the connection between thermal de Broglie wave length and size of the space-time sheet

Also real space-time sheets are assumed to be characterized by p-adic prime p and assumed to have a size determined by primary p-adic length scale L_p or possibly n-ary p-adic length scale $L_p(n)$. More generally, each space-time dimension could correspond to its own p-adic length scale and even several p-adic primes could be associated with single dimension.

The possibility to assign a p-adic prime to the real space-time sheets is required by the success of the elementary particle mass calculations and various applications of the p-adic length scale hypothesis. Rationals are common to reals and all p-adic number fields. The p-adic-to-real transition transforming intentions to actions is made possible by a large number of common rational points between p-adic and real space-time surfaces, which supports the view that real space-time sheets obeys effective p-adic topology as an approximate topology in some resolution and below some length scale. p-Adic prime thus characterizes the classical non-determinism of the Kähler action.

Parallel space-time sheets with distance about 10^4 Planck lengths form a hierarchy. Each material object (...atom, molecule, ..., cell,...) corresponds to this kind of space-time sheet. The p-adic primes $p \simeq 2^k$, k prime or power of prime, characterize the size scales of the space-time sheets in the hierarchy. The p-adic length scale $L(k)$ can be expressed in terms of cell membrane thickness as

$$L(k) = 2^{(k-151)/2} \times L(151) \ , \quad (1)$$

$L(151) \simeq 10$ nm. These are so called primary p-adic length scales but there are also n-ary p-adic length scales related by a scaling of power of \sqrt{p} to the primary p-adic length scale. Quite recent model for photosynthesis [K6] gives additional support for the importance of also n-ary p-adic length scales so that the relevant p-adic length scales would come as half-octaves in a good approximation but prime and power of prime values of k would be especially important.

2.3 Topological light rays (massless extremals, MEs)

I have described MEs, or "topological light rays", in previous articles of JNLRMI [27] and in [J4, J7], and describe here only very briefly the basic characteristics of MEs and concentrate on new idea about their possible role for consciousness and life.

2.3.1 What MEs are?

MEs can be regarded as topological field quanta of classical radiation fields [J4, J7]. They are typically tubular space-time sheets inside which radiation fields propagate with light velocity in single direction without dispersion. The simplest case corresponds to a straight cylindrical ME but also curved MEs, kind of curved light rays, are possible. The initial values for a given moment of time are arbitrary by light likeness. Therefore MEs are ideal for precisely targeted communications. What distinguishes MEs from Maxwellian radiation fields in empty space is that light like vacuum 4-current is possible: ordinary Maxwell's equations would state that this current vanishes. Quite generally, purely geometric vacuum charge densities and 3-currents are purely TGD based prediction and could be seen as a classical correlate of the vacuum polarization predicted by quantum field theories.

MEs are fractal structures containing MEs within MEs. The so called scaling law of homeopathy predicts that the high frequency MEs inside low frequency MEs are in a ratio having discrete values [K5]. One can indeed justify this relationship. As ions drop from smaller space-time sheets to magnetic flux tubes, zero point kinetic energy is liberated as high frequency MEs, and the ions dropped to magnetic flux tubes generate cyclotron radiation, and the ratio of the fundamental frequencies is constant not depending on particle mass and being determined solely by p-adic length scale hypothesis. The model for the radio waves induced by the irradiation of DNA by laser light [30] gives support for this picture [K2].

2.3.2 Two basic types of MEs

MEs have 2-dimensional CP_2 projection which means that electro-weak holonomy group is Abelian (color holonomy is always Abelian which suggests that physical states in TGD Universe correspond to states of color multiplets with vanishing color hypercharge and isospin rather than color singlets). If CP_2 projection belongs to a homologically non-trivial geodesic sphere, only em and Z^0

fields and Abelian color gauge fields are present. In the homologically trivial case only classical W fields are non-vanishing.

1. Neutral MEs can be assigned to various kinds of communications from biological body to the magnetic body and fractal hierarchy of EEGs and ZEGs represent the basic example in this respect [M3].
2. Dark W MEs serving as correlate for dark W exchanges induce an exotic ionization of atomic nuclei [F8, F9, M3]. This induces charge entanglement between magnetic body and biological body generating dark plasma oscillation patterns inducing nerve pulse patterns and ion waves at the space-time sheets occupied by the ordinary matter. The mechanism is based on many-sheeted Faraday law inducing electromagnetic fields at ordinary space-time sheet in turn giving rise to ohmic currents. State function reduction selects one of the exotically ionized configurations. This mechanism is the most plausible candidate for how magnetic body as an intentional agent controls biological body.

2.3.3 Negative energy MEs

MEs can have either positive or negative energy. The understanding of negative energy MEs has increased considerably. Phase conjugate laser waves [28] are the most plausible standard physics counterparts of negative energy MEs since they can be interpreted as time reversed laser beams and do not possess direct Maxwellian analog. By quantum-classical correspondence one can interpret the frequencies associated with negative energy MEs as energies. One can also assume that the Bose-Einstein condensed photons associated with negative energy MEs and with the coherent light generated by the light like vacuum current have negative energies.

For frequencies which are above thermal energy there is no system which could interact with negative energy MEs or absorb negative energy photons. Therefore negative energy MEs and corresponding photons should propagate through matter practically without any interaction. Feinberg has demonstrated that phase conjugate laser beams behave similarly: for instance, one can see through chickens using these laser beams [31]. This means that negative energy MEs do not respect Faraday cages and thus represent an attractive candidate for the hypothetical Psi field. Note that MEs are not a mere classical correlate for photons, as is clear from the fact that in the case of Z^0 MEs there are no Z^0 photons.

Negative energy MEs have many applications.

1. Negative energy MEs ideal for generating time like entanglement. Since negative energies are involved, this entanglement can be seen as a correlate for the bound state entanglement leading to a macro-temporal quantum coherence. Negative energy MEs make thus possible telepathic sharing of mental images. Negative energy MEs are involved with both sensory perception, long term memory, and motor action.

2. Negative energy MEs are ideal for a precisely targeted realization of intentions. p-Adic ME having a large number of common rational points with negative energy ME is generated and transformed to a real ME in quantum jump. The system receives positive energy and momentum as a recoil effect and the transition is not masked by ordinary spontaneously occurring quantum transitions since the energy of the system increases. One can say that negative energy ME represents the desires communicated to the geometric past and inducing as a reaction the desired action realized as say neuronal activity and generation of positive energy MEs.
3. The generation of negative energy MEs is also in a key role in remote metabolism and MEs serve as quantum credit cards implying an extreme flexibility of the metabolism. During the writing of this article one new and important aspect of remote metabolism became obvious. If the system receiving negative energy MEs is a population inverted laser or its many-sheeted counterpart, then quite a small field intensity associated with negative energy MEs (intensity of negative energy photons) can lead to the amplification of the time reflected positive energy signal. The reason is that the rate for the induced emission is proportional to the number of particles dropped to the ground state from the excited state. Therefore even negative energy bio-photons might serve as quantum controllers of metabolism and induce much more intense beams of positive energy photons, say when interacting with mitochondria.

2.3.4 How MEs propagate in matter

MEs can propagate in matter in two different manners: along interior or along boundaries (this is new).

1. The interaction analogous to the ordinary interaction of electromagnetic fields with matter is based on the formation of wormhole contacts between ME and the interior of the material space-time sheet. As a consequence, MEs tend to stuck to the interior of the space-time sheets while interacting with matter. This leads to the lowering of the phase velocity from light velocity. Since the sizes of the wormhole contacts are extremely small, about 10^4 Planck lengths, the effect is usually small. At the quantum level the reduction of the phase velocity could be interpreted in terms of the shifting of the positive energy ME in each quantum jump relative to the background space-time sheet to the direction of the geometric future so that the phase associated with a ME would be observed to change more slowly. For negative energy MEs would be opposite if they shift to the direction of geometric past and apparent super-luminal light velocity would result. This mechanism is proposed as an explanation for the observed super-luminal light velocities [32] in photon tunnelling [68].
2. MEs can also propagate along boundaries of the material space-time sheets. What can happen that ME joins partially along its boundaries to two

space-time sheets, which can be characterized by different p-adic primes. Particles can flow between space-time sheets and charged particles experience the transversal electric field of ME as an external electric potential forcing the particles to flow in a particular direction (note that all nuclei are complete Z^0 ions). The sizes of the join along boundaries contacts are gigantic as compared to the sizes of wormhole contacts and one expects that the reduction of the phase velocity is dramatic. The quantum mechanism for the reduction is same as in the previous case. EEG phase velocity could be interpreted as a reduced effective phase velocity of Z^0 and em boundary MEs [M2, M4]. One can assign also to boundary MEs dielectric constant allowing to model their interaction with matter.

An open question is whether also negative energy MEs can propagate along boundaries or whether topological considerations related to the notion of time orientations forbid this. For negative energy MEs the propagation along boundaries would predict highly super-luminal effective phase velocities.

2.4 Magnetic flux quanta and electrets

Magnetic flux tubes and electrets are extremals of Kähler action dual to each other. Also layer like magnetic flux quanta and their electric counterparts are possible. The magnetic/electric field is in a good approximation of constant magnitude but has varying direction.

2.4.1 Magnetic fields and life

The magnetic field associated with any material system is topologically quantized, and one can speak about magnetic body. An attractive idea is that the relationship of the magnetic body to the material system is to some degree that of the manual to an electronic instrument. Magnetic body would thus allow to realize both sensory and abstract symbolic representations about the material body. Magnetic body would in this case serve as a kind of computer screen at which the data items processes in say brain are communicated either classically (positive energy MEs) or by sharing of mental images (negative energy MEs).

Magnetic body is also an active intentional agent: motor actions are controlled from magnetic body and proceed as cascade like processes from long to short length and time scales as quantum communications of desires at various levels of hierarchy of magnetic bodies. Communication occurs backwards in geometric time by negative energy MEs. Motor action as a response to these desires occurs by classical communications by positive energy MEs and as neural activities. This explains the coherence and synchrony of motor actions difficult to understand in neuroscience framework. The sizes of flux tubes are astrophysical: for instance, EEG frequency of 7.8 Hz corresponds to a wave length defined by Earth's circumference. The non-locality in the length scale of magnetosphere, and even in length scales up to light life, is forced by Uncertainty Principle alone, if taken seriously in macroscopic length scales. Magnetic

The leakage of supra currents of ions and their Cooper pairs from magnetic flux tubes of the Earth's magnetic field to smaller space-time sheets and their dropping back involving liberation of the zero point kinetic energy defines one particular metabolic "Karma's cycle". The dropping of protons from $k = 137$ atomic space-time sheet involved with the utilization of ATP molecules is only a special instance of the general mechanism involving an entire hierarchy of zero point kinetic energies defining universal metabolic currencies. This leads to the idea that the topologically quantized magnetic field of Earth defines the analog of central nervous system and blood circulation present already during the pre-biotic evolution and making possible primitive metabolism. This has far reaching implications for the understanding of how pre-biotic evolution led to living matter as we understand it [L4].

For instance, it has recently become clear that the dropping of atoms and molecules from $k = 131$ space-time sheets creates photons at visible and near infrared wave lengths. The hot $k = 131$ space-time sheets (with temperatures above 1000 K) could have served as a source of metabolic energy for life-forms at cool $k = 137$ sheets. Photosynthesis could have developed in the circumstances where solar radiation was replaced with these photons. The correct prediction is that chlorophylls should be especially sensitive to these wave lengths. In particular, it is predicted that also IR wave lengths 700-1000 nm should have been utilized. There indeed are bacteria using only this portion of solar radiation. This leads to a scenario making sense only in TGD universe. Pre-biotic life could have developed at the cool space-time sheets in the hot interior of Earth below crust, where $k = 131$ space-time sheets are possible and this life could still be there [L4]. Also the life as we know it, could involve hot spots generated by the cavitation of water inside cell. The classical repulsive Z^0 force causes a strong acceleration during final stages of bubble collapse creating high temperatures, and could explain also sono-luminescence [33] as suggested in [F9].

Magnetic Mother Gaia could also form sensory and other representations receiving input from several brains via negative energy EEG MEs entangling magnetosphere with brains. The multi-brained magnetospheric selves could be responsible for the third person aspect of consciousness and for the evolution of social structures. Some aspects of remote viewing very difficult to understand if remote viewing involves only the target and viewer [34], the successful healing by prayer and meditation groups [35], and the experiments of Mark Germaine [36] support the view that multi-brained possibly magnetospheric selves are involved. Magnetic flux tubes could function as wave guides for MEs and this aspect is crucial in the model of long term memory.

2.4.2 Electrets and bio-systems

Bio-systems are known to be full of electrets and liquid crystals [37]. Perhaps the most fundamental electret structure is cell membrane. In particular, the water inside cells tends to be in gel phase which is liquid crystal phase. There are many good reasons for why water should be in ordered phase. One very fundamental reason is that bio-polymers are stable in liquid crystal/ordered water phase

since there are no free water molecules available for the depolymerization by hydration. In fact, only a couple of years ago it was experimentally discovered that bio-polymers can be stabilized around ice.

The capacitor model for sensory receptor is one very important application of the electret concept (see the article "Quantum model of sensory receptor" in [26] and [K3]). Sensory qualia result in the flow of particles with given quantum numbers from the plate to another one in quantum discharge. This kind of amplification of quantum number *resp.* zero mode increments would give rise to both geometric *resp.* non-geometric qualia [K3].

Also micro-tubuli are electrets. Sol-gel transition, as any phase transition, is an good candidate for the representation of a conscious bit and controlled local sol-gel transitions between ordinary and liquid crystal water could be a basic control tool making possible cellular locomotion, changes of protein conformations, etc... The tubulin dimers of micro-tubuli could induce sol-gel transformations by generating negative energy MEs, and micro-tubular surface could provide bit maps of their environment somewhat like sensory areas of brain provide maps of body. If gel→sol transition around tubulin inducing conformational change induces sol→gel transformation in some point of environment as would be the case for the seesaw mechanism to be discussed below, a one-one correspondence would result. By this one-one correspondence micro-tubules would automatically generate kind of conscious log files about the control activities which could have evolved to micro-tubular declarative memory representations about what happens inside cell [K6].

3 Some applications of the many-sheeted space-time concept

In this section some applications of the many-sheeted space-time concept are represented in the hope that they might give idea about how the basic concepts and rules can be applied in practice.

3.1 A general model for energy storage and energy utilization by remote metabolism

The general model for energy storage and utilization based on remote metabolism is surprisingly simple [K6].

1. Metabolic energy can be stored as a zero point kinetic energy to various space-time sheets. Typically there are two space-time sheets involved: the larger space-time sheet characterized by p-adic prime k_{gr} defines the ground state of the many-sheeted laser and the smaller space-time sheet characterized by k_{ex} defines the excited state serving as the energy storage. At least the particles at $k = k_{gr}$ space-time sheet form Bose-Einstein condensate. The energy storage involves the kicking of particles to $k = k_{ex}$

space-time sheet and is analogous to a population inversion in laser. Bose-Einstein condensates of electronic Cooper pairs, H atoms, H₂ atoms and protonic Cooper pairs, O and O₂ atoms,... are possible. The dropping of a particle to a larger space-time sheet liberates a standardized energy quantum. Since Bose-Einstein condensate is in question, this process can occur coherently which allows high metabolic power. The power is especially high if both space-time sheets carry Bose-Einstein condensates.

2. Remote metabolism provides an elegant manner to utilize the stored energy. The user must only send negative energy ME at energy sufficiently near to the energy currency. This implies a highly economical use of the metabolic energy. For instance, when an enzyme needs energy, it generates negative energy ME activating ADP to ATP by kicking proton to the atomic $k = 137$ space-time sheet. In this case .5 eV plus possibly an additional energy .34 eV to kick phosphate ion to $k = 131$ space-time sheet is needed [K6]. .
3. "Seesaw" mechanism minimizes the waste of metabolic energy since the same energy can be used repeatedly [K6]. In the simplest situation two users send alternately negative energy MEs to each other so that dissipative losses are minimized. Negative energy MEs and seesaw mechanism are not restricted to transitions involving the dropping of particles between space-time sheets: any transitions will do but it would seem that Bose-Einstein condensates must be in question. For instance, the model applies also to cyclotron transitions.
4. The fact that proton mass is with 6 percent accuracy 2^{11} times the mass of electron implies approximate symmetry. Proton or hydrogen atom at space-time sheets k corresponds to electronic Cooper pair at space-time sheet $k + 10$ as far as zero point kinetic energies are considered so that one has an approximate $(proton, k) \rightarrow (2e, k + 10)$ symmetry. This means that the protonic and electronic energy currencies are consistent with each other. Concerning the construction of the models, this implies certain degree of non-uniqueness.

3.2 Capacitor model of sensory qualia

The assumption that sensory qualia are realized at the level of sensory receptors, when combined with the requirement that the average increments are non-vanishing, and perhaps even same from quantum jump to quantum jump and amplified to a quantum phase transition, poses strong constraints on the model of the sensory receptor. The detailed model is discussed in the article "Quantum model for sensory receptor" in [26] and in [K3].

These constraints motivate what might be called the capacitor model of the sensory receptor.

1. There are two reservoirs of quantum charges having total charges of equal magnitude but of opposite sign (quantum charges refer to any quantum

numbers, not only electric charge). The net charges are macroscopic in order to guarantee robustness. These reservoirs are analogous to capacitor plates, and only the second one corresponds to the sensory experienced quale unless both the quale and its conjugate are experienced simultaneously. Capacitor plates can carry several charges simultaneously.

2. When the sensory quale is generated, there is a flow of charge quanta between the quantum capacitor plates. The charge quanta are more or less constant. This requirement could be relaxed to the condition that only the average increment is constant.

Cell membrane, or rather the pair formed by cell interior and exterior, and synaptic junction are excellent candidates for quantum capacitors.

1. During nerve pulse various ions flow between cell interior and exterior, which suggests that sub-neuronal sensory qualia are generated in a time scale of millisecond. Also membrane oscillations might give rise to some kind of sensory qualia. In particular, super-conducting Cooper pairs and bosonic ions enter or leave the Bose-Einstein condensates at the magnetic flux tubes and this should give rise to a chemical experience defined by the quantum numbers of the carrier particle. Not only the increment of electric charge but increments of magnetic quantum numbers characterize the qualia in question. Various information molecules transferred through the cell membrane could also give rise to sensory qualia.
2. In the synaptic contact the vesicles containing neurotransmitter are transmitted, and the net quantum numbers for the vesicles should determine the neuronal chemical qualia associated with the process.
3. One realization of the capacitor plates as parallel space-time sheets with different values of p-adic prime. Also now there could be electric or Z^0 electric potential difference between space-time sheets along join along boundaries bonds. A population reversed many-sheeted laser might perhaps describe what is involved. The generation of population reversal for Bose-Einstein condensed bosons followed by the dropping of the bosons to the larger space-time sheet would correspond to a generation of quale. Quale and its conjugate quale could correspond to generation of population reversal and its decay. Population reversal would also provide a storage of metabolic energy and remote metabolism sending negative energy MEs to the system inducing dropping of bosons to a larger space-time sheet would thus perhaps induce a sensory quale. Photosynthesis and $ADP \rightarrow ATP$ transformation would be typical examples about this kind of remote metabolism involving "metabolic" qualia.

Capacitor model does not apply to all qualia. Qualia might be also associated with the quantum phase transitions at magnetic flux quanta. A typical example is a coherently occurring cyclotron transition for a macroscopic phase of Cooper pairs. It would seem that quantum phase transitions at the magnetic flux quanta

and particle flows between the quantum electrodes associated with electret type structures could define two basic types of qualia. Note that electret structures are dual to magnetic flux quanta as solutions of field equations. Vision and hearing would be basic examples of these two types of qualia.

Dark matter hierarchy suggests a possible generalization of the capacitor model of sensory qualia so that the capacitor discharges would occur between sensory organ and its magnetic body. The argument goes as follows.

From the time scale of sensory experience it seems obvious that all qualia are realized at the level of dark matter. .1 seconds defines a unit of time for sensory experience which suggests that EEG relates closely to sensory qualia. Hence a modification of the original capacitor model of sensory receptor must be considered. In the original model the capacitor discharge was associated with the sensory receptor. The time scale .1 seconds characterizing sensory mental images would support the view that the capacitor discharge producing the sensory qualia should be assigned to the Josephson junctions at $k_{em} = 3$ level of dark matter hierarchy with $\hbar = \lambda^{k_{em}} \hbar_0$, $\lambda \simeq 2^{11}$, rather than cell membrane which corresponds to $k_{em} = 0$ level in the hierarchy of selves.

Charge entanglement by W ME would induce non-local capacitor discharges which can be regarded also as exchanges of virtual W bosons inducing exotic ionization leading to dark plasma oscillation patterns inducing various kinds of physiological activity such as Ca^{2+} waves. .1 seconds could be seen as a period of recurring plasma oscillations.

This model would unify models for emotions, cognition, and sensory qualia in the sense that emotions and cognitions would correspond to sensory qualia of the magnetic body assignable to cyclotron phase transitions and ordinary sensory qualia would result in capacitor discharges induced by entanglement by W MEs and color charged gluonic MEs. Even sensory organs would cognize and feel to some extent. The temporal coherence of cognitive and emotional would be spoiled by nerve pulses. Sensory receptors do not fire so that this is not a problem. At the level of cortex however only glial cells would remain viable candidates for carrying higher level sensory, cognitive, and emotional qualia. Neural activity would be responsible for the carving of the sensory percepts: sensory back projections to sensory organs would be in crucial role in this process. This picture is discussed in more detail in [M5].

3.3 Support for the notion of remote metabolism

The list of applications of negative energy MEs is now quite long. Below some examples providing support for the notion of remote metabolism are discussed.

3.3.1 Remote metabolism, photosynthesis, and ionic pumps

Photosynthesis is a fundamental metabolic function and a many-sheeted model allows to concretize the general ideas about quantum metabolism. What happens in photosynthesis at the level of energy balance seems to be relatively well-understood [38, 39] but the detailed molecular mechanisms remain obscure.

Several strange features, such as the appearance of electron pairs, suggest that super-conductivity and atomic and molecular Bose-Einstein condensates are involved.

p-Adic length scale hypothesis gives stringent quantitative guidelines in the attempt to understand photosynthesis in many-sheeted space-time, and one ends up to a general view about how Bose-Einstein condensates store metabolic energy as zero point kinetic energy and how this energy is utilized by remote metabolism by generating negative energy MEs sent to population inverted many-sheeted lasers. Electronic Cooper pairs kicked to $k_{ex} = 155$ space-time sheet from $k_{gr} = 149$ lipid layer of cell membrane space-time sheets are involved with the photo-system II. Electrons kicked to $k_{ex} = 157$ space-time sheet from $k_{gr} = 151$ cell membrane space-time sheets are involved with photo-system I. The resulting simple model of photosynthesis is successful both at qualitative and quantitative level. In particular, the energy 1 eV/electron for the excitations of the reaction center is predicted correctly from p-adic length scale hypothesis. The model also explains why the electrons from photo-system II producing oxygen from water and generating ATP molecules end up to the photo-system I [K6].

TGD provides also a new view about ionic pumps and channels whose behavior is found to be in a dramatic conflict with what one expects [40]. At theoretical level the idea that every possible biologically interesting ion needs a separate pump leads to absurd conclusions. Furthermore, it is found that the ionic flows continue even under metabolic deprivation. Finally, the ionic currents seem to be quantal and universal (same for cell membrane and an artificial membrane!) which is not consistent with the idea of ionic channels.

In TGD framework ionic pumps and channels would be actually sensors which measure chemical concentration gradients and voltages [K6]. The dominating part of the ionic currents would flow along cell membrane space-time sheets (perhaps as dark ion currents) and dissipate minimally. Most of the metabolic energy would be used to build up the hierarchy of EEGs making possible communications to the magnetic bodies and to provide energy for negative energy W MEs responsible for the generation of generalized motor actions of magnetic body at biological body.

The model for how brain constructs sensory, cognitive, and emotional representations leads to the view that non-firing astrocytes are responsible for higher level cognitive and emotional representations at magnetic bodies. Glial cells would not serve as energy reservoirs but be the main users of the metabolic energy and neurons would be specialized to communications and processing of information [M5].

3.3.2 Memory feats of synesthetes

Synesthesia involve also exceptional episodal memory feats with simultaneous lowering of metabolic rate in left brain with as much as 18 per cent [41] (for TGD inspired model of synesthesia see [H4]). This should be lethal according to the standard wisdom. The simplest explanation is that the starving neurons

in the left cortex generate negative energy MEs which entangle left brain with the geometric past. This allows left cortex to get energy from the brain of the geometric past and as a by-product induces episodal memories.

The explanation of various findings of Libet about the time delays of sensory consciousness discussed in the article "Time, space-time, and consciousness" in [26] suggests a more complex model. Starving neurons draw energy from sensory organs so that the magnetic body, usually drawing energy from the sensory organs, is forced to draw energy from the geometric past. Thus sensory experience with an input coming from the geometric past results, and could give rise to episodal long term memories. This model applies also to the experiences generated by an artificial electric or magnetic stimulation of neurons. Also the life review of NDE experiences could be a by-product of neuronal starvation. Philosophizing a little bit, one might perhaps see the purpose of suffering as generating bound state entanglement and thus making possible the macroscopic and macro-temporal quantum coherence.

3.3.3 Insect-plant communications

Callahan has made very important discoveries related to the olfaction of insects and insect-plant interaction. Callahan's work [42, 43] demonstrates that the insect olfaction is based on infrared light generated by the odorant molecules interacting with the antennae of the insects. Also the olfaction of higher organisms could rely on IR light generated by odorant molecules. Callahan has also shown plants communicate with insects utilizing infrared light [43]. This conforms with the findings of Albrecht-Buehler [44] showing that all cells contain micro-tubular structures acting as receiving antennae for infrared light . Furthermore, plants suffering from de-nutrition are found more easily by insects than healthy plants.

These findings encourage to consider the following mechanism for insect-plant communications. This mechanism could apply also to the plant-human interactions [L1].

1. Insects generate infrared MEs propagating like massless particles inside low frequency negative energy MEs acting as bridges quantum entangling the plant and the insect. Both classical communications by positive energy IR MEs and quantum communications by negative energy IR MEs are in principle possible.
2. In the case that plant suffers from de-nutrition, it can gain metabolic energy by sending negative energy MEs received by insect. This gives for plant metabolic energy and at the same time generates the quantum entanglement bridge making it possible for the insect to find the plant.

3.3.4 Dogs and their masters

Dogs are also claimed to be able to anticipate that their masters are arriving home. Some dogs are able to anticipate the epileptic attacks of their master. The

highly developed sense of smell of dogs is usually represented as an explanation of this ability. This might be a correct conclusion but in different sense as usually believed. If IR MEs represent a crucial element of olfaction, one can consider the possibility that dog precognizes its master's epileptic attack by receiving the negative energy MEs generated by the starving neurons in the master's brain in the geometric future. This explanation requires that epileptic attacks occur in the master's brain also in the geometric future where intentions are not yet realized. Similar mechanism might be involved with the ability to anticipate the arrival of the master to home. It is possible to test this hypothesis: are dogs more able to precognize the activities of their master if master is tired or sick.

The proposed model is also consistent with the hypothesis that olfaction corresponds to a "skin sense" in the sense that the back projection from brain is based on classical communications and sensory organs entangle with external world. The hypothesis is motivated by the observations about the development of embryo [K3] and is discussed in the article "Quantum model of sensory receptor" in [26].

4 Time and intentionality

The highly non-trivial question is how psychological time emerges in TGD framework, where moments of consciousness correspond to quantum jump between quantum histories (histories in the sense that configuration space spinor fields have space-time surfaces as classical correlates). I have proposed several mechanisms to achieve this. For all options the time-asymmetry of the future light cone is the fundamental inducer of the arrow of psychological time.

1. The contents of conscious experience come from finite-sized space-time sheet and since there is more room in the geometric future than in past of lightcone, the average locus of space-time sheet must drift to the geometric future during quantum jump sequence.
2. Space-time sheets having finite geometro-temporal duration drift to the direction of the geometric future. The direction of drifting is forced by the breaking of time reflection symmetry implied by the geometry of the future light cone. This option will not be discussed in this article.
3. Psychological time defines the front of p-adic-to-real phase transition transformation intentions to actions. This option seems to be more plausible. It does not however exclude the possibility that also mind like space-time sheets indeed drift to the direction of geometric future.
4. The latest proposal relies on recent formulation of quantum TGD in terms of zero energy ontology and the identification of the space-time correlate of self as the causal diamond defined by a pair of future and past directed lightcones, which is a subspace of imbedding space rather than space-time sheet. Configuration space spinor field represents a quantum superposition of space-time surfaces. Assume that the attention of self is directed to

a fixed volume of the 8-D imbedding space. Quantum classical correspondence requires that this quantum superposition in the first approximation shifts towards geometric past of the imbedding space so that self experiences effective flow of the geometric time associated with the space-time surface. This explanation works only if macroscopic quantum coherence holds true so that one cannot regard the space-time surface as a fixed arena of dynamics. Also the representability of the space-time surfaces as sub-manifolds of 8-D imbedding space is essential. The identification of the fundamental volume of attention as a causal diamond inspired by zero energy ontology based formulation of quantum TGD provides answers to more detailed questions.

There are also other questions about time and intentionality.

1. How consensus time emerges and is there a universal time in some sense?
2. Are there also doers besides the deeds? That is: are there also causal agents and how they could be defined;
3. Can one distinguish between quantum randomness and the non-determinism of intentionality? Is it possible to measure whether the system is intentional?

4.1 The notions of psychological time and self in zero energy ontology

Zero energy ontology provides an explanation for the arrow of psychological time - which I have considered earlier but only half-seriously - looks to me the most elegant at this moment. The explanation also unifies the original notion of self based on the identification of self as a sequence of quantum jumps the notion of reducing self hierarchy to a fractal hierarchy of quantum jumps within quantum jumps. This option is also favored by Occam's razor since it uses only the assumption that space-time sheets are replaced by more evolved ones in each quantum jump. Also the model of DNA as topological quantum computer favors it [O4].

4.1.1 How the arrow of psychological time emerges in zero energy ontology?

1. In standard picture the attention would gradually shift towards geometric future and space-time in 4-D sense would remain fixed. Now however the fact that quantum state is quantum superposition of space-time surfaces allows to assume that the attention of the conscious observer is directed to a fixed volume of 8-D imbedding space. Quantum classical correspondence is achieved if the evolution in a reasonable approximation means shifting of the space-time sheets and corresponding field patterns backwards backwards in geometric time by some amount per quantum jump

so that the perceiver finds the geometric future in 4-D sense to enter to the perceptive field. This makes sense since the shift with respect to M^4 time coordinate is an exact symmetry of extremals of Kähler action. It is also an excellent approximate symmetry for the preferred extremals of Kähler action and thus for maxima of Kähler function spoiled only by the presence of light-cone boundaries. This shift occurs for both the space-time sheet that perceiver identifies itself and perceived space-time sheet representing external world: both perceiver and percept change.

2. Both the landscape and observer space-time sheet remain in the same position in imbedding space but both are modified by this shift in each quantum jump. The perceiver experiences this as a motion in 4-D landscape. Perceiver (Mohammed) would not drift to the geometric future (the mountain) but geometric future (the mountain) would effectively come to the perceiver (Mohammed)!
3. There is an obvious analogy with Turing machine: what is however new is that the tape effectively comes from the geometric future and Turing machine can modify the entire incoming tape by intentional action. This analogy might be more than accidental and could provide a model for quantum Turing machine operating in TGD Universe. This Turing machine would be able to change its own program as a whole by using the outcomes of the computation already performed.
4. The concentration of the sensory input and the effects of conscious motor action to a narrow interval of time (.1 seconds typically, secondary p-adic time scale associated with the largest Mersenne M_{127} defining p-adic length scale which is not completely super-astronomical) can be understood as a concentration of sensory/motor attention to an interval with this duration: the space-time sheet representing sensory "me" would have this temporal length and "me" definitely corresponds to a zero energy state.
5. The fractal view about topological quantum computation strongly suggests an ensemble of almost copies of sensory "me" scattered along my entire life cycle and each of them experiencing my life as a separate almost copy.
6. The model of geometric and subjective memories would not be modified in an essential manner: memories would result when "me" is connected with my almost copy in the geometric past by braid strands or massless extremals (MEs) or their combinations (ME parallel to magnetic flux tube is the analog of Alfven wave in TGD).

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

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

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

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

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

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

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

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

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

Let us make the following assumptions.

1. Assume the hierarchy of causal diamonds within causal diamonds in a sense to be specified more precisely below. Causal diamonds would represent the volumes of attention. Assume that the highest level in this hierarchy defines the quantum jump containing sequences of lower level quantum jumps in some sense to be specified. Assume that these quantum jumps integrate to single continuous stream of consciousness as long as the sub...-sub-self in question remains unentangled and that entangling means loss of consciousness or at least that it is not possible to remember anything about contents of consciousness during entangled state.
2. Assume that the contents of conscious experience come from the interior of the causal diamond. A stronger condition would be that the contents come from the boundaries of the two light-cones involved since physical states are defined at these in the simplest picture. In this case one could identify the lower light-cone boundary as giving rise to memory.
3. The time span characterizing the contents of conscious experience associated with a given quantum jump would correspond to the temporal distance T between the tips of the causal diamond. T would also characterize the average and approximate shift of the superposition of space-time surfaces backwards in geometric time in single quantum jump at a given level of hierarchy. This time scale naturally scales as $T_n = 2^n T_{CP_2}$ so that p-adic length scale hypothesis follows as a consequence. T would be essentially the secondary p-adic time scale $T_{2,p} = \sqrt{p} T_p$ for $p \simeq 2^k$. This assumption - absolutely essential for the hierarchy of quantum jumps within quantum jumps - would differentiate the model from the model in which T corresponds to either CP_2 time scale or p-adic time scale T_p . One would have hierarchy of quantum jumps with increasingly longer time span for memory and with increasing duration of geometric chronon at the highest level of fractal quantum jump. Without additional restrictions, the quantum jump at n^{th} level would contain 2^n quantum jumps at the lowest level of hierarchy. Note that in the case of sub-self - and without further assumptions which will be discussed next - one would have just two quantum jumps: mental image appears, disappears or exists all the time. At the level of sub-sub-selves 4 quantum jumps and so on. Maybe this kind of simple predictions might be testable.
4. We know that that the contents of sensory experience comes from a rather narrow time interval of duration about .1 seconds, which corresponds to

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

5. These assumptions relate the hierarchy of quantum jumps to p-adic hierarchy. One can also include also dark matter hierarchy into the picture. For dark matter hierarchy the time scale hierarchy $\{T_n\}$ is scaled by the factor $r = \hbar/\hbar_0$ which can be also rational number. For $r = 2^k$ the hierarchy of causal diamonds generalizes without difficulty and there is a kind of resonance involved which might relate to the fact that the model of EEG favors the values of $k = 11n$, where $k = 11$ also corresponds in good approximation to proton-electron mass ratio. For more general values of \hbar/\hbar_0 the generalization is possible assuming that the position of the upper tip of causal diamond is chosen in such a manner that their positions are always the same whereas the position of the lower light-cone boundary would correspond to $\{rT_n\}$ for given value of Planck constant. Geometrically this picture generalizes the original idea about fractal hierarchy of quantum jumps so that it contains both p-adic hierarchy and hierarchy of Planck constants.

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

This framework explains also the sharp distinction between geometric future and past (not surprisingly since energy and time are dual): this distinction has

also been a long standing problem of TGD inspired theory of consciousness. Precognition is not possible unless one assumes that communications and sharing of mental images between selves inside disjoint causal diamonds is possible. Physically there seems to be no good reason to exclude the interaction between zero energy states associated with disjoint causal diamonds.

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

1. Suppose that the causal diamonds with tips at different points of $H = M^4 \times CP_2$ and characterized by distance between tips T define sectors CH_i of the full configuration space CH ("world of classical worlds"). Precognition would represent an interaction between zero energy states associated with different sectors CH_i in this scheme and tensor factor description is required.
2. Inside given sector CH_i it is not possible to speak about second quantization since every quantum state correspond to a single mode of a classical spinor field defined in that sector.
3. The question is thus whether the Clifford algebras and zero energy states associated with different sectors CH_i combine to form a tensor product so that these zero energy states can interact. Tensor product is required by the vision about zero energy insertions assignable to CH_i which correspond to causal diamonds inside causal diamonds. Also the assumption that zero energy states form an ensemble in 4-D sense - crucial for the deduction of scattering rates from M -matrix - requires tensor product.
4. The argument unifying the two definitions of self requires that the tensor product is restricted when CH_i correspond to causal diamonds inside each other. The tensor factors in shorter time scales are restricted to the causal diamonds hanging from a light-like radial ray at the upper end of the common past directed light-cone. If the causal diamonds are disjoint there is no obvious restriction to be posed, and this would mean the possibility of also precognition and sharing of mental images.

This scenario allows also to answers the questions related to a more precise definition of volume of attention. Causal diamond - or rather - the associated light-like boundaries containing positive and negative energy states define the primitive volume of attention. The obvious question whether the attention of a given self is doomed to be fixed to a fixed volume can be also answered. This is not the case. Selves can delocalize in the sense that there is a wave function associated with the position of the causal diamond and quantum jumps changing this position are possible. Also many-particle states assignable to a union of several causal diamonds are possible. Note that the identification of magnetic flux tubes as space-time correlates of directed attention in TGD inspired quantum biology makes sense if these flux tubes connect different causal

diamonds. The directedness of attention in this sense should be also understood: it could be induced from the ordering of p-adic primes and Planck constant: directed attention would be always from longer to shorter scale.

4.2 Psychological time and intentionality

In materialism's world one might have experience of free will but non-determinism would be replaced with non-computability or something akin to that. In theories of quantum consciousness based on standard QM one has only state function collapse and it is difficult to understand where the intentionality comes from and how quantum non-determinism differs from randomness. In TGD framework one has both the experience of free will and genuine non-determinism. p-Adicity and the new view about space-time allow precisely targeted intentionality, and one can characterize the long range temporal correlations and the failure of the statistics based on real topology as signatures of intentionality.

The basic vision would be that volitional act is realized as a phase transition of a p-adic space-time sheet to a real space-time sheet. These phase transitions are 4-dimensional and induced in quantum jumps. The natural guess was that the propagation of phase transition front to the direction of future could give rise to the flow of the psychological time.

This is a rather nice looking idea but it turns out that the recent form of quantum TGD (I am writing this June 2008) leads to a much simpler view about flow and arrow of psychological time and also explains sharp asymmetry between geometric future and past and why sensory experience is about so narrow time interval.

4.2.1 What causality means in TGD framework?

In order to minimize confusion it is in order to clarify the various meanings that one can give to causality in TGD framework.

1. At the level of space-time surfaces the absolute minimization of Kähler action defines dynamics of the space-time surfaces and defines the causality of passive events at classical level. Induced spinors (spinors of the 8-D imbedding space restricted to the space-time surface) obey the supersymmetric variant of field equations for the space-time surface and single particle Schrödinger equation can be identified as the non-relativistic limit for the dynamics of the induced spinor fields. The finite size of the space-time sheet defines naturally the notions of coherence length and time for both classical fields and spinor fields. In both cases classical determinism is broken in its naive form. For p-adic space-time sheets p-adic variants of field equations hold true and have the inherent p-adic non-determinism.
2. At configuration space level general coordinate invariance together with huge super-conformal invariance related symmetries can be said to dictate the behavior configuration space spinor fields playing a role analogous to

quantum states of quantum field theories. If the naive classical determinism of Kähler were not broken, the physics would reduce to the boundary of the future light cone, the moment of big bang and time would be lost as in the canonical quantization of General Relativity. Fortunately this does not happen.

3. Quantum jumps can be said to realize the causality with respect to the subjective time, the causality of deeds. Selves can be seen as self-organization patterns acting as causal agents. At this level system's behavior is based on rules analogous to those governing the behavior of statistical cellular automata and are a result of self-organization. The laws are not absolute but analogous to traffic rules obeyed or possibly disobeyed by intentional agents.

A further question concerns causal agents: everyday thinking suggests that deeds indeed have doers. In quantum consciousness theories based on standard quantum measurement theory doers are "observers" somewhere outside. In TGD causal agents are rather abstract: ensembles of quantum jumps deciding to some degree what kind of quantum jump they want to add to the ensemble defining them.

4.2.2 Materialization of intentions

Em fields, in particular ELF em fields, are crucial for the TGD inspired model of brain and a natural assumption is that p-adic-real phase transitions occur also for massless extremals (MEs).

A concrete picture about the materialization of intentions emerges, when one asks how a precisely targeted intention could be realized at the atomic or molecular level. The basic point is that molecules can only intend to make simple quantum transitions.

1. If the transition occurs to a lower energy state it can occur spontaneously whereas the transitions to a higher energy states cannot. Spontaneous transitions mask the possibly occurring intended transitions so that only the transitions which cannot occur spontaneously allow precisely targeted intention.
2. What would happen is that first a p-adic ME representing the intention to perform the transition is generated. Then the transition occurs and conservation laws require that the p-adic ME is transformed to a negative energy ME in the transition. Physical intuition suggests that the p-adic ME and the corresponding real ME resemble each other maximally in the sense that they go through the same rational imbedding space points in some p-adic resolution and with respect to the p-adic topology which is effective topology. In the case of the real ME.
3. Quite generally, it seems that intention can be realized in a precisely targeted manner only for the transitions which cannot occur spontaneously, and thus involve the emission of negative energy MEs.

4. The generation of negative energy MEs utilizes the buy now-let others pay mechanism of metabolism, which implies extreme flexibility. Of course, there must exist an unselfish self, which is able to pay and this puts severe constraints on the mechanism.

4.2.3 Psychological time as a front of volition identified as p-adic-to-real phase transition?

A possible resolution of the problems related to the preferred role of single moment of time for conscious experience could be based on the idea that biological growth and self-organization is a phase transition front proceeding in the direction of the geometric future quantum jump by quantum jump. And, in particular, that the dominating contribution to the conscious experience comes from the front of the phase transition where the volition is realized. The phase transition in question would be nothing but transformation of intentions to action and thus p-adic-to-real phase transition proceeding quantum jump by quantum jump towards geometric future.

This proposal forces to make ad hoc assumptions in order to avoid paradoxical conclusions and at this moment I cannot take it seriously although it is clear that intentional actions are certainly associated with the brief interval of geometric time about which also sensory experience is about. Despite this I will discuss this option.

It seems that our geometric past is relatively stable and that quantum transitions affecting geometric future in long time scales occur rarely. If this were not the case, miraculous events would occur. Physicist would transform in single quantum jump to a musician when the young student in the geometric past of subjective now would change his future plans. There are however anecdotal reports about miraculous healings in which the entire physical appearance of the person suddenly changes so that one must be cautious here. Certainly our long term memories, which in TGD framework are interpreted as mental images of the geometric past shared by quantum entanglement with geometric now, are unstable. This means that the geometric past is probably unstable in sufficiently short length and time scales. Hence it seems reasonable to assume that geometric past does not involve intentional action in length/time scales much longer than neuronal length/time scale responsible for mental images.

One of course ask what is the time scale in which geometric past p-adicizes in long time scales and our four-dimensional body can be lived again. It is quite conceivable that there is this kind of refractory period. Certainly this period must be longer than the time scale in which the intentions affect the geometric future. One fascinating question is what in the geometric future is p-adic: are only MEs p-adic?; are p-adic magnetic flux tubes there?; could the developing organism have a rough p-adic body plan; could cognitive mental images be represented in terms of p-adic neutrino-antineutrino pairs? Be as it may, the conservation of energy and various other quantum numbers forces to conclude that the material world exists also in the geometric future and the question is how wide is the range of intentional action. A good guess is that intentional

action selects between the almost degenerate absolute minima of Kähler action implied by the spin glass degeneracy and thus having same induced Kähler field.

A natural guess for the average increment of the geometric time in quantum jump is as CP_2 time so that there would be about 10^{39} quantum jumps per second. This assumption is motivated by the quantum jump as the elementary particle of consciousness metaphor and by the fact that CP_2 time represents naturally a fundamental unit of time. If the rate of increase for selves able to communicate and observe each other, rather counter intuitive conclusions would follow.

Note that macro-temporal quantum coherence effectively increases the duration of the quantum jump to the duration of the bound state responsible for the coherence. During these experiences ordinary categories of time and space do not apply. These experiences can be also interpreted as experiences about what it is to be in quantum superposition. Sensory qualia like colors seem to correspond to this kind of mental images having no reduction to the level of classical space-time dynamics.

4.2.4 How consensus geometric time emerges for p-adic option?

The assumption that the dominating contributions to the contents of our everyday consciousness correspond to roughly same value of time seems to be an intuitively obvious fact. In TGD framework this assumption translates to the hypothesis that there is collective higher level self having us as sub-selves and that there is a phase transition front in which intentions represented by p-adic space-time sheets transform to real space-time sheets representing actions.

To get convinced that this assumption is necessary, one can imagine a situation in which the intention-to-action phase transition occurs at different values of geometric time so that Bob would be transforming his intentions to actions in the geometric future of Alice or vice versa. If Bob would live in the geometric future of Alice, Alice would see Bob's geometric past. Bob would behave like an almost robot like entity without expressing intentions and free will. If Bob would live in the geometric past of Alice, then Alice would experience Bob's behavior as utterly unpredictable.

The presence of collective levels of consciousness in astrophysical length scale is thus necessary for a consensus time. This requires macro-temporal quantum coherence in astrophysical length scales made possible by the spin glass degeneracy of TGD universe. Bound state formation in astrophysical length scales is crucial for this coherence and gravitational interaction becomes a key player here although TGD suggests strongly that also classical Z^0 forces are important: in fact, classical em and Z^0 fields are unavoidably accompanied by gravitational fields. For instance, negative energy MEs inducing time like entanglement carry both classical gravitational and em/ Z^0 fields so that it is a matter of taste whether one speaks about gravitational/em or Z^0 MEs.

It is interesting to notice that there is a close connection with the basic difficulty of quantum field theories. In QFT framework it has not been really possible to appropriately describe bound states. Even the model of hydrogen atom

based on Bethe-Salpeter equation has dramatic failures whereas non-relativistic models work very satisfactorily [47]. The basic difference between relativistic and non-relativistic treatments is that non-relativistic treatment assumes common time for particles forming the bound state. In Poincare invariant quantum field theory this kind of assumption cannot be made so that each particle has its own time. In TGD framework particles are 3-surfaces and bound states of them involve the generation of join along boundaries bonds so that the common time emerges automatically. This does not break Poincare invariance since it is realized in the 8-dimensional imbedding space rather than at space-time surfaces.

The subjective and geometric times are universal in a well-defined sense whereas the correspondence between subjective and geometric time depends on which corner of 4-dimensional space-time surface the self lives. Subjective time is universal by definition since quantum jumps are performed by the entire universe. Macro-temporal quantum coherence leads to the integration of a large number of quantum jumps to single effective quantum jump, whose duration serves as a unit of subjective time. p-Adic time scales are highly suggestive as universal chronons. There is an infinite number of manners of selecting a geometric time coordinate for space-time surface but under rather general conditions one can use the light cone proper time defining cosmic time as a unique universal geometric time coordinate. In general relativity this kind of universal time does not exist.

4.3 Why p-adic intentionality does not reduce to quantum randomness?

The basic argument against quantal free will is that quantum non-determinism is basically randomness of a particular kind so that one can apply statistical determinism to predict the behavior for an ensemble of systems. The crucial question is whether also p-adic intentionality reduces to randomness so that statistical determinism applies. One can imagine two mutually consistent approaches to the problem.

1. The notion of randomness is based on the notion of probability, and it could happen that the notion of probability simply does not make sense at all for a system exhibiting an intentional behavior or that the probabilities do not exist in the real sense but only as p-adic probabilities. Thus abnormal statistics might serve as a signature of an intentional system.
2. Intentionality involves free will and unpredictability in short time scales but predictability in long time scales. This could serve as a signature of an intentional system. Quantum-classical correspondence states that the dynamics of space-time surface mimics quantum dynamics and therefore also the dynamics of consciousness and intentionality. If so the behavioral patterns of an intentional system characterized by p-adic prime p should obey p-adic topology, which is a strong and testable prediction.

4.3.1 p-Adic topology for time series as a signature of intentionality

Intentional behavior means that there is unpredictability in short time scales but predictability in long time scales because system can realize its long term plans and use its partially free will to cope with the changing challenges of the everyday life.

p-Adic topology could realize this idea.

1. The rational values of real and p-adic imbedding space coordinates correspond to the same points of the generalized imbedding space (essentially union of real and p-adic imbedding spaces for various values of p with common rational points identified).
2. The points, which are p-adically close to each other can have arbitrarily long real distance since the points x and $x + kp^n$, $k \in \{0, p - 1\}$, become arbitrarily near to each other p-adically and arbitrarily far way in real sense as n increases for the p-adic topology characterized by prime p .

Thus p-adic long range fractal correlations could simply result from p-adic continuity. The local unpredictability would be mimicked by a discontinuous behavior in the real topology resulting from the fact that time values close to each other in the real sense are far from each other in p-adic sense.

p-Adic non-determinism means that integration constants of p-adic differential equations having by definition vanishing derivatives, are functions of the binary cutoffs x_N defined as $x = \sum_k x_k p^k \rightarrow x_N = \sum_{k < N} x_k p^k$ of the arguments of the function. Since the rational values of real and p-adic coordinates correspond to same points of imbedding space, this means that p-adic non-determinism realizes intentionality by fixing the solution of field equations at a finite number of points below some real time (length) scale defined by N . The choice of these pseudo constants would characterize p-adic intentionality, the future plan of the system relatively stable against quantum jumps and the range of intentional action would be finite, which could explain why the young person in the geometry youth now cannot make choices affecting dramatically the geometric now decades later.

There is an analogous non-determinism also in the real sector due to the dramatic failure of the complete non-determinism of the basic action principle determining the dynamics of space-time surfaces. This non-determinism makes it possible to transform intentions to actions by p-adic-to-real transitions occurring in quantum jumps. It also justifies the characterization of the real space-time sheets by a p-adic primes.

Consider now a situation in which some observables of might -be intentional system are measured as a function of time. Suppose that measurements are carried out at moments $t_n = n\Delta T$, $\Delta T = T/N_m$, where T is the duration of the experiment and N_m is the number of measurements.

1. With respect to the real topology the behavior of the system would look random in short time scales with violent discontinuities independently how

precise the time resolution is made: fluctuations would actually become more violent with the improving time resolution.

2. p-Adic fractality would predict long range correlations over arbitrarily long time scales p^n in this kind of situation. Time values t and $t + rp^k \Delta T$ would be near to each other p-adically so that the values of the observables measured at these time values would be near to each other. Long range temporal correlations would thus quantify the ideas that will is not completely free and that intentionality implies an approximate predictability in long time scales. The fact that p-adic pseudo constants allow intentional free will only below some time and length scales, justifies the idea that our life is in long time scales determined by what might be called fate although we can make freely decisions in short time scales. The stability of the p-adic pseudo constants and pinary cutoff N in quantum jumps would also mean that the realization of p-adic intentions occurring subjectively now in my geometric childhood would not have dramatic implications in the geometric now.
3. p-Adic fractality would also mean that similar behavioral time patterns could repeat themselves as temporally scaled-up versions. Person would react in a similar manner in different time scales, say in stressing situation lasting for few minutes or many years. What is used to call as personality might have something to do with these fractal behavioral patterns. There is indeed statistical evidence for the possibility to predict much about the life cycle of a person from the behavioral patterns in childhood. The child who wants all now tends to become an adult who does the same. Some aspects of personality would perhaps represent something not invariant under time translations but under p-adic time scalings.

4.3.2 How statistical behavior could exhibit intentionality?

Consider an ensemble of consisting of N_m measurements of some observables of a system during a fixed time interval T occurring at equally spaced moments of time $t_n = n \times \Delta T$, $\Delta T = T/N_m$. Classify the measurements by some equivalence relation so that there are I possible outcomes and estimate the probabilities for the outcomes as rational numbers $p_i = n_i/N_m$, $\sum n_i = N_m$. When N_m becomes large one should obtain estimates for the probabilities of various instances labelled by $i = 1, \dots, I$. The standard frequency interpretation of probability theory relies on the assumption is that these estimates converge in real topology so that the estimates $p(i, N_m + k) = n_i/N_m + k$, $k \ll N_m$ and $p(i, N_m) = n_i/N_m$ do not differ much for large values of N_m .

It is however quite possible that $p(N_m)$ converges in some p-adic topology which would mean that in the real topology the estimates would fluctuate wildly without any convergence, in a typically fractal manner. The estimates for probabilities would however converge p-adically in which case the system would be intentional and characterized by some p-adic prime p . The quantum-classical correspondence suggests that the sequence of N_m measurements performed for

an intentional system during time interval T can be modelled as a sequence of measurements performed for a p-adic space-time sheet serving as its correlate. With this assumption one can immediately conclude that the estimates for the probabilities do not converge since various observables are continuous functions with respect to p-adic rather than real topology and ΔT does not approach zero at the limit $N_m \rightarrow \infty$ but fluctuates wildly. Only for N_m and $N_m + kp^n$ p-adic continuity guarantees that probabilities estimated in this manner are near each other.

It must be emphasized that the notion of p-adic probability based on frequency interpretation satisfies the Kolmogorov axioms as demonstrated by Khrennikov [48]. The notion of resolution $\Delta T = T/N_m$ defining what $N_m \rightarrow \infty$ limit really means is an absolutely essential additional element. If one defines $N_m \rightarrow N_m + 1$ as an addition of one additional measurement to existing sequence of measurements, the frequencies convergence to ordinary real probabilities with a given resolution since only one of the numbers n_i changes in $N_m \rightarrow N_m + 1$. The notion of resolution makes sense also in spatial degrees of freedom.

The notion of resolution is unavoidable already in quantum field theories in order to reduce degrees of freedom which are not directly experimentally detectable since the that measurement resolution is always finite. The notion of renormalization group realizes mathematically the notion of finite resolution [49]. Thus resolution dependent statistics is not anything new. What is new is p-adicity and the long range correlations reducing to the p-adic continuity because of different concept of nearness. Note also that p-adically small structures have real sizes which are astrophysical so that cognition and intentionality are naturally astrophysical phenomena in accordance with the notions of magnetic body and ME.

These considerations suggests how one could try to demonstrate p-adic intentionality experimentally.

1. One might hope of demonstrating that intentional systems behave apparently randomly in short time scales but that there are long range temporal correlations in time scales $t_n = p^n \Delta T$, $\Delta T = T/N_m$. Wild fluctuation of the probability estimates as function of N_m is a direct signature of intentionality. The approximate invariance of the frequencies under the transformations $N_m \rightarrow N_m + p^n \Delta T$ in turn allow to identify the value p . This approach could be used to prove the presence of the p-adic intentionality even at the molecular level or at level of say solar and planetary magnetospheres by studying the temporal behavior of the fluctuations of magnetic fields. For instance, it is known that solar magnetic field has what might be called memory [50], which should not be there if it were really random. For tornadoes the presence of short range chaos and long range order in at least spatial degrees of freedom is obvious. Period doubling in the systems approaching chaos could be a signature for the appearance of 2-adic intentionality in increasingly longer time scales. Also $1/f$ noise, not really understood in standard physics framework, might be related to intentionality.

2. One could also test the number theoretic information measures suggested by the p-adic approach using preferred resolutions defined by $N_m = kp^n$. Number theoretic information measures make sense for rational valued probabilities, and are obtained from Shannon entropy by replacing ordinary logarithm with the p-adic logarithm $Log_p(x) = \log(|x|_p) = \log(p^k) = k \log(p)$ to get $S_p = -\sum_n p_n Log_p(p_n)$. The number theoretic entropies can have also negative values in which case one can say that the ensemble contains genuine information.

4.3.3 How the p-adic primes involved with intentionality and ordinary physics are related?

In real physics the p-adic primes involved are very large, for instance, $p = 2^{127} - 1$ for electron. These large primes however labels real space-time sheets and characterize their fractality and *effective* p-adic topology. p-Adic length scale hypothesis in its basic form predicts that primary and n-ary length/time scales correspond to powers of $\sqrt{2}$ of the fundamental p-adic length/time scales so that 2-adic fractality would indeed be realized in this sense. Besides the basic units for time and length also their integer multiples can take the role of the basic unit, this of course in accordance with the very notion of fractality.

Small primes would characterize p-adic space-time sheets serving as correlates of intentions. It seems that only relatively small values p , $p = 2$ being the simplest guess, are realized as far as intentionality is considered. The octaves in music realize 2-adic fractality and it might not be an accident that binary mathematics is mathematics of computation.

4.4 Some paradoxes solved by the new view about time

In the sequel some paradoxes of modern physics and philosophy of mind related closely to the notion of time, are discussed.

4.4.1 Paradoxes related to quantum physics

The basic paradox is the conflict between the non-determinism of the state function reduction and the determinism of the Schrödinger equation. At a more general level this paradox is the conflict between the subjectively experienced actuality of the free will and the determinism of the objective world. The resolution of this paradox in TGD context is already discussed.

In the context of the deterministic physics, theoretician encounters three rather unpleasant paradoxes.

1. The determinism implies that the unique objective reality corresponds to a single solution of the field equations. The first question is "What determines the initial conditions, say at the moment of the big bang?". The attempt to answer this question leads necessarily outside the physical theory: one possibility is to postulate anthropic principle. In TGD objective reality changes at each quantum jump and the localization in zero modes

and Negentropy Maximization Principle imply a genuine p-adic evolution: therefore the recent objective reality is indeed an outcome of conscious selections.

2. The second paradox encountered by a theoretician is that in principle it is not possible to test a deterministic theory since only single solution of the field equations is realized and a genuine testing would require the comparison of the time developments for various initial data. In practice this problem can be circumvented by assuming the existence of identical sub-systems having very weak interactions with the external world but in principle the problem remains unsolved. In TGD framework the hopping in the space of quantum histories makes possible the conscious comparison of the "solutions of field equations".
3. A further paradox relates to the dualism between theories and reality. Sooner or later theoretician is forced to ask about in what sense the theories exists. In TGD framework there is no need to postulate any further reality behind the theory. Quantum histories/configuration space spinor fields are what exists, model of reality is the reality. The hopping around in the space of these mathematical structures gives rise to the experiences of the pain and the concepts of toe and stone.

The famous Einstein-Bohr debate was related with the question whether God plays dice or not. In TGD context both were correct in their own ways. Quantum histories are indeed deterministic but God can replace the old quantum history with a new one: perhaps one should not however call this act dice playing but simply an act of free will. Einstein was also an advocate of local realism: this led to Einstein-Podolski-Rosen paradox created by the possibility of quantum entanglement between distant system. In TGD framework local realism holds true at the level of the infinite-dimensional configuration space but not at the level of space-time since point like particles are replaced with 3-surfaces.

The phenomenon of dissipation is paradoxical from the point of view of standard physics. It is generally accepted that the fundamental laws of classical physics are reversible whereas everyday reality is manifestly irreversible. Thus the situation is rather schizophrenic. Two worlds, the reversible and extremely beautiful world of the fundamental physics and the irreversible and mathematically rather ugly "real" world, seem to exist simultaneously. The quantum jumps between quantum histories concept solves the paradox and one can understand the dissipative world as an effective description forming an 'almost'-envelope for the sequence of reversible worlds (time developments).

4.4.2 Paradoxes related to the theories of consciousness

Chalmers describes in his book 'Conscious Mind' [51] several paradoxes related to the materialistic and dualistic theories of mind. A common denominator for

these problems is the assumption that consciousness is a property of a physical state: hence these paradoxes disappear in TGD context. These paradoxes are encountered also in the quantum theories of consciousness identifying consciousness as a property of a macroscopic quantum state, say Bose Einstein condensate.

In the materialistic theories of mind, postulating a unique objective reality, consciousness is an epiphenomenon and free will is necessarily a peculiar illusion and one can always ask why the consciousness is needed at all. Nothing changes in the physical reality if consciousness is dropped away. It is also very difficult to understand how the contents of consciousness are determined by the state of the material world.

In the dualistic theories postulating a unique objective reality (say the theory of Chalmers [51]), the problems are related to the coupling between matter and mind. The basic problem of the dualistic theories is what Chalmers calls hard problem: how the physical processes in the brain give rise to conscious experience? If the laws of the physics determine the behavior of the system completely then one ends up immediately either with a complete separation of the mind and matter so that our conscious experience tells nothing about the material world or with materialism and epiphenomenalism. One can also consider a non-trivial coupling between matter and “mind like” fields but assuming a deterministic physics one ends up with a situation in which the mind fields are effectively just additional physical fields and consciousness is again redundant.

In TGD framework, which could be called tripartistic, hard problem and other problems of the dualistic theories disappear since there is no need to assign consciousness to quantum history. Moment of consciousness as quantum jump between quantum histories hypothesis allows even to define measures for the information contents of the conscious experience despite the fact that one cannot write explicit formulas for the contents of conscious experience.

4.4.3 Logical paradoxes and concept of time

Many logical paradoxes could be resolved if one assumes that there are two times: geometric and subjective and that the space-time surface providing linguistic representations changes quantum jump by quantum jump. In particular, during the conscious argument leading to the logical paradox!

The objections of Uri Fidelman [52] against the Platonic vision about reality involve the paradoxes of the cyclic cosmology (one might think that Turing machine in cyclic cosmology might be able to ‘know’ whether it has halted immediately after starting and thus be much more powerful than ordinary Turing machine). Basic paradox is that in cyclic cosmology allowing time travel one can imagine a psychopathic son who murders his mother.

It is interesting to consider this paradox as resulting from identification of the identification of subjective time with geometric time, which I see only as an approximation. In TGD the counterpart of time travel would be sequence of quantum jumps changing the entire classical history quantum jump by quantum jump and inducing the shift of the space-time region, where the contents of

consciousness of time traveller are concentrated, to the geometric past. No paradoxes result since space-time is not a fixed arena of dynamics but changes in each quantum jump.

As a second example one can take the second objection of Uri Fidelman [52] against Penrose's program known as Berry's paradox.

Non-formalizable theory cannot provide a model of the physical world which includes the brain's cognitive function, since such a model must be lingual, written or spoken. However, such a model implies the following paradox of Berry: Let n be the smallest number which cannot be defined by an English sentence having less than, say, a hundred letters. This number exists, since the number of all possible combinations of a hundred letters is finite. Nevertheless, it has just now been defined by a sentence comprising less than a hundred letters.

Berry's paradox could be understood when the piece of text is seen as inducing a sequence of quantum jumps in which the space-time region at which the argument is represented symbolically changes. For the initial space-time region representing my cognitive state there is indeed smallest number n which cannot be defined by using less than one hundred words (using the English in that space-time!). After reading the statement quantum history is replaced by a new, more complex one in which this this number can be defined by using less than one hundred words since a new reflective level of cognitive consciousness has emerged and is represented at space-time level.

This example encourages to think the possibility of replacing the idea of a fixed axiomatic system with a living and dynamically evolving system becoming conscious of new axioms from which new theorems can grow. Mathematician would not be anymore an outsider but and active participator affecting the mathematical system he is studying. For instance, when paradoxical statement represented symbolically becomes conscious in quantum jump sequence, also the context in which it was originally stated changes. This dynamical view about mathematical system could allow to solve antinomies.

4.5 Comparison with the approach of Barbour

The comparison of TGD based view about time with that of Barbour might help to understand what distinguishes TGD view from quantum general relativistic view. Barbour has proposed in his book "....." [53] that time is illusion. Barbour is a proponent of canonically quantized general relativity, where the canonical quantization rules eliminate time completely from the formulation. This reflects that fact that the dynamical arena is the space of 3-geometries rather than 4-geometries. This is also the situation in the super-space approach of Wheeler, which served as an inspirer of the configuration space geomery approach in TGD framework. Barbour's conclusion that time is illusion is certainly counter-intuitive but perfectly logical if one identifies time as geometric time and takes canonically quantized general relativity completely seriously.

There are of course objections against this conclusion. General coordinate invariance is a four-dimensional symmetry and the notion of space-time is crucial in all practical applications of general relativity: therefore the disappearance

of time from quantum theory tells that something has gone wrong. Indeed, Schrödinger equation and canonical quantizations were derived originally for non-relativistic systems so that the application of the formalism in general relativity might lead to astray. Secondly, the mathematical formalism resulting exists only formally since the naive generalization of non-linear field equations to infinite-dimensional context fails.

Accepting for a moment the absence of geometric time, one can ask whether the experienced time could have a place in Barbour's universe. If one accepts the notion of quantum jump sequence also the space of 3-geometries, one would indeed have subjective time. In the transition to TGD Universe space-times become 4-surfaces and the geometric time would emerge automatically. The fundamental deviation from the canonical quantization is that the fundamental variational principle means absolute minimization, not only extremization of the action defining the theory. Besides allowing to get rid of the infinities of the local quantum field theories, absolute minimization implies generalized Bohr rules and assigns to given 3-surface (counterpart of 3-geometry) unique space-time surface. Even this is not enough for having the psychological time: the localization of conscious experience requires classical non-determinism (which becomes determinism if 3-surfaces are generalized to sequences of 3-surfaces with time like separations). As found, also p-adic physics as physics of intentionality is required to understand the emergence of the psychological time.

5 Local p-adic physics and the p-adic fractality of the real physics and p-adic-to-real transition as a space-time correlate for the transformation of intention to action

This section provides the recent view about transformation of intentions to actions and the presence of this a motivation for its presence of p-adic cognitive neutrino pair. The interpretation of the p-adic as physics of cognition and the vision about reduction of physics to rational physics continuable algebraically to various extensions of rationals and p-adic number fields is an attractive general framework allowing to understand how p-adic fractality could emerge in real physics. In this section it will be found that this vision provides a concrete tool in principle allowing to construct global solutions of field equations by reducing long length scale real physics to short length scale p-adic physics. Also p-adic length scale hypothesis can be understood and the notion of multi-p p-fractality can be formulated in precise sense in this framework. This vision leads also to a concrete quantum model for how intentions are transformed to actions and the S-matrix for the process has the same general form as the ordinary S-matrix.

5.1 p-Adic physics and the construction of solutions of field equations

The number theoretic vision about physics relies on the idea that physics or, rather what we can know about it, is basically rational number based. One interpretation would be that space-time surfaces, the induced spinors at space-time surfaces, configuration space spinor fields, S-matrix, etc..., can be obtained by algebraically continuing their values in a discrete subset of rational variant of the geometric structure considered to appropriate completion of rationals (real or p-adic). The existence of the algebraic continuation poses very strong additional constraints on physics but has not provided any practical means to solve quantum TGD.

In the following it is however demonstrated that this view leads to a very powerful iterative method of constructing global solutions of classical field equations from local data and at the same time gives justification for the notion of p-adic fractality, which has provided very successful approach not only to elementary particle physics but also physics at longer scales. The basic idea is that mere p-adic continuity and smoothness imply fractal long range correlations between rational points which are very close p-adically but far from each other in the real sense and vice versa.

5.1.1 The emergence of a rational cutoff

For a given p-adic continuation only a subset of rational points is acceptable since the simultaneous requirements of real and p-adic continuity can be satisfied only if one introduces ultraviolet cutoff length scale. This means that the distances between subset of rational points fixing the dynamics of the quantities involved are above some cutoff length scale, which is expected to depend on the p-adic number field R_p as well as a particular solution of field equations. The continued quantities coincide only in this subset of rationals but not in shorter length scales.

The presence of the rational cutoff implies that the dynamics at short scales becomes effectively discrete. Reality is however not discrete: discreteness and rationality only characterize the inherent limitations of our knowledge about reality. This conforms with the fact that our numerical calculations are always discrete and involve finite set of points.

The intersection points of various p-adic continuations with real space-time surface should code for all actual information that a particular p-adic physics can give about real physics in classical sense. There are reasons to believe that real space-time sheets are in the general case characterized by integers n decomposing into products of powers of primes p_i . One can expect that for p_i -adic continuations the sets of intersection points are especially large and that these p-adic space-time surfaces can be said to provide a good discrete cognitive mimicry of the real space-time surface.

Adelic formula represents real number as product of inverse of its p-adic norms. This raises the hope that taken together these intersections could allow

to determine the real surface and thus classical physics to a high degree. This idea generalizes to quantum context too.

The actual construction of the algebraic continuation from a subset of rational points is of course something which cannot be done in practice and this is not even necessary since much more elegant approach is possible.

5.1.2 Hierarchy of algebraic physics

One of the basic hypothesis of quantum TGD is that it is possible to define exponent of Kähler action in terms of fermionic determinants associated with the modified Dirac operator derivable from a Dirac action related supersymmetrically to the Kähler action.

If this is true, a very elegant manner to define hierarchy of physics in various algebraic extensions of rational numbers and p-adic numbers becomes possible. The observation is that the continuation to various p-adic numbers fields and their extensions for the fermionic determinant can be simply done by allowing only the eigenvalues which belong to the extension of rationals involved and solve field equations for the resulting Kähler function. Hence a hierarchy of fermionic determinants results. The value of the dynamical Planck constant characterizes in this approach the scale factor of the M^4 metric in various number theoretical variants of the imbedding space $H = M^4 \times CP_2$ glued together along subsets of rational points of H . The values of \hbar are determined from the requirement of quantum criticality [C7] meaning that Kähler coupling strength is analogous to critical temperature.

In this approach there is no need to restrict the imbedding space points to the algebraic extension of rationals and to try to formulate the counterparts of field equations in these discrete imbedding spaces.

5.1.3 p-Adic short range physics codes for long range real physics and vice versa

One should be able to construct global solutions of field equations numerically or by engineering them from the large repertoire of known exact solutions [D1]. This challenge looks formidable since the field equations are extremely non-linear and the failure of the strict non-determinism seems to make even in principle the construction of global solutions impossible as a boundary value problem or initial value problem.

The hope is that short distance physics might somehow code for long distance physics. If this kind of coding is possible at all, p-adicity should be crucial for achieving it. This suggests that one must articulate the question more precisely by characterizing what we mean with the phrases "short distance" and "long distance". The notion of short distance in p-adic physics is completely different from that in real physics, where rationals very close to each other can be arbitrary far away in the real sense, and vice versa. Could it be that in the statement "Short length scale physics codes for long length scale physics" the

attribute "short"/"long" could refer to p-adic/real norm, real/p-adic norm, or both depending on the situation?

The point is that rational imbedding space points very near to each other in the real sense are in general at arbitrarily large distances in p-adic sense and vice versa. This observation leads to an elegant method of constructing solutions of field equations.

1. Select a rational point of the imbedding space and solve field equations in the real sense in an arbitrary small neighborhood U of this point. This can be done with an arbitrary accuracy by choosing U to be sufficiently small. It is possible to solve the linearized field equations or use a piece of an exact solution going through the point in question.
2. Select a subset of rational points in U and interpret them as points of p-adic imbedding space and space-time surface. In the p-adic sense these points are in general at arbitrary large distances from each and real continuity and smoothness alone imply p-adic long range correlations. Solve now p-adic field equations in p-adically small neighborhoods of these points. Again the accuracy can be arbitrarily high if the neighborhoods are choose small enough. The use of exact solutions of course allows to overcome the numerical restrictions.
3. Restrict the solutions in these small p-adic neighborhoods to rational points and interpret these points as real points having arbitrarily large distances. p-Adic smoothness and continuity alone imply fractal long range correlations between rational points which are arbitrary distant in the real sense. Return to 1) and continue the loop indefinitely.

In this manner one obtains even in numerical approach more and more small neighborhoods representing almost exact p-adic and real solutions and the process can be continued indefinitely.

Some comments about the construction are in order.

1. Essentially two different field equations are in question: real field equations fix the local behavior of the real solutions and p-adic field equations fix the long range behavior of real solutions. Real/p-adic global behavior is transformed to local p-adic/real behavior. This might be the deepest reason why for the hierarchy of p-adic physics.
2. The failure of the strict determinism for the dynamics dictated by Kähler action and p-adic non-determinism due to the existence of p-adic pseudo constants give good hopes that the construction indeed makes it possible to glue together the (not necessarily) small pieces of space-time surfaces inside which solutions are very precise or exact.
3. Although the full solution might be impossible to achieve, the predicted long range correlations implied by the p-adic fractality at the real space-time surface are a testable prediction for which p-adic mass calculations and applications of TGD to biology provide support.

4. It is also possible to generalize the procedure by changing the value of p at some rational points and in this manner construct real space-time sheets characterized by different p -adic primes.
5. One can consider also the possibility that several p -adic solutions are constructed at given rational point and the rational points associated with p -adic space-time sheets labelled by p_1, \dots, p_n belong to the real surface. This would mean that real surface would be multi- p p -adic fractal.

I have earlier suggested that even elementary particles are indeed characterized by integers and that only particles for which the integers have common prime factors interact by exchanging particles characterized by common prime factors. In particular, the primes $p = 2, 3, \dots, 23$ would be common to the known elementary particles and appear in the expression of the gravitational constant. Multi- p p -fractality leads also to an explanation for the weakness of the gravitational constant. The construction recipe for the solutions would give a concrete meaning for these heuristic proposals.

This approach is not restricted to space-time dynamics but is expected to apply also at the level of say S-matrix and all mathematical object having physical relevance. For instance, p -adic four-momenta appear as parameters of S-matrix elements. p -Adic four-momenta very near to each other p -adically restricted to rational momenta define real momenta which are not close to each other and the mere p -adic continuity and smoothness imply fractal long range correlations in the real momentum space and vice versa.

5.1.4 p -Adic length scale hypothesis

Approximate p_1 -adicity implies also approximate p_2 -adicity of the space-time surface for primes $p \simeq p_1^k$. p -Adic length scale hypothesis indeed states that primes $p \simeq 2^k$ are favored and this might be due to simultaneous $p \simeq 2^k$ - and 2-adicity. The long range fractal correlations in real space-time implied by 2-adicity would indeed resemble those implied by $p \simeq 2^k$ and both $p \simeq 2^k$ -adic and 2-adic space-time sheets have larger number of common points with the real space-time sheet.

If the scaling factor λ of \hbar appearing in the dark matter hierarchy is in good approximation $\lambda = 2^{11}$ also dark matter hierarchy comes into play in a resonant manner and dark space-time sheets at various levels of the hierarchy tend to have many intersection points with each other.

There is however a problem involved with the understanding of the origin of the p -adic length scale hypothesis if the correspondence via common rationals is assumed.

1. The mass calculations based on p -adic thermodynamics for Virasoro generator L_0 predict that mass squared is proportional to $1/p$ and Uncertainty Principle implies that L_p is proportional to \sqrt{p} rather than p , which looks more natural if common rationals define the correspondence between real and p -adic physics.

2. It would seem that length $d_p \simeq pR$, R or order CP_2 length, in the induced space-time metric must correspond to a length $L_p \simeq \sqrt{p}R$ in M^4 . This could be understood if space-like geodesic lines at real space-time sheet obeying effective p-adic topology are like orbits of a particle performing Brownian motion so that the space-like geodesic connecting points with M^4 distance r_{M^4} has a length $r_{X^4} \propto r_{M^4}^2$. Geodesic random walk with randomness associated with the motion in CP_2 degrees of freedom could be in question. The effective p-adic topology indeed induces a strong local wiggling in CP_2 degrees of freedom so that r_{X^4} increases and can depend non-linearly on r_{M^4} .
3. If the size of the space-time sheet associated with the particle has size $d_p \sim pR$ in the induced metric, the corresponding M^4 size would be about $L_p \propto \sqrt{p}R$ and p-adic length scale hypothesis results.
4. The strongly non-perturbative and chaotic behavior $r_{X^4} \propto r_{M^4}^2$ is assumed to continue only up to L_p . At longer length scales the space-time distance d_p associated with L_p becomes the unit of space-time distance and geodesic distance r_{X^4} is in a good approximation given by

$$r_{X^4} = \frac{r_{M^4}}{L_p} d_p \propto \sqrt{p} \times r_{M^4} \quad , \quad (2)$$

and is thus linear in M^4 distance r_{M^4} .

5.1.5 Does cognition automatically solve real field equations in long length scales?

In TGD inspired theory of consciousness p-adic space-time sheets are identified as space-time correlates of cognition. Therefore our thoughts would have literally infinite size in the real topology if p-adics and reals correspond to each other via common rationals (also other correspondence based on the separate canonical identification of integers m and n in $q = m/n$ with p-adic numbers).

The cognitive solution of field equations in very small p-adic region would solve field equations in real sense in a discrete point set in very long real length scales. This would allow to understand why the notions of Universe and infinity are a natural part of our conscious experience although our sensory input is about an infinitesimally small region in the scale of universe.

The idea about Universe performing mimicry at all possible levels is one of the basic ideas of TGD inspired theory of consciousness. Universe could indeed understand and represent the long length scale real dynamics using local p-adic physics. The challenge would be to make quantum jumps generating p-adic surfaces having large number of common points with the real space-time surface. We are used to call this activity theorizing and the progress of science towards smaller real length scales means progress towards longer length scales in p-adic sense. Also real physics can represent p-adic physics: written language and computer represent examples of this mimicry.

5.2 A more detailed view about how local p-adic physics codes for p-adic fractal long range correlations of the real physics

The vision just described gives only a rough heuristic view about how the local p-adic physics could code for the p-adic fractality of long range real physics. There are highly non-trivial details related to the treatment of M^4 and CP_2 coordinates and to the mapping of p-adic H -coordinates to their real counterparts and vice versa.

5.2.1 How real and p-adic space-time regions are glued together?

The first task is to visualize how real and p-adic space-time regions relate to each other. It is convenient to start with the extension of real axis to contain also p-adic points. For finite rationals $q = m/n$, m and n have finite power expansions in powers of p and one can always write $q = p^k \times r/s$ such that r and s are not divisible by p and thus have pinary expansion of in powers of p as $x = x_0 + \sum_1^N x_n p^n$, $x_i \in \{0, p\}$, $x_0 \neq 0$.

One can always express p-adic number as $x = p^n y$ where y has p-adic norm 1 and has expansion in non-negative powers of p . When x is rational but not integer the expansion contains infinite number of terms but is periodic. If the expansion is infinite and non-periodic, one can speak about *strictly p-adic* number having infinite value as a real number.

In the same manner real number x can be written as $x = p^n y$, where y is either rational or has infinite non-periodic expansion $y = r_0 + \sum_{n>0} r_n p^{-n}$ in negative powers of p . As a p-adic number y is infinite. In this case one can speak about strictly real numbers.

This gives a visual idea about what the solution of field equations locally in various number fields could mean and how these solutions are glued together along common rationals. In the following I shall be somewhat sloppy and treat the rational points of the imbedding space as if they were points of real axis in order to avoid clumsy formulas.

1. The p-adic variants of field equations can be solved in the strictly p-adic realm and by p-adic smoothness these solutions are well defined also in as subset of rational points. The strictly p-adic points in a neighborhood of a given rational point correspond as real points to infinitely distant points of M^4 . The possibility of p-adic pseudo constants means that for rational points of M^4 having sufficiently large p-adic norm, the values of CP_2 coordinates or induced spinor fields can be chosen more or less freely.
2. One can solve the p-adic field equations in any p-adic neighborhood $U_n(q) = \{x = q + p^n y\}$ of a rational point q of M^4 , where y has a unit p-adic norm and select the values of fields at different points q_1 and q_2 freely as long as the spheres $U_n(q_1)$ and $U_n(q_2)$ are disjoint (these spheres are either identical or disjoint by p-adic ultra-metricity).

The points in the p-adic continuum part of these solutions are at an infinite distance from q in M^4 . The points which are well-defined in real sense form a discrete subset of rational points of M^4 . The p-adic space-time surface constructed in this manner defines a discrete fractal hierarchy of rational space-time points besides the original points inside the p-adic spheres. In real sense the rational points have finite distances and could belong to disjoint real space-time sheets. The failure of the strict non-determinism for the field equations in the real sense gives hopes for gluing these sheets partially together (say in particle reactions with particles represented as 3-surfaces).

3. All rational points q of the p-adic space-time sheet can be interpreted as real rational points and one can solve the field equations in the real sense in the neighborhoods $U_n(q) = \{x = q + p^n y\}$ corresponding to real numbers in the range $p^n \leq x \leq p^{n+1}$. Real smoothness and continuity fix the solutions at finite rational points inside $U_n(q)$ and by the phenomenon of p-adic pseudo constants these values can be consistent with p-adic field equations. Obviously one can continue the construction process indefinitely.

5.2.2 p-Adic scalings act only in M^4 degrees of freedom

p-Adic fractality suggests that finite real space-time sheets around points $x+p^n$, $x = 0$, are obtained as by just scaling of the M^4 coordinates having origin at $x = 0$ by p^n of the solution defined in a neighborhood of x and leaving CP_2 coordinates as such. The known extremals of Kähler action indeed allow M^4 scalings as dynamical symmetries.

One can understand why no scaling should appear in CP_2 degrees of freedom. CP_2 is complex projective space for which points can be regarded as complex planes and for these p-adic scalings act trivially. It is worth of emphasizing that here could lie a further deep number theoretic reason for why the space S in $H = M^4 \times S$ must be a projective space.

5.2.3 What p-adic fractality for real space-time surfaces really means?

The identification of p-adic and real M^4 coordinates of rational points as such is crucial for p-adic fractality. On the other hand, the identification rational real and p-adic CP_2 coordinates as such would not be consistent with the idea that p-adic smoothness and continuity imply p-adic fractality manifested as long range correlations for real space-time sheets

The point is that p-adic fractality is not stable against small p-adic deformations of CP_2 coordinates as function of M^4 coordinates for solutions representable as maps $M^4 \rightarrow CP_2$. Indeed, if the rational valued p-adic CP_2 coordinates are mapped as such to real coordinates, the addition of large power p^n to CP_2 coordinate implies small modification in p-adic sense but large change in

the real sense so that correlations of CP_2 at p-adically scaled M^4 points would be completely lost.

The situation changes if the map of p-adic CP_2 coordinates to real ones is continuous so that p-adically small deformations of the p-adic space-time points are mapped to small real deformations of the real space-time points.

1. Canonical identification $I : x = \sum x_n p^n \rightarrow \sum x_n p^{-n}$ satisfies continuity constraint but does not map rationals to rationals.
2. The modification of the canonical identification given by

$$I(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)} \quad (3)$$

is uniquely defined for rational points, maps rationals to rationals, has a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$.

3. The form of this map is not general coordinate invariant nor invariant under color isometries. The natural requirement is that the map should respect the symmetries of CP_2 maximally. Therefore the complex coordinates transforming linearly under $U(2)$ subgroup of $SU(3)$ defining the projective coordinates of CP_2 are a natural choice. The map in question would map the real components of complex coordinates to their p-adic variants and vice versa. The residual $U(2)$ symmetries correspond to rational unitary 2×2 -matrices for which matrix elements are of form $U_{ij} = p^k r/s$, $r < p$, $s < p$. It would seem that these transformations must form a finite subgroup if they define a subgroup at all. In case of $U(1)$ Pythagorean phases define rational phases but sufficiently high powers fail to satisfy the conditions $r < p$, $s < p$. Also algebraic extensions of p-adic numbers can be considered.
4. The possibility of pseudo constant allows to modify canonical identification further so that it reduces to the direct identification of real and p-adic rationals if the highest powers of p in r and s ($q = p^n r/s$) are not higher than p^N . Write $x = \sum_{n \geq 0} x_n p^n = x^N + p^{N+1} y$ with $x^N = \sum_{n=0}^N x_n p^n$, $x_0 \neq 0$, $y_0 \neq 0$, and define $I_N(x) = x^N + p^{N+1} I(y)$. For $q = p^n r/s$ define $I_N(q) = p^n I_N(r)/I_N(s)$. This map reduces to the direct identification of real and p-adic rationals for $y = 0$.
5. There is no need to introduce the imaginary unit explicitly. In case of spinors imaginary unit can be represented by the antisymmetric 2×2 -matrix ϵ_{ij} satisfying $\epsilon_{12} = 1$. As a matter fact, the introduction of imaginary unit as number would lead to problems since for $p \bmod 4 = 3$ imaginary unit should be introduced as an algebraic extension and CP_2 in this sense would be an algebraic extension of RP_2 . The fact that the algebraic extension of p-adic numbers by $\sqrt{-1}$ is equivalent with an extension

introducing $\sqrt{p-1}$ supports the view that algebraic imaginary unit has nothing to do with the geometric imaginary unit defined by Kähler form of CP_2 . For $p \bmod 4 = 1$ $\sqrt{-1}$ exists as a p-adic number but is infinite as a real number so that the notion of finite complex rational would not make sense.

5.2.4 Preferred CP_2 coordinates as a space-time correlate for the selection of quantization axis

Complex CP_2 coordinates are fixed only apart from the choice of the quantization directions of color isospin and hyper charge axis in $SU(3)$ Lie algebra. Hence the selection of quantization axes seems to emerge at the level of the generalized space-time geometry as quantum classical correspondence indeed requires.

In a well-defined sense the choice of the quantization axis and a special coordinate system implies the breaking of color symmetry and general coordinate invariance. This breaking is induced by the presence of p-adic space-time sheets identified as correlates for cognition and intentionality. One could perhaps say that the cognition affects real physics via the imbedding space points shared by real and p-adic space-time sheets and that these common points define discrete coordinatization of the real space-time surface analogous to discretization resulting in any numerical computation.

5.2.5 Relationship between real and p-adic induced spinor fields

Besides imbedding space coordinates also induced spinor fields are fundamental variables in TGD. The free second quantized induced spinor fields define the fermionic oscillator operators in terms of which the gamma matrices giving rise to spinor structure of the "world of classical worlds" can be expressed.

p-Adic fractal long range correlations must hold true also for the induced spinor fields and they are in exactly the same role as CP_2 coordinates so that the variant of canonical identification mapping rationals to rationals should map the real and imaginary parts of of real induced spinor fields to their p-adic counterparts and vice versa at the rational space-time points common to p-adic and real space-time sheets.

5.2.6 Could quantum jumps transforming intentions to actions really occur?

The idea that intentional action corresponds to a quantum jump in which p-adic space-time sheet is transformed to a real one traversing through rational points common to p-adic and real space-time sheet is consistent with the conservation laws since the sign of the conserved inertial energy can be also negative in TGD framework and the density of inertial energy vanishes in cosmological length scales [D5]. Also the non-diagonal transitions $p_1 \rightarrow p_2$ are in principle possible

and would correspond to intersections of p-adic space-time sheets having a common subset of rational points. Kind of phase transitions changing the character of intention or cognition would be in question.

1. Realization of intention as a scattering process

The first question concerns the interpretation of this process and possibility to find some familiar counterpart for it in quantum field theory framework. The general framework of quantum TGD suggests that the points common to real and p-adic space-time sheets could perhaps be regarded as arguments of an n-point function determining the transition amplitudes for p-adic to real transition or $p_1 \rightarrow p_2$ -adic transitions. The scattering event transforming an p-adic surface (infinitely distant real surface in real M^4) to a real finite sized surface (infinitely distant p-adic surface in p-adic M^4) would be in question.

2. Could S-matrix for realizations of intentions have the same general form as the ordinary S-matrix?

One might hope that the realization of intention as a number theoretic scattering process could be characterized by an S-matrix, which one might hope of being unitary in some sense. These S-matrix elements could be interpreted at fundamental level as probability amplitudes between intentions to prepare a define initial state and the state resulting in the process.

Super-conformal invariance is a basic symmetry of quantum TGD which suggests that the S-matrix in question should be constructible in terms of n-point functions of a conformal field theory restricted to a subset of rational points shared by real and p-adic space-time surfaces or their causal determinants. According to the general vision discussed in [C1], the construction of n-point functions effectively reduces to that at 2-dimensional sections of light-like causal determinants of space-time surfaces identified as partonic space-time sheets.

The idea that physics in various number fields results by algebraic continuation of rational physics serves as a valuable guideline and suggests that the form of the S-matrices between different number fields (call them non-diagonal S-matrices) could be essentially the same as that of diagonal S-matrices. If this picture is correct then the basic differences to ordinary real S-matrix would be following.

1. Intentional action could transform p-adic space-time surface to a real one only if the exponent of Kähler function for both is rational valued (or belongs to algebraic extension of rationals).
2. The points appearing as arguments of n-point function associated with the non-diagonal S-matrix are a subset of rational points of imbedding space whereas in the real case, where the integration over these points is well defined, all values of arguments can be allowed. Thus the difference between ordinary S-matrix and more general S-matrices would be that a continuous Fourier transform of n-point function in space-time domain is

not possible in the latter case. The inherent nature of cognition would be that it favors localization in the position space.

3. *Objection and its resolution*

Exponent of Kähler function is the key piece of the configuration space spinor field. There is a strong counter argument against the existence of the Kähler function in the p-adic context. The basic problem is that the definite integral defining the Kähler action is not p-adically well-defined except in the special cases when it can be done algebraically. Algebraic integration is however very tricky and numerically completely unstable.

The definition of the exponent of Kähler function in terms of Dirac determinants or, perhaps equivalently, as a result of normal ordering of the modified Dirac action for second quantized induced spinors might however lead to an elegant resolution of this problem. This approach is discussed in detail in [B4, D1]. The idea is that Dirac determinant can be defined as a product of eigenvalues of the modified Dirac operator and one ends up to a hierarchy of theories based on the restriction of the eigenvalues to various algebraic extensions of rationals identified as a hierarchy associated with corresponding algebraic extensions of p-adic numbers. This hierarchy corresponds to a hierarchy of theories (and also physics!) based on varying values of Kähler coupling constant and Planck constant. The elegance of this approach is that no discretization at space-time level would be needed: everything reduces to the generalized eigenvalue spectrum of the modified Dirac operator.

4. *A more detailed view*

Consider the proposed approach in more detail.

1. Fermionic oscillator operators are assigned with the generalized eigenvectors of the modified Dirac operator defined at the light-like causal determinants:

$$\begin{aligned}\Psi &= \sum_n \Psi_n b_n \ , \\ D\Psi_n &= \Gamma^\alpha D_\alpha \Psi_n = \lambda_n O \Psi_n \ , \quad O \equiv n_\alpha \Gamma^\alpha \ .\end{aligned}\tag{4}$$

Here $\Gamma^\alpha = T^{\alpha k} \Gamma_k$ denote so called modified gamma matrices expressible in terms of the energy momentum current $T^{\alpha k}$ assignable to Kähler action [B4]. The replacement of the ordinary gamma matrices with modified ones is forced by the requirement that the super-symmetries of the modified Dirac action are consistent with the property of being an extremal of Kähler action. n_α is a light like vector assignable to the light-like causal determinant and $O = n_\alpha \Gamma^\alpha$ must be rational and have the same value at real and p-adic side at rational points. The integer n labels the eigenvalues λ_n of the modified Dirac operator, and b_n corresponds to the corresponding fermionic oscillator operator.

2. The condition that the p-adic and real variants Ψ if the Ψ are identical at common rational points of real and p-adic space-time surface (the same applies to 4-surfaces corresponding to different p-adic number fields) poses a strong constraint on the algebraic continuation from rationals to p-adics and gives hopes of deriving implications of this approach.
3. Ordinary fermionic anti-commutation relations do not refer specifically to any number field. Super Virasoro (anti-)commutation relations involve only rationals. This suggest that fermionic Fock space spanned by the oscillator operators b_n is universal and same for reals and p-adic numbers and can be regarded as rational. Same would apply to Super Virasoro representations. Also the possibility to interpret configuration space spinor fields as quantum superpositions of Boolean statements supports this kind of universality. This gives good hopes that the contribution of the inner products between Fock states to the S-matrix elements are number field independent.
4. Dirac determinant can be defined as the product of the eigenvalues λ_n restricted to a given algebraic extension of rationals. The solutions of the modified Dirac equation correspond to vanishing eigen values and define zero modes generating conformal super-symmetries and are not of course included.
5. Only those operators b_n for which λ_n belongs to the algebraic extension of rationals in question are used to construct physical states for a given algebraic extension of rationals. This might mean an enormous simplification of the formalism in accordance with the fact that configuration space Clifford algebra corresponds as a von Neumann algebra to a hyper-finite factor of type II₁ for which finite truncations by definition allow excellent approximations [C7]. One can even ask whether this hierarchy of algebraic extensions of rationals could in fact define a hierarchy of finite-dimensional Clifford algebras. If so then the general theory of hyper-finite factors of type II₁ would provide an extremely powerful tool.

6 Consciousness and time

The new view about time implies has quite far reaching implications. The notion of 4-dimensional body is the basic concept involved. One can understand long term memories as communications with the geometric past. Sensory perceptions can be seen as memories of magnetic body about the state of the material body in a time scale of a fraction of second. Also some other unexpected symmetries are predicted. Long term memory and precognition seem to be aspects of one and a same phenomenon. The same applies to psychokinesis and retro PK. In fact, both sensory perception, motor action, and memory can be seen as being based on the same mechanism if one accepts that personal magnetic

body corresponds to "me". Libet's findings about active and passive aspects of consciousness provide empirical support for the notion of magnetic body.

6.1 Passive and active aspects of consciousness

The division of the aspects of conscious experience to active and passive ones is not so obvious as one might think. Sensory experiencing is more like building a piece of artwork than passive receipt of the sensory input and active processes like healing could be rather passive receipt of negative energy MEs from the patient so that the healee gets in this manner only metabolic energy and does the healing herself. It is also far from obvious whether precognition is passive experiencing of the geometric future or psychokinesis actively affecting it.

A precise theoretical dichotomy, at least apparently analogous to active-passive dichotomy, however exists if one accepts that MEs provide the basic mechanism of remote viewing and intentional action. Negative energy MEs can induce mere entanglement making sharing of mental images possible. This would naturally correspond to the passive aspects of consciousness as far as the receiver of negative energy MEs is considered. The generation of negative energy MEs makes possible remote metabolism at the end of system generating the negative energy ME. The receiver of the negative energy ME, say precognizer would be the passive counterpart whereas its sender, say an area of left cortex suffering from under-nutrition as might be in the case of synesthesia, would be the active counterpart. One must be however cautious here. It is not at all clear whether one can talk about sender/receiver of the negative energy ME since entanglement is completely symmetric process. In the sequel it is assumed that the notion of sucking of negative energy does not make sense.

Low frequency MEs can also contain also high frequency MEs inside them and positive energy MEs of this kind are especially natural for the realization of active aspects of consciousness. Positive energy MEs could directly provide energy to the receiver. They can also induce bridges along which various particles leak between space-time sheets so that basic metabolic activities are induced and controlled remotely.

6.2 Sensory perception, motor action, and time

TGD view about sensory perception differs dramatically from that of the standard neuroscience in that sensory organs are carriers of basic sensory representations and the magnetic body rather than body or brain is the experiencer with which we can identify ourselves. Magnetic body is also the intentional agent and both motor action, sensory perception, and long term memory which all involve also intentional elements, are based on the time mirror mechanism. Intentions are represented by p-adic MEs generated at the magnetic body. p-Adic ME is then transformed to a desire about a particular action and represented as a negative energy ME propagating to the direction of the geometric past. Actions are realized as responses to the negative energy MEs as various kinds of neural activities and as a generation of positive energy MEs. A more realistic model

involves an entire sequence of this kind of steps proceeding like a sequence of sub-program calls downwards along the hierarchy of the magnetic bodies down to the level of CNS. A good metaphor is obtained by regarding magnetic bodies as bosses in the hierarchy of some organization and CNS as the lowest level ultimately realizing the desire of the big boss.

6.2.1 Sensory organs as seats of qualia

According to the music metaphor, sensory organs are responsible for the music whereas brain writes it into notes by building symbolic and cognitive representations communicated to the magnetic body. Back projection to the sensory organs is an essential aspect of this process and is discussed in [K3]. Sensory perception at the level of magnetic body involves the generation of negative energy MEs entangling with sensory organs involving possibly also brain as an intermediate entangler.

The assumption that sensory organs are carriers of the sensory representations entangling with symbolic representations realized at the level of cortex does not mean any revolution of neuroscience, just adding something what is perhaps lacking [K3].

Neuronal/symbolic level would do its best to symbolically represent what occurs naturally at the level of qualia. Color constancy could be understood as a basic characteristic of color qualia represented symbolically at the neuronal level. Center-surround opponency for the conjugate colors is the neural counterpart for the contrast phenomenon in which the boundary for a region of the perceptive field with a given color carries the conjugate color (black-white opponency associated with the luminance is only a special case of this). The contrast phenomenon at the level of visual qualia could derive from the vanishing of the net color quantum numbers for the electrodes of the retinal color capacitors.

The basic prediction is the presence of the back projection at least in the sensory modalities in which hallucinations are possible. MEs with MEs mechanism is the most natural candidate for realizing the back projection, negative/positive energy MEs would realize the back projection based on quantum/classical communications, and the capacitor model of the sensory receptor can be applied to model photoreceptors and retina. This picture integrates nicely with the various speculations about the role of the ciliary micro-tubules in vision. The obvious question is how the presence and character of the back projection reflects itself in the structure of the sensory pathways and sensory organs.

Basic facts about how gastrulation and neurulation proceed during the development of the embryo, lead to testable hypothesis about the character of the back projection for various sensory modalities. According to the hypothesis, one can speak about "brain senses" and "skin senses" according to whether the back projection is based on quantum or classical communications.

6.2.2 How motor action differs from sensory perception?

There is a deep similarity between sensory perception and motor action in TGD framework, the basic difference being that classical signals propagate in different direction in CNS and in geometric time. Motor action is initiated by the magnetic body by the sending of negative energy to motor organs by generating negative energy MEs, and proceeds by similar processes backwards in the geometric time to the level of brain and magnetic body, very much like an instruction of a boss at the top of organization to the lower levels of hierarchy and induces lower level instructions. The analogy with computer program calls (quantum communications, desires) and their executions (classical signals, actions) is also obvious. Also classical signals from the magnetic body to the body and brain are possible.

Analogous picture applies to sensory perception with motor organs replaced by sensory organs except that the fundamental communications occur to geometric future from biological body to magnetic body via a hierarchy of EEGs. There is however also an active building of sensory percepts by feedback from the magnetic body which selects between quantum superposed alternative percepts already at the level of sensory organs.

Sensory *resp.* motor imagination differ from sensory perception *resp.* motor action only in that the magnetic body entangles with some higher level of CNS. Therefore there is no danger that imagined motor action would become real or that imagined sensory perception would be experienced as real. This picture is in accordance with the idea of quantum credit card implying maximal flexibility, and with respect to the geometric time would mean that motor actions are only apparently initiated from the brain.

6.2.3 Strange time delays of consciousness: experiments related to the active role of consciousness

Libet has carried out classical experiments about active and passive aspects of consciousness [54, 56]. It has gradually become clear that these experiments can be interpreted as a support for the identification of "me" as the personal magnetic body. The first class of experiments [54, 55] is related to the active role of consciousness. For example, the human subject moves his hand at free will. What happens is that neurophysiological processes (changes in EEG, readiness potential) start $T_1 = .35 - .45$ seconds before the conscious decision to move the hand whereas the awareness about the decision to move the hand comes $T_2 = .2 - .1$ seconds before the hand movement. Decision seems to be followed by the action rather than action by decision! This is in apparent accordance with the point of view that consciousness is indeed a passive spectator and the act of free will is pure illusion. What is interesting from the p-adic point of view, is that the most plausible estimates for the time delays involved are $T_1 \simeq .45$ seconds and $T_2 = .1$ seconds [55]. T_1 is very near to the p-adic time scale $T(6, 43) = .4$ seconds and T_2 to the fundamental p-adic time scale $T(2, 127)$ defining the duration of the memetic codon.

One can imagine two explanations for the paradoxical findings. The explanations turn out to be mutually consistent.

1. The geometric past changes in quantum jump

Quantum jump between histories picture explains the time delays associated with the active aspect of consciousness nicely and also gives an example of two kinds of causalities.

1. The simplest assumption is that the subjective experience of the hand movement corresponds to the moment, when subject person experiences that hand movement occurs.
2. The space-time surfaces (resulting as the final state of quantum jump) associated with the new quantum history differ in a detectable manner from the old quantum history already before the moment of hand movement since otherwise the new space-time surface would contain an instantaneous and discontinuous jump from the initial to final body configuration, which is not allowed by field equations. Same argument applies to the state of brain. $\Delta T \sim .5$ seconds seems to be the relevant time scale.
3. The attempt of the experimenter to be objective means that in an ideal experiment the observations correspond to the new deterministic history in the associated quantum jump and hence experimenter sees neurophysiological processes as the (apparent) cause of the hand movement with respect to geometric time. With respect to the subjective time the cause of the hand movement is the decision of the subject person.

2. Motor action is initiated from the magnetic body and proceeds to shorter length scales in reversed direction of geometric time

The vision that motor actions are initiated by magnetic body by feeding negative energy to motor organs and proceed upwards in CNS in a reversed time direction is in accordance with the idea of quantum credit card implying maximal flexibility and would mean that motor actions are only apparently initiated from brain. Motor organs send negative energy MEs to get metabolic energy, say to cortex. If there is lapse $\sim .5$ seconds involved then the observed lapse would find explanation. This view concretizes the idea about the editing of the geometric past and is consistent with the more general explanation discussed above.

This view about motor action means that it proceeds from long length scales to short ones whereas in the standard neuroscience view motor motor action would be planned and initiated in the brain and proceed to the level of motor organs, from short to long length scales. This certainly seems to be the case if one looks only the classical communications (say nerve pulse patterns). The extreme coherence of and synchrony of motor activities is however in conflict with this picture: neuronal communications are simply too slow to achieve the synchrony. This has been emphasized by Mae-Wan Ho [37]. Since quantum

communications proceed backwards in geometric time, classical signalling such as nerve pulses from brain to motor organs are actually reactions to the initiation of the motor action from the magnetic body.

6.2.4 Strange time delays of consciousness: experiments related to the passive role of consciousness

Libet's experiments [56] about the strange time delays related to the passive aspects of consciousness have served as a continual source of inspiration and headache. Every time I read again about these experiments, I feel equally confused and must start explanations from scratch.

What is so important and puzzling is that the backwards time referral of sensory experience is so immensely long: about .5 seconds. The time taken for nerve pulses to travel through brain is not more than .01 seconds and the time to arrive from sensory organs is at most .1 seconds (for axon with length of 1 meter and very slow conduction velocity 10 m/s). For the purposes of survival it would be advantageous to have a sensory input with a minimal time delay.

Why then this long delay? TGD inspired answer is simple: the "me" does not correspond to the material body but to the magnetic body associated with the physical body, and is analogous to the manual of electronic instrument, kind of a monitor screen to which sensory, symbolic and cognitive representations are projected by quantum and classical communications. Since the size of the magnetic body is measured using Earth's circumference as a natural unit, the long time lapse results from the finite velocity of light.

The following explanation is a variant of the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths. The basic sensory representations are realized at the level of the sensory organs and entangled with magnetic body whereas symbolic representations are either shared as mental images by or communicated classically to the magnetic body. This differs from the original scenario in which sensory representations were assumed to result by classical communications from brain to the magnetic body.

1. Communications from brain to magnetic body

One must consider two kinds of communications from body to magnetic body corresponding to positive energy MEs generated by at least brain and negative energy ME sent by magnetic body to at least sensory organs. The assumptions are following.

1. Negative energy MEs bound state entangle the magnetic body with the sensory representations realized at the level of sensory organs, and constructed using back projection from brain and possibly also from higher levels. Fusion and sharing sensory mental images is involved. Also the classical communication of memories to magnetic body could be involved with the build up of sensory and symbolic representations at the magnetic body. In both cases sensory representations are memories with the same

time lapse determined by the length of the MEs involved, a fraction of second typically if the magnetic body is of an astrophysical size. During sensory and motor imagination magnetic body entangles by negative energy MEs with some higher level of CNS.

2. Symbolic representations in brain can entangle with the sensory representations entangling in turn with the magnetic body so that CNS defines tree like structure with roots corresponding to sensory organs and branches and leaves corresponding to the higher levels of CNS. Direction of attention selects some path along this tree somewhat analogous to the path defining computer file in some subdirectory.
3. Symbolic representations of the perceptive field can be projected to the magnetic body using also classical signalling by positive energy MEs with phase velocity in a good approximation equal to the light velocity. For instance, if perceptive field contains something important, classical signal to the magnetic body could induce the generation of negative energy MEs turning attention to a particular part of perceptive field. Projection to the magnetic flux tubes of the Earth's magnetic field is possible. The spatial direction of the object could be coded by the direction of ME located in brain whereas its distance could be coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results. Field pattern could be realized the coding of information to bits in some time scale, perhaps even in the time scale of millisecond associated with the memetic code. Positive energy MEs generated by brain realize the representation and this implies time delay. In the original model it was assumed that the direction and distance of the object of perceptive field are coded as direction and distance at the magnetic body. The representations are expected to be rather abstract, and it might be enough to perform this coding at the level of magnetic bodies associated with the sensory organs.

2. Libet's findings

Libet's experiments [56] about the strange time delays related to the passive aspects of consciousness serve as a continual source of inspiration and headache. Every time one reads again about these experiments, one feels equally confused and must start explanations from scratch. The following explanation is based on the model of the sensory representations on the magnetic canvas outside the body and having size measured by typical EEG wave lengths [H4].

The basic argument leading to this model is the observation that although our brain changes its position and orientation, the mental image of the external world is not experienced to move: as if we were looking some kind of sensory canvas inside cortex from outside so that the motion of canvas does not matter. Or equivalently: the ultimate sensory representation is outside brain at a fixed sensory canvas. In this model the objects of the perceptive field are represented

on the magnetic canvas. The direction of the object is coded by the direction of ME located on brain whereas its distance is coded by the dominating frequency of ME which corresponds to a magnetic transition frequency which varies along the radial magnetic flux tubes slowly so that place coding by magnetic frequency results.

According to the summary of Penrose in his book 'Emperor's New Mind' these experiments tell the following.

1. With respect to the psychological time of the external observer subject person becomes conscious about the electric stimulation of skin in about .5 seconds. This leaves a considerable amount of time for the construction of the sensory representations.
2. What is important is that subject person feels no time delay. For instance she can tell the time clock shows when the stimulus starts. This can be understood if the sensory representation which is basically a geometric memory takes care that the clock of the memory shows correct time: this requires backwards referral of about .5 seconds. Visual and tactile sensory inputs enter into cortex essentially simultaneously so that this is possible. The projection to the magnetic canvas and the generation of the magnetic quantum phase transition might quite well explain the time lapse of .5 seconds.
3. One can combine an electric stimulation of skin with the stimulation of the cortex. The electric stimulation of the cortex requires a duration longer than .5 seconds to become conscious. This suggests that the cortical mental image (sub-self) is created only after this critical period of stimulation. A possible explanation is that there stimulation generates quantum phase transition "waking up" the mental image so that threshold is involved.
4. If the stimulation of the cortex begins (with respect to the psychological time of the observer) for not more than .5 seconds *before* the stimulation of the skin starts, both the stimulation of the skin and cortex are experienced separately but their time ordering is experienced as being reversed!

A crucial question is whether the ordering is changed with respect to the subjective or geometric time of the subject person. If the ordering is with respect to the subjective time of the subject person, as it seems, the situation becomes puzzling. The only possibility seems to be that the cortical stimulus generates a sensory mental image about touch only after it has lasted for .5 seconds. In TGD framework sensory qualia are at the level of of sensory organs so that the sensation of touch requires back-projection from cortex to the skin. If the formation of back projection would takes about .5 seconds the observations can be understood. Genuine sensory stimulus creates cortical mental image almost immediately: this mental image is then communicated to magnetic body (time like entanglement).

5. If the stimulation of the cortex begins in the interval $T \in [25 - .5]$ seconds *after* the stimulation of the skin, the latter is not consciously perceived.

This effect - known as backward masking - looks really mysterious. It would be interesting to know whether also in this case there is a lapse of .5 seconds before the cortical stimulation is felt.

According to the TGD based vision sensory mental images are at the level of sensory organs and brain constructs symbolic representations about them using intensive back-projections to the sensory organs. These representations give rise to a decomposition of the perceptive field to standardized sensory mental images. The most effective manner to achieve back-projection is by using negative energy signals propagating backwards in geometric time just like in the case of intentional action. Accepting this framework one can at least make questions.

i) Could the stimulation of the cortex induce a negative energy back-projection signal to the skin representing a stimulus effectively interfering to zero with the real stimulus? That the skin stimulus is perceived consciously for $T < .25$ seconds means that the compensating back projection is sent only if cortex has received information about skin stimulation. One can imagine that it takes .25 seconds to form a symbolic representation about the sensory mental images at sensory organ. Why the back-projection would compensate the skin stimulus?

It is known that brain acts like a highly selective gardener applying strong inhibition to certain sensory stimuli and strong excitation to others in order to build percepts. If this principle applies also in time domain - as it should if the paradigm of 4-D brain is accepted- the elimination of the sensory stimulus could be seen as a tendency to build sensory percepts which are sharply localized in time. A precise localization in time is indeed important in the case of sensory percepts.

Second explanation would be based on compensating back-projection. Everyone who has been swimming in windy sea, feels the waves for a long time after coming to the shore. This sensation would correspond to back-projection in TGD framework but it is not clear to me whether this back-projection tends to compensate the actual sensation in order to achieve metabolic economy.

ii) Could it be that the skin stimulus is actually consciously perceived but that this experience is not remembered? In TGD framework the memory about skin stimulus would be realized as a skin stimulus still continuing in the geometric past. If the cortical stimulation for some reason modifies the geometric past by destroying the skin stimulus using back-projection, there would be no memory about the skin stimulus.

6.3 Long term memories and time

TGD based model of long term memory requires no storage of memories of past to the brain of the geometric now. The memories are in the geometric past as dynamical self organization patterns and subject to changes.

1. In the case of active memory recall the desire to remember is communicated to the geometric past by sharing and fusion of mental images made possible by entanglement. In the case of episodal memories also the memory recall would result in this manner. For non-episodal memories the memory would be communicated from the geometric past using classical communications.
2. In the case of episodal memories active precisely targeted memory recall might be difficult since the entanglement with a correct mental image seems to require good luck. In principle it is possible to select the distance T to the geometric past where the memory comes from by selecting the fundamental frequency of ME. There are huge amounts of information, which is useless unless the person is an artist. Ironically, the loss of cognitive abilities would be compensated by episodal memories providing mental powers making an idiot a genius able to tell whether a given number is prime and to perform extremely complex calculations. A mild variant of the idiot savant phenomenon can be induced artificially by trascranial magnetic stimulation even in ordinary persons [57]. The miraculous memory feats of synesthetes and idiot savants, and also sensory memories and strange abilities induced by electric and transcranial magnetic stimulation could involve the entanglement of the stimulated brain areas rather than that of magnetic body with sensory representations with brain areas taking the role of sucker of positive energy. In this kind of situation the starving magnetic body could send negative energy sensory MEs to a more distant geometric past and experience episodal memories instead of the sensory input.
3. Classically communicated memories are symbolic and thus the amount of information is minimized. They are also reliable since it is enough for the brain of the geometric past to share the desire to remember. If the desire is communicated to a wide temporal range in geometric past, some self of the geometric past is able to communicate the answer. Context sensitivity is the drawback of this memory mode. Memes defined as sequences of memes defined by sequences of 21 DNA triplets might define what might be called universal language helping to overcome the context sensitivity [L1].
4. Brains could also generate automatically classical signals about often needed declarative memories to the geometric past at various lengths of magnetic flux tubes. The memory recall would require only the tuning to receive the classical signal. This would require an organization of brain analogous to sensory areas so that a particular neuron group is tuned to receive signals from a particular distance to geometric past. One can also imagine a situation in which the communication of the memory from the past occurs as repeated communications over shorter time interval, somewhat like ordinary communications using radio stations receiving and re-sending the message. For instance, classical communications could circulate around the magnetic loops associated with the personal magnetic body or that

of Earth's magnetic field much like neural signals in neural circuits. This would make the memory retrieval more reliable. The automatic classical communications could be also involved with the communications by active memory recall. The extreme situation would be the transfer of information from the geometric past like a news about some event in a population via communications between individuals. This mechanism would also establish the memory representation along the entire life span.

6.3.1 Basic model for memory recall

For the time-mirror model of long term memory the ULF dark MEs must be generated both at the personal magnetic body and in the brain.

1. At the personal magnetic body cyclotron phase transition would give rise to negative energy neutral MEs sucking energy from the biological body of the geometric past. This radiation would be reflected back to the geometric future as positive energy neutral MEs. The response would depend on the state of the brain. Motor action would differ from memory recall only in that it would involve negative energy W MEs inducing exotic ionization at both ends and leading to a physiological outcome. The entanglement via W MEs could induce direct sensory memories relying on sharing and fusion of mental images.
2. The ULF radiation representing the response to the memory recall would correspond to Josephson radiation giving rise to a scaled up dark EEG in the relevant time scale characterized by the level of the dark matter hierarchy. The size of Josephson junctions assignable to cells and cell structures would be scaled up from cell membrane thickness by a power λ^k , $\lambda \simeq 12^{11}$ at the k^{th} level of the dark matter hierarchy and magnetic flux quanta would define the Josephson junctions naturally. The de-coherence of higher level dark photons to single ordinary EEG dark photon or their decay to EEG dark photons is probably involved with the memory call and would transform the response from the geometric past to ordinary cognitive and emotional input at personal magnetic body.

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

Higher levels of dark matter hierarchy provide neat quantitative view about self hierarchy and its evolution. For instance, EEG time scales corresponds to $k = 4$ level of hierarchy and a time scale of .1 seconds [J6], and EEG frequencies correspond at this level dark photon energies above the thermal threshold so that thermal noise is not a problem anymore. Various levels of dark matter hierarchy would naturally correspond to higher levels in hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question.

The level would determine also the time span of long term memories as discussed in [M3]. $k = 7$ would correspond to a duration of moment of conscious

of order human lifetime which suggests that $k = 7$ corresponds to the highest dark matter level relevant to our consciousness whereas higher levels would in general correspond to transpersonal consciousness. $k = 5$ would correspond to time scale of short term memories measured in minutes and $k = 6$ to a time scale of memories measured in days.

The emergence of these levels must have meant evolutionary leap since long term memory is also accompanied by ability to anticipate future in the same time scale. This picture would suggest that the basic difference between us and our cousins is not at the level of genome as it is usually understood but at the level of the hierarchy of magnetic bodies [L2, M3]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible social rules and moral.

6.3.3 How to achieve precisely time-targeted communication to and from geometric past?

Negative energy MEs are ideal candidates for sending a signal to the geometric past and inducing entanglement and sharing of the mental image representing the desire to remember. The magnetic flux tubes of the personal magnetic body with sizes measured in light years in turn can act as wave guides along which the negative energy curvilinear MEs propagate along or are parallel to. Also negative energy em MEs are possible since negative energy MEs interact very weakly with the external world in any case. Also the positive energy MEs sent to the direction of the geometric future as a response and representing classically communicated declarative memories would propagate along magnetic flux tubes. The same magnetic flux tube could be used for both communications.

One can consider several variants about how long terms memories are realized as communications between geometric now and geometric past.

1. *Mirror model*

The original idea was that MEs could be reflected at the ends or kinks of a magnetic flux tube serving as kind of mirrors. The outcome was the mirror model of long term memory in which the signal from the geometric past represented by ME is reflected at the end of the magnetic flux tube of astrophysical size. In the similar manner also the negative energy ME would be reflected. The model was still based on the idea that "me" is the physical body or brain. The basic objections are that there is no convincing identification of the mirrors and there is no guarantee that the mirrored ME returns to the original brain.

2. *Loop model*

One can also consider the possibility that closed magnetic flux tubes associated with the personal magnetic body could function as wave guides for curvilinear MEs, so that MEs would automatically return to the brain if they

propagate while attached to the boundary of a closed magnetic flux tube. Also this model is still based on idea that the size of the personal magnetic body is not much larger than Earth's size so that one can idealize "me" as brain, at least in the length scale defined by the time span of the long term memories. Furthermore, despite the fundamental similarity between motor action, sensory perception, and memory, the mechanism of long term memory would differ from the mechanism of motor action and sensory perception. A further serious objection is that MEs parallel to the closed magnetic flux tubes and representing closed topological light rays might not be allowed as solutions of the field equations.

3. Brain and body as time like mirror

If one takes completely seriously idea about "me" as the magnetic body with size at least of order light lifetime which can be regarded as single quantum coherent structure, one ends up to a variant of the model a). First of all, the whole magnetic body becomes the experiencer and classical communications need not be spatially precisely targeted. Secondly, brain and body serve as time like mirrors in the sense space-like reflection is replaced with both spatial and temporal reflection. Negative energy ME characterized by frequency and wave vector is replaced with time reflected positive energy ME: $(-E, -k) \rightarrow (E, k)$ in the reflection. Ideal reflection changes only the sign of the normal component of 3-momentum. If this is the case also now then also the magnitude of energy would be conserved so that the classically communicated memory would be automatically communicated to a correct temporal position in the geometric future.

If the transverse area S of flux tube codes for the temporal distance T to the geometric past by its transverse area ($T \propto S$) and thus by cyclotron frequency scale, the mechanism of long term memory becomes precisely identical with that of sensory perception and motor action. The desire to remember is communicated quantally from the magnetic body to brain along flux tube, and the reply arrives as a classical communication along same flux tube at the fundamental frequency and the reply communicated classically generates cyclotron transitions at the receiver's end at a correct temporal distance in future. In light of the fractality of consciousness, this model is certainly the unique one and is certainly consistent with the field equations.

The memory mental image communicated classically should reach the temporal position of the 4-D brain, which communicated the desire to remember. High precision communication is not absolutely necessary although it is favored by metabolic considerations: it is enough that the memory is communicated to a time interval containing the temporal position wherefrom the desire to remember was communicated. Memory could even diffuse like an interesting news in a 4-D society formed by mental images in brains at different times.

If MEs are amplified by Alfvén wave resonance (closed magnetic flux tubes or flux tubes with ends), the wave length of ME should correspond to the length of the magnetic flux tube involved. If negative and positive energy MEs are associated with same magnetic flux tubes and the thickness of the magnetic

flux tube varies as $S \propto L$, cyclotron transitions occur automatically at a correct temporal and spatial position of the flux tube and the sender of the memory recall receives the answer. In this case however memory is communicated to some time interval in geometric future.

If temporally selective communication is required, the frequency associated with ME must correspond to the same time value for the negative and positive energy MEs involved. A relative precision of $\Delta f/f \simeq 10^{-9}$ is required if the time span of the memory is 10 years and precision about .1 seconds (sensory memories). Of course, the needed precision could be much lower already because the time span of short term memories is of the order of minute. The active loss of memories could result from the refusal or inability of the "mes" of the geometric past to communicate memories or of the "me" of now to generate memory recalls. Later a model of time like reflection which could conserve the frequency with this precision will be discussed.

Second solution to the problem is to have several copies of the memory mental image so that the probability to hit one of them is high. Very probably brain applies this trick. This would explain why the standard model for long term memories seems to work reasonably well.

4. Variants of the time-mirror model

One can consider several variants of the time-mirror model.

1. For the simplest model the MEs involved are more or less linear structures. For classical communications with light velocity the lengths $L = cT$ of the flux tubes would be measured in light years for a typical time span T of long term memory. If the memory recall originates simultaneously from various points of the magnetic body, the reply to the memory recall is received simultaneously by different part of the personal magnetic body in the approximation that the response at the biological body is instantaneous (so that also the received response emerges instantaneously). For EEG phase velocities L would be of the order of the size of the magnetic body of Earth for typical values of T so that the declarative memory could be communicated also to the magnetic Mother Gaia responsible for the third person aspects of the memory.
2. What is intriguing that for a typical EEG phase velocity v the distance $L_B = vT$ travelled during T corresponds to a wave length $\lambda = L_B = c/f_{high}$ of EEG wave propagating with light velocity. This brings strongly in mind the scaling law of homeopathy and its generalizations [K5], and suggests that the boundary ME corresponds to EEG wave with EEG phase velocity v . This numerical coincidence encourages to consider also time like reflection in which energy is not conserved. The scaling law of homeopathy suggests that low frequency negative energy ME could transform in the reflection to high frequency positive energy ME:

$$f_{low} \rightarrow f_{high} .$$

This transformation could be interpreted in terms of the Alfvén resonance condition $f_{high} = c/L_B$ for a ME propagating in the flux loop of length L_B (recall however the objection against closed topological light rays).

3. Positive energy EEG MEs could propagate with light velocity along the closed loops of personal magnetic body of Earth's magnetic field and return again and again to brain very much like neural signals circulate in neural circuits. This would provide a manner to refresh often needed memories. The main theme of [N1] was indeed the fractal correspondence between the structures of the brain and magnetosphere.
4. Fractality suggests that magnetic loops of all possible sizes are involved with classical communications by boundary MEs, even the magnetic loops of the material body serving as templates for neural circuits. The requirement that frequencies are identical for these fractally scaled magnetic circuits could be seen as an entrainment phenomenon. This would predict ultra-slow neural signals serving as correlates for the classical communications of long term memories at brain level. It is indeed known that Ca_{++} have extremely wide velocity spectrum [58].

The model based on W MEs as inducers of motor actions explains these velocities explains these velocities differently. Classical W field depends on the light like longitudinal coordinate and single transversal coordinate. One expects that the maxima for the intensity of W field are the loci around which physiological effects concentrate. These maxima in general propagate in the transversal direction. This velocity could correspond to the velocity of the physiological wave.

6.4 Remote mental interactions and time

If the notion of magnetic body is taken completely seriously, sooner or later comes the realization that not only motor action, sensory perception, and memory, but also various forms of remote mental interactions could be based on essentially the same mechanism. Motor action and memory recall certainly involve the active aspect but so does sensory perception via direction of attention and selection between percepts.

Magnetic bodies are the intentional agents, and accompany even "non-living" targets. The intention of the magnetic body to achieve something is transformed first to a negative energy ME representing the communication of the desire to achieve something to the geometric past by sharing of mental images. Already the sharing of mental images might be enough, as in the case of remote viewing of the geometric past, in special case long term memory. Then the receiver of the negative energy ME, be it lower level magnetic body or material body, tries to realize the desire and generates classical signals. These signals could be also positive energy MEs and could propagate back to the magnetic body as in case of declarative memory recall. They could also propagate

to another magnetic body, which would mean that mind-mind interactions are involved.

This unified view means that the distinction between active and passive aspects of remote mental interactions is far from trivial, and it is not so easy to tell where the boundary line between precognition and psychokinesis is. The first realization along these lines was that precognition and long term memory are different aspects of the same phenomenon. Then came the idea that also PK and retro PK could be seen as different aspects of the same phenomenon if PK can be regarded a generalized motor action in which target becomes effectively part of the body of the psychokinesist.

6.4.1 A possible view about remote viewing

The basic question is whether negative energy MEs are always generated actively by the system in the geometric future or whether also active sucking of the negative energy from the geometric future is possible. The simplest assumption is that the sucking of negative energy is not a sensible concept. The motivation comes from the fact that it seems to be impossible to distinguish between sucking and passive receipt of the negative energy since the entangled systems are in a completely symmetric position.

1. *Active and passive aspects*

Whether one can regard remote viewing as active or passive process depends on whether it is geometric past or future which is viewed.

1. If geometric future is viewed, the task of the remote viewer is to tune to the "correct wave length" in order to be able to receive the negative energy ME from the geometric future. This requires that remote viewer tries to get rid of mental images competing for the metabolic resources and tend to mask the viewed mental image. The initiative is possessed by the system in the geometric future sending the negative energy ME. The reaction of the remote viewer realized as classical communications could give rise to PK effect in the target. If the time-mirror mechanism based on induced phase transition is involved also with remote viewing, the reaction of remote viewer would be automatic so that some kind of PK effect would be unavoidable.

One cannot completely exclude the possibility of time reversed classical communications. In ordinary classical communications the high frequency positive energy MEs absorbed by the receiver kicks it to a higher energy state wherefrom it returns to the ground state spontaneously. A system receiving high frequency negative energy MEs inside low frequency negative energy ME can drop to a lower energy state only if the magnitude of the energy is below thermal energy or if the system is analogous to population inverted laser. In the latter case the receiver would not however return spontaneously to the original state unless there is a feed of energy to the system.

2. If the geometric past is viewed, the process is active process and completely analogous to long term memory recall except that negative energy MEs generated by the remote viewer are not received by the brain of the viewer but some other system. Note that now also classical communications are possible and would be analogous declarative memories. These communications might be possible if the target is living system and be based on memetic code using the common vocabulary defined by common memes [L1].

2. Sharing of mental images

Since remote viewing by the sharing of mental images does not involve classical communications at all so that one cannot characterize the process in terms of bit currents. There are indeed arguments that if the field patterns of EEG waves were responsible for the remote viewing realized as classical communications, the bit rates required would not be high enough since the frequency defines an upper bound for the bit rate [59].

Sharing of mental images does not pose any obvious upper bound for the amount of conscious information transferred. Measures for the amount of information contained by mental image could be provided by the number theoretical information measures predicted by TGD approach [H8, H2].

What would be communicated would be more like impressions instead of messages consisting of symbol sequences. The message, say visual perception, would contain huge amounts of irrelevant information. Of course, the mental images could be also cognitive or symbolic representation, say internal speech. The translation of these impressions to language involves cognition and analytic thinking and can lead to misinterpretations. The reports about telepathic communications suggest that mental images transferred in telepathic communications are fragmented: more like sensory and emotional impressions and often what might be regarded as separate "features" of the perceptive field rather than complete percepts. If sensory organs are the seats of the sensory representations, telepathy should thus involve entanglement of the viewer with the brain of the sender containing the symbolic representations. Fragmentation would reflect that fact that brain does for sensory input same as catabolism makes for food.

It is known that the entropy gradients associated with the target correlate with the probability that target is remote viewed [60]. In TGD framework this can explained as a basic characteristic of conscious experience [K3]. All gradients, also spatial gradients, such as textures of visual field or gradients of illumination at particular wave length, are transformed to subjecto-temporal gradients and only changes are perceived in accordance with quantum jump as moment of consciousness identification. In TGD Universe the intensities of emotions are proportional to the gradients of entropies associated with various quantum number and zero mode increments and only objects generating strong enough emotional response catch the attention. Targets with low entropy gradients do not generate intense mental images in any perceiver (not necessarily

human!), and thus do not generate remote perception by a sharing of mental images.

3. Remote viewing is not only viewer-target phenomenon

Remote viewing does not seem to be only a viewer-target phenomenon but involves many-brained magnetospheric selves receiving information from the brains involved with the typical experiment whose protocol is such that viewer does not know the location of the target. In particular, the ability of the remote viewer to view target about which he knows only coordinates having no significance as such to him but for someone involved with the protocol supports this view [34]. Also the reported healings induced by prayer groups and meditation groups whose members do not know the healees and even where they are, support the same conclusion [35]. Thus remote viewing as well as healing might involve multiple entanglement. For instance, healer would be entangled with higher level self in turn entangled with the healee. Fractality suggests that one could apply the wisdom about brain functioning to the modelling of the multi-brained selves. The notion of associations might make sense for instance. The analogy with brain encourages to think that also classical communications by positive energy MEs might be involved and make possible feedback and thus PK.

An interesting practical question is how to characterize the strength of the entanglement by negative energy MEs. The lifetime of the resulting bound state is one such measure. One could guess that this time scale is of the order of the relevant p-adic time scale. Somewhat paradoxically but in consistency with Uncertainty Principle, the duration would be the longer, the weaker the binding energy would be. Second measure is the number of MEs involved. If collective multi-brained selves are involved the number of brains involved and having information about target would be a significant factor.

6.4.2 Sharing of mental images as the basic mechanism of remote viewing

Sharing of mental images does not require neither target nor receiver to be able to communicate symbolically. Therefore the target and receiver could be any living system: animal, plant, even bacterium. In TGD Universe one cannot exclude even "non-living" systems as targets and even sharers of mental images. The remote viewing of non-living targets is indeed possible and in this case either mental images of target or some system perceiving target are shared.

Support for the extreme generality of the sharing of the mental images as a basic mechanism of remote viewing comes the fascinating experimental discoveries made by Cleve Backster [61, 62]. These findings have led Backster to introduce the notion of primary perception, which seems to have a natural identification as sharing of mental images.

1. Plants, eggs, and even bacteria are able to have primary perceptions. Backster tells in the interview that even yoghurt got wild when he took a

chicken out of refrigerator and began pulling off strips of meat. Plants respond electrically to strong negative emotions and to the violence or death suffered by other living organisms. That primary perception correlates with the strength of emotions conforms with the view that entropy gradients with respect to subjective time, which are indeed identifiable as emotions, measure the strength of perception.

2. Distance does not seem to matter much. Sperm separated by a large distance from its donor reacted when the donor inhaled amyl nitrate. White cells were found to remotely react to the emotions of their donors. Same was found to apply to plants and their owners.
3. Plants and even bacteria seem to have a defence mechanism resembling shock. If bacteria share the mental images of suffering organisms by receiving negative energy MEs sent by them, the shock could be interpreted as resulting from the depletion of positive energy resources (all excited states of population inverted many-sheeted lasers decay to the ground state) or be a mechanism preventing this depletion.

An interesting question is whether humans have lost this ability or is this reaction usually unconscious at our level of self hierarchy and whether human skin could exhibit GSR to say death of other life-forms.

6.4.3 Precognition and memory as different aspects of the same phenomenon?

It is tempting to see precognition and long term memory as different aspects of the same phenomenon involving sharing of the mental image resulting as fusion of mental images by time-like entanglement induced by negative energy ME.

1. This identification would explain why precognition is a rare instance whereas memories would pop up more or less spontaneously. The reason is that precognition means giving energy to the future self whereas memory means receiving it. During wake-up period brain has to utilize its metabolic energy to build sensory representations, to plan and realize motor actions, and cognize. Therefore not much energy is not available unless these activities are silenced. This kind of silencing is indeed a prerequisite for precognition [34].
2. Sleep state is for metabolic reasons ideal for precognition. During sleep state it is however the larger self resulting as a fusion of brain with some other self which precognizes, so that these precognitions are usually not remembered. It should be however possible to precognize during dreams, especially so during lucid dreaming. The problem is that dreams are forgotten very rapidly unless they are documented immediately. The classic work "Experiment with time" of Dunne provides strong support for the prediction that dreams can be precognitive [63]. Also Joe McMoneagle has told in his book about heightened precognitive abilities during lucid

dreaming [34]. Probably almost anyone has had dreams which develop logically to the ringing of the alarm clock.

3. In this picture the one who remembers, that is generates negative energy ME, is a natural candidate for the active participant in the process. Therefore precognizer can only calm his/her mind and try to "tune at the same wave length" in order to entangle with the self of geometric future and try to eliminate the mental images that would mask the precognized one and compete for metabolic resources. The tuning to the same wave length has quite literal meaning since the fundamental frequency of ME determined by its temporal duration characterizes what might be called the extension of the memory field. There is indeed evidence for the notion of memory field [64]. If memory and precognition are aspects of the same phenomenon then also the notion of precognitive field makes sense.

6.4.4 PK and retro PK as essentially same phenomenon?

The ideas that PK is just motor action with target taking the role of the motor organs and motor action involves negative energy W ME leads to a new view about PK and retro PK.

1. Ordinary motor actions are initiated by higher level selves by sucking negative energy from motor organs and the process proceeds upwards in CNS to the direction of geometric past wherefrom classical response comes from. In the case of PK this would mean that psychokinesis would be initiated by psychokinesists by sucking energy from the target by sending negative energy MEs to the target. If this picture is correct, all motor actions, in particular PK, would be by definition retro PK since the reaction would occur in the geometric past always and only the time scale of the time lapse would distinguish between PK and retro PK.
2. One can of course imagine also a situation in which positive energy W MEs are generated and exotically ionize and entangle part of brain with a system located in the geometric future. Certainly this mechanism is not the one favored by the life in jungle. It is also far from obvious whether magnetic body has the needed metabolic energy resources to generate positive energy W MEs.

In the case of non-living targets one can imagine that PK able person is able to transfer the metabolic energy of his own biological body to the target, perhaps by sucking it first to his own magnetic body and sending then to the target. Target could also generate negative energy MEs send most naturally to motor organs or perhaps skin of the psychokinesist. This could induce the flow of various particles to say atomic space-time sheets, where they can induce dissipative effects. This and the universality of metabolism based on zero point kinetic energies forces to consider quite seriously the possibility that the magnetic body of almost any system can be a conscious experiencer or an intentional agent.

3. Not all targets are optimal. Targets should allow the generation of dark plasmoids giving rise to dark plasma oscillations. Capacitor like systems near di-electric breakdown would be optimal in this respect and this kind of systems has been used in PK experiments (this is discussed in [H9]). Targets made of organic material are also favored. If all PK is actually retro PK, PK is possible only if the target is able to provide or receive from some source the metabolic energy needed. Organic or living targets would be optimal but one might expect that living systems have developed immune systems in order to avoid of becoming possessed by alien magnetic bodies. There are indeed reports about PK effects on films which have gelatin as one component [69]: I have discussed a model for these effects in [K5].
4. MEs can also play a role of mere control function by acting as bridges along which particles can flow between various space-time sheets but not accelerating the charges. The flow of particles between say magnetic flux tubes and atomic space-time-sheets induces a recoil effect and the explanation for the report of Modanese and Podkletnov [67] about a new kind of radiation which induces motion of material particles without giving them appreciable energy, supports the view that this recoil effect can induce macroscopic motion. Also the model for the PK effects induced by Russian psychokinesists in charged objects at table near the critical potential inducing discharge leads to the idea that the flow of ions between space-time sheets inducing recoil effects is responsible for PK effect [H9]. Psychokinesist would provide the energy needed for the control of motion but that part of the momentum could come from (say) magnetic flux tubes carrying the ionic supra currents.
5. The idea about long term memory and precognition as different aspects of the same phenomenon does not generalize as such. Psychokinesist would perform (retro) PK to the target while living target could communicate sensory data as a reaction to the motor action coded into Josephson radiation giving rise to generalized EEGs. Hence remote sensing could appear as one aspect of PK and make possible controlled OK in the case that direct sensory input from the target is not available.

In the famous chicken-robot [65] experiments chicken was imprinted to a robot with the consequence that the robots motion in room coded earlier to a random number sequence changed so that the robot tended to stay near chicken. In this case one could say that chicken performed retro PK in the computer program responsible for generating the random number sequence or sequence itself by generating negative energy MEs. The resulting PK effect on chicken was at the level of chicken brain and provided for chicken metabolic energy. Perhaps the interaction between child and parents involves a similar transfer of energy.

6.4.5 From remote viewing to quantum remote sensing?

Ordinary remote sensing technology is limited by the finite velocity of light making it impossible to remote sense actively objects that are too faraway. Time mirror mechanism (see Fig. 9.4) not only makes it possible to survive utilizing .3-.5 seconds old sensory data but also suggest a technology of active remote sensing based on time reflection at the studied object and thus involving no time lapse, and making possible remote sensing of arbitrarily distant, even astrophysical, objects.

A phase conjugate laser wave would travel to the geometric past and time-reflect back as an ordinary laser wave from an object containing population inverted many-sheeted laser mirrors. If negative energy ME is able to draw some critical number of particles to the ground state, a phase transition to the ground state occurs since the rate for the transition is proportional to the number of particles already existing in the ground state. The only additional condition is the presence of the many-sheeted population reversal. This condition could be satisfied for living matter at least.

Dela-Warr camera [66] might be based on this mechanism. Even more science-fictionally and a little bit of tongue in cheek, one can consider also the possibility of communicating with the civilizations of the geometric future by using population inverted lasers. Send to the geometric future classical k -bit signals (k harmonics of the fundamental) at p -adic frequencies $f(n, k)$ to tell that we have discovered p -adic cognitive codes, and wait whether the population inverted lasers at these frequencies return to the ground state with an abnormally high rate! One can easily imagine simple codes for communication. For instance, for p -adic length scales corresponding to visible wave lengths the typical number of bits would be 163.

In the technological context remote metabolism would translate to a remote utilization of energy stores making un-necessary the costly transport of the fuel. Only negative energy signal of critical intensity would be required to generate amplified positive energy signal from the geometric past providing the energy instantaneously and over long distances. For instance, the need to carry large amounts of fuel and the limitations posed by the maximal classical signal velocity are the basic problems of the space technology. The technological variant of the remote metabolism might provide at least a partial solution to these problems.

7 About the nature of time: few years later

The notion of time remains one of the most problematic concepts of physics. In classical physics the different properties of the time of Newton's equations and thermodynamical time are puzzling. In special relativity and general relativity the notion of simultaneity becomes a problematic concept and challenges the naive Newtonian view about time flow as a motion of 3-D time=constant snapshot of 4-D space-time. The replacement of time=constant 3-surface with past directed light-cone assignable to the world-line of observer resolves this problem.

In general relativity the problem is that past light-cones need make sense only locally. In quantum measurement theory the localization of the state function reduction process into a finite space-time volume is in conflict with the determinism of Schrödinger equation. In biology the presence of self-organization processes like self assembly challenge second law of thermodynamics in short time scales. In neuroscience the finding of Libet suggesting that neural activity seems to precede conscious decision forces to give up the notion of free will or the naive identification of experienced and geometrical time.

The construction of quantum TGD leads to a radical revision of space-time concept (many-sheeted space-time and topological field quantization), and forces also to generalize the original view about imbedding space. p-Adic physics as physics of cognition and intentionality is part of TGD inspired theory of consciousness and the need to fuse real and p-adic physics to single coherent whole forces to revise the notions of number and space-time. It has been also necessary to replace the standard positive energy ontology with what I call zero energy ontology. These generalizations are of special importance in TGD inspired theory of consciousness and of quantum biology.

There are several first principle approaches to quantum TGD and following gives only a very concise summary of them.

1. Generalization of Einstein's program of geometrizing classical physics so that quantum theory can be seen as a theory of *classical* spinor fields in the world of classical worlds (WCW) consisting of light-like 3-surfaces and possessing Kähler geometry [B2, B3, B4]. By general coordinate classical physics becomes an exact part of quantum theory in a well-defined sense. A geometrization of Fermi statistics is obtained, and the Clifford algebra associated with the spinors of WCW can be regarded as a direct sum of von Neumann algebras known as hyper-finite factors of type II_1 (HFFs) closely related to quantum groups and non-commutative geometry;
2. Quantum TGD as almost topological field theory (TQFT) with fundamental objects identified as light-like 3-surfaces and having generalized super-conformal symmetries as symmetries [C1, C2]: the notion of braid is the basic building block of this approach;
3. There are two kinds of conformal symmetries corresponding to the boundary of light-cone of Minkowski space and light-like 3-surfaces, and these symmetries alone dictate to high degree the physics. Quite recently it turned that also a symplectic analog of conformal field theory emerges naturally in TGD framework (super-canonical symmetries) and this led to a concrete proposal for how to construct n-point functions needed to calculate M-matrix [16];
4. Physics as a generalized number theory involving three different threads corresponding to need fuse real and various p-adic physics to single coherent whole by using a generalization of number concept obtained by gluing reals and various p-adic number fields and their extensions together

along rationals and common algebraics [E1]; the observation that standard model symmetries and dynamics of quantum and classical TGD are to high degree dictated by classical number fields [E2]; and the ideas inspired by the notion of infinite prime [E3];

5. The identification of WCW Clifford algebra elements as hyper-octonion (subspace of complexified octonions spanned by real unit and octonionic imaginary units multiplied by the commuting additional imaginary unit) valued conformal fields having values in HFF provides a justification for the concept of number theoretic braid needed both in the fusion of real and p-adic physics and in TGD as almost TQFT approach;
6. The hierarchy of Planck constants realizing quantum criticality [C8] forces a generalization of the notion of imbedding space by replacing it with a book like structure having as its pages singular coverings and factor spaces of H and allowing to realize geometric correlates for the choice of quantization axis in quantum measurement: the particles at different pages of this book are "relatively dark" since they do not possess local interaction vertices which means a radically new manner to interpret dark matter;
7. Zero energy ontology and the notion of finite measurement resolution formulated in terms of inclusions of HFFs fix quantum dynamics highly in terms of Connes tensor product allowing to interpret quantum theory as a square root of thermodynamics [16, C2]: finite measurement resolution has number theoretic braid as its space-time correlate so that various approaches to TGD are closely related;
8. Quantum theory of consciousness as a generalization of quantum measurement theory to include observer to the theory [18].

The notion of number theoretic braid is a common denominator of various approaches to quantum TGD and leads to effective discretization of the imbedding space which is however due to the finite measurement resolution and number theoretic constraints rather than being something fundamental so that there are no problems with standard conservation laws.

The article series about TGD and its applications to biology and consciousness [16, 18, 19, 20, 21, 22, 23, 24] gives an overall view about quantum TGD. In the following I will concentrate only on the aspects of quantum TGD relevant for the notion of time. I will first describe zero energy ontology and p-adicization program and after that consider the problem of time.

8 The most recent vision about zero energy ontology and p-adicization

The generalization of the number concept obtained by fusing real and p-adics along rationals and common algebraics is the basic philosophy behind p-adicization.

One must be able to speak about rational points common to real and various p-adic variants of H . The basic objection is the necessity to fix some special coordinates in turn implying the loss of a manifest general coordinate invariance. The isometries of the imbedding space could save the situation provided one can identify some special coordinate system in which isometry group reduces to its discrete subgroup. The loss of the full isometry group could be compensated by assuming that WCW is union over sub-WCWs obtained by applying isometries on basic sub-WCW with discrete subgroup of isometries.

The combination of zero energy ontology realized in terms of a hierarchy of causal diamonds (CD s) and hierarchy of Planck constants providing a description of dark matter and leading to a generalization of the notion of imbedding space suggests that it is possible to realize this dream. The article [16] provides a brief summary about recent state of quantum TGD helping to understand the big picture behind the following considerations.

8.1 Zero energy ontology briefly

1. The basic construct in the zero energy ontology is the space $CD \times CP_2$, where the causal diamond CD is defined as an intersection of future and past directed light-cones with time-like separation between their tips regarded as points of the underlying universal Minkowski space M^4 . In zero energy ontology physical states correspond to pairs of positive and negative energy states located at the boundaries of the future and past directed light-cones of a particular CD .
2. CD s form a fractal hierarchy and one can glue smaller CD s within larger CD s. This construction recipe when combined with TGD inspired theory of consciousness allows to understand the asymmetry between positive and negative energies and why the arrow of experienced time corresponds to the arrow of geometric time and why the contents of sensory experience is located to so narrow interval of geometric time. One can imagine evolution to occur as quantum leaps in which the size of the largest CD in the hierarchy of personal CD s increases in such a manner that it becomes sub- CD of a larger CD . p-Adic length scale hypothesis [16] follows if the values of temporal distance T between tips of CD come in powers of 2^n : $T = 2^n T_0$. All conserved quantum numbers for zero energy states have vanishing net values. The interpretation of zero energy states in the framework of positive energy ontology is as physical events, say scattering events with positive and negative energy parts of the state interpreted as initial and final states of the event.
3. In the realization of the hierarchy of Planck constants $CD \times CP_2$ is replaced with a Cartesian product of book like structures formed by almost copies of CD s and CP_2 s defined by singular coverings and factor spaces of CD and CP_2 with singularities corresponding to intersection $M^2 \cap CD$ and homologically trivial geodesic sphere S^2 of CP_2 for which the induced Kähler form vanishes. The coverings and factor spaces of CD s are glued

together along common $M^2 \cap CD$. The coverings and factors spaces of CP_2 are glued together along common homologically non-trivial geodesic sphere S^2 . The choice of preferred M^2 as subspace of tangent space of X^4 at all its points and interpreted as space of non-physical polarizations, brings M^2 into the theory also in different manner. S^2 in turn defines a subspace of the much larger space of vacuum extremals as surfaces inside $M^4 \times S^2$.

4. Configuration space (the world of classical worlds, WCW) decomposes into a union of sub-WCWs corresponding to different choices of M^2 and S^2 and also to different choices of the quantization axes of spin and energy, color isospin and hyper-charge for each choice of this kind. This means breaking down of the isometries to a subgroup. This can be compensated by the fact that the union can be taken over the different choices of this subgroup.
5. p-Adicization requires a further breakdown to discrete subgroups of the resulting sub-groups of the isometry groups but again a union over sub-WCWs corresponding to different choices of the discrete subgroup can be assumed. Discretization relates also naturally to the notion of number theoretic braid.

Is it really possible to speak about zero energy states for a given sector defined by generalized imbedding space with fixed M^2 and S^2 ? Classically this is possible and conserved quantities are well defined. In quantal situation the presence of the light-cone boundaries breaks full Poincare invariance although the infinitesimal version of this invariance is preserved. Note that the basic dynamical objects are 3-D light-like "legs" of the generalized Feynman diagrams glued together along their ends at generalized vertices.

8.2 Definition of energy in zero energy ontology

The approach relying on the two super conformal structures of quantum TGD gives hopes of defining the notion of energy for positive and negative energy parts of the state.

1. Since light-like 3-surfaces assignable to incoming and outgoing legs of the generalized Feynman diagrams are the basic objects, one can hope of having enough translational invariance to define the notion of energy. If translations are restricted to time-like translations acting in the direction of the future (past) then one has local translation invariance of dynamics for classical field equations inside δM_{\pm}^4 as a kind of semigroup. Also the M^4 translations leading to interior of X^4 from the light-like 2-surfaces surfaces act as translations. Classically these restrictions correspond to non-tachyonic momenta defining the allowed directions of translations realizable as particle motions. These two kinds of translations have been assigned to super-canonical conformal symmetries at $\delta M_{\pm}^4 \times CP_2$ and

and super Kac-Moody type conformal symmetries at light-like 3-surfaces. Equivalence Principle in TGD framework states that these two conformal symmetries define a structure completely analogous to a coset representation of conformal algebras so that the four-momenta associated with the two representations are identical [C1].

2. The condition selecting preferred extremals of Kähler action is induced by a global selection of $M^2 \subset M^4$ as a plane belonging to the tangent space of X^4 at all its points [C1] and interpreted as a plane of nonphysical polarizations so that direct connection with number theory and gauge symmetries emerges. The M^4 translations of X^4 as a whole in general respect the form of this condition in the interior. Furthermore, if M^4 translations are restricted to M^2 , also the condition itself - rather than only its general form - is respected. This observation, the earlier experience with p-adic mass calculations, and also the treatment of quarks and gluons in QCD encourage to consider the possibility that translational invariance should be restricted to M^2 translations so that mass squared, longitudinal momentum and transversal mass squared would be well defined quantum numbers. This would be enough to realize zero energy ontology. Encouragingly, M^2 appears also in the generalization of the causal diamond to a book-like structure forced by the realization of the hierarchy of Planck constant at the level of the imbedding space.
3. That the cm degrees of freedom for CD would be gauge like degrees of freedom sounds strange. The paradoxical feeling disappears as one realizes that this is not the case for sub- CD s, which indeed can have non-trivial correlation functions with either upper or lower tip of the CD playing a role analogous to that of an argument of n-point function in QFT description. One can also say that largest CD in the hierarchy defines infrared cutoff.

8.3 p-Adic variants of the imbedding space

The need to fuse p-adic physics with TGD emerged originally from the discovery that p-adic mass calculations based on p-adic thermodynamics give excellent predictions for elementary particle masses if one assumes p-adic length scale hypothesis stating that primes near integer powers of 2 are physically favored [16]. Later came the interpretation of p-adic physics as cognition cognition and intentionality. The following somewhat technical construction of p-adic variants of the imbedding space provides new insights concerning the understanding of the arrow of geometric time.

1. Rational values of p-adic coordinates are non-negative so that light-cone proper time $a_{4,+} = \sqrt{t^2 - z^2 - x^2 - y^2}$ is the unique Lorentz invariant choice for the p-adic time coordinate near the lower tip of CD . For the upper tip the identification of a_4 would be $a_{4,-} = \sqrt{(t - T)^2 - z^2 - x^2 - y^2}$. In the p-adic context the simultaneous existence of both square roots poses

additional conditions on T . For 2-adic numbers $T = 2^n T_0$, $n \geq 0$ (or more generally $T = \sum_{k \geq n_0} b_k 2^k$), would allow to satisfy these conditions, which would be one additional reason for $T = 2^n T_0$ implying p-adic length scale hypothesis. The remaining coordinates of CD are naturally (hyperbolic) cosines and sines of the spherical coordinates θ and ϕ (hyperbolic angle $\eta_{\pm,4}$).

2. The existence of the preferred plane M^2 of un-physical polarizations would suggest that 2-D light-cone proper times $a_{2,+} = \sqrt{t^2 - z^2}$ $a_{2,-} = \sqrt{(t - T)^2 - z^2}$ can be also considered. The remaining coordinates would be naturally $\eta_{\pm,2}$ and cylindrical coordinates (ρ, ϕ) .
3. The p-adically transcendental values of a_4 and a_2 are literally infinite as real numbers and could be visualized as points in infinitely distant geometric future so that the arrow of time might be said to emerge number theoretically.
4. The selection of the preferred quantization axes of energy and angular momentum unique apart from a Lorentz transformation of M^2 would have purely number theoretic meaning in both cases. One must allow a union over sub- WCW s labeled by points of $SO(1,1)$. This suggests a deep connection between number theory, quantum theory, quantum measurement theory, and even quantum theory of mathematical consciousness.
5. In the case of CP_2 there are three real coordinate patches involved [70]. The compactness of CP_2 allows to use cosines and sines of the preferred angle variable for a given coordinate patch.

$$\begin{aligned}\xi^1 &= \tan(u) \exp\left(i \frac{(\Psi + \Phi)}{2}\right) \cos\left(\frac{\Theta}{2}\right) , \\ \xi^2 &= \tan(u) \exp\left(i \frac{(\Psi - \Phi)}{2}\right) \sin\left(\frac{\Theta}{2}\right) .\end{aligned}\tag{5}$$

The ranges of the variables u, Θ, Φ, Ψ are $[0, \pi/2], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively. Note that u has naturally only positive values in the allowed range. S^2 corresponds to the values $\Phi = \Psi = 0$ of the angle coordinates.

6. The rational values of the (hyperbolic) cosine and sine correspond to Pythagorean triangles having sides of integer length and thus satisfying $m^2 = n^2 + r^2$ ($m^2 = n^2 - r^2$). These conditions are equivalent and allow the well-known explicit solution [71]. One can construct a p-adic completion for the set of Pythagorean triangles by allowing p-adic integers which are infinite as real integers as solutions of the conditions $m^2 = r^2 \pm s^2$. These angles correspond to genuinely p-adic directions having no real counterpart. Hence one obtains p-adic continuum also in the angle degrees of freedom. Algebraic extensions of the p-adic numbers bringing in cosines

and sines of the angles π/n lead to a hierarchy increasingly refined algebraic extensions of generalized imbedding space. Since the different sectors of *WCW* directly serve as correlates of selves, this means a direct correlation with the evolution of the mathematical consciousness. Trigonometric identities allow to construct points which in the real context correspond to sums and differences of angles.

7. Negative rational values of the cosines and sines correspond as p-adic integers to infinite real numbers and it seems that one use several coordinate patches obtained as copies of the octant ($x \geq 0, y \geq 0, z \geq 0, \dots$). An analogous picture applies in CP_2 degrees of freedom.

9 Zero energy ontology, self hierarchy, and the notion of time

Consider now the formulation of TGD inspired quantum theory of consciousness [18] and quantum biology [19] in terms of zero energy ontology.

One should understand the asymmetry between positive and negative energies and between two directions of geometric time at the level of conscious experience, the correspondence between experienced and geometric time, and the emergence of the arrow of time. One should explain why human sensory experience is about a rather narrow time interval of about .1 seconds and why memories are about the interior of much larger *CD* with time scale of order life time. One should have a vision about the evolution of consciousness: how quantum leaps leading to an expansion of consciousness occur.

Negative energy signals to geometric past - about which phase conjugate laser light represents an example - provide an attractive tool to realize intentional action as a signal inducing neural activities in the geometric past (this would explain Libet's classical findings), a mechanism of remote metabolism, and the mechanism of declarative memory as communications with geometric past. One should understand how these signals are realized in zero energy ontology and why their occurrence is so rare.

In the following I try to demonstrate that TGD inspired theory of consciousness and quantum TGD proper indeed are in tune.

9.1 Causal diamonds as correlates for selves

Quantum jump as a moment of consciousness, self as a sequence of quantum jumps integrating to self, and self hierarchy with sub-selves experienced as mental images, are the basic notions of TGD inspired theory of consciousness. In the most ambitious vision self hierarchy reduces to a fractal hierarchy of quantum jumps within quantum jumps.

It is natural to interpret *CDs* as correlates of selves. *CDs* can be interpreted either as subsets of the generalized imbedding space or as sectors of *WCW*. Accordingly, selves correspond to *CDs* of the generalized imbedding space or

sectors of WCW, literally separate interacting quantum Universes. The spiritually oriented reader might speak of Gods. Sub-selves correspond to sub-*CDs* geometrically. The contents of consciousness of self is about the interior of the corresponding *CD* at the level of imbedding space. For sub-selves the wave function for the position of tip of *CD* brings in the delocalization of sub-WCW.

The fractal hierarchy of *CDs* within *CDs* is the geometric counterpart for the hierarchy of selves: the quantization of the time scale of planned action and memory as $T(k) = 2^k T_0$ suggest an interpretation for the fact that we experience octaves as equivalent in music experience.

9.2 Why sensory experience is about so short time interval?

CD picture implies automatically the 4-D character of conscious experience and memories form part of conscious experience even at elementary particle level. Amazingly, the secondary p-adic time scale of electron is $T = 0.1$ seconds defining a fundamental time scale in living matter. The problem is to understand why the sensory experience is about a short time interval of geometric time rather than about the entire personal *CD* with temporal size of order life-time. The explanation would be that sensory input corresponds to subselves (mental images) with $T \simeq .1$ s at the upper light-like boundary of *CD* in question. This requires a strong asymmetry between upper and lower light-like boundaries of *CDs*.

The localization of the contents of the sensory experience to the upper light-cone boundary and local arrow of time could emerge as a consequence of self-organization process involving conscious intentional action. Sub-*CDs* would be in the interior of *CD* and self-organization process would lead to a distribution of *CDs* concentrated near the upper or lower boundary of *CD*. The local arrow of geometric time would depend on *CD* and even differ for *CD* and sub-*CDs*.

1. The localization of contents of sensory experience to a narrow time interval would be due to the concentration of sub-*CDs* representing mental images near the either boundary of *CD* representing self.
2. Phase conjugate signals identifiable as negative energy signals to geometric past are important when the arrow of time differs from the standard one in some time scale. If the arrow of time establishes itself as a phase transition, this kind of situations are rare. Negative energy signals as a basic mechanism of intentional action and transfer of metabolic energy would explain why living matter is so special.
3. Geometric memories would correspond to the regions near "lower" boundaries of *CD*. Since the density of sub-*CDs* is small there geometric memories would be rare and not sharp. A temporal sequence of mental images, say the sequence of digits of a phone number, would correspond to a temporal sequence of sub-*CDs*.

4. Sharing of mental images corresponds to a fusion of sub-selves/mental images to single sub-self by quantum entanglement: the space-time correlate could be flux tubes connecting space-time sheets associated with sub-selves represented also by space-time sheets inside their *CDs*.

9.3 Arrow of time

TGD forces a new view about the relationship between experienced and geometric time. Although the basic paradox of quantum measurement theory disappears the question about the arrow of geometric time remains.

1. Selves correspond to *CDs*. The *CDs* and their projections to the imbedding space do not move anywhere. Therefore the standard explanation for the arrow of geometric time cannot work.
2. The only plausible interpretation at classical level relies on quantum classical correspondence and the fact that space-times are 4-surfaces of the imbedding space. If quantum jump corresponds to a shift for a quantum superposition of space-time sheets towards geometric past in the first approximation (as quantum classical correspondence suggests), one can understand the arrow of time. Space-time surfaces simply shift backwards with respect to the geometric time of the imbedding space and therefore to the 8-D perceptive field defined by the *CD*. This creates in the materialistic mind a temporal variant of train illusion. Space-time as 4-surface and macroscopic and macro-temporal quantum coherence are absolutely essential for this interpretation to make sense.

Why this shifting should always take place to the direction of geometric past of the imbedding space? Does it so always? The proposed mechanism for the localization of sensory experience to a short time interval suggests an explanation in terms of intentional action.

1. *CD* defines the perceptive field for self. Selves are curious about the space-time sheets outside their perceptive field and perform quantum jumps tending to shift the superposition of the space-time sheets so that unknown regions of space-time sheets emerge to the perceptive field. Either the upper or lower boundary of *CD* wins in the competition and the arrow of time results as a spontaneous symmetry breaking. The arrow of time can depend on *CD* but tends to be the same for *CD* and its sub-*CDs*. Global arrow of time could establish itself by a phase transitions establishing the same arrow of time globally by a mechanism analogous to percolation phase transition.
2. Since the news come from the upper boundary of *CD*, self concentrates its attention to this region and improves the resolution of sensory experience. The sub-*CDs* generated in this manner correspond to mental images with contents about this region. Hence the contents of conscious experience, in

particular sensory experience, tends to be about the region near the upper boundary.

9.4 Can selves interact and evolve?

Interesting questions relate to how dynamical selves are.

1. Is self doomed to live inside the same sub-WCW eternally as a lonely god? This question has been already answered: there are interactions between sub- CD s of given CD , and one can think of selves as quantum superposition of states in CD s with wave function having as its argument the tips of CD , or rather only the second one since T is assumed to be quantized.
2. Is there largest CD in the personal CD hierarchy of self in an absolute sense? Or is the largest CD present only in the sense that the contribution to the contents of consciousness coming from very large CD s is negligible? Long time scales T correspond to low frequencies and thermal noise might mask these contributions. Here however the hierarchy of Planck constants and generalization of the imbedding space could come in rescue by allowing dark EEG photons to have energies above thermal energy.
3. Can selves evolve in the sense that the size of CD increases in quantum leaps so that the corresponding time scale $T = 2^k T_0$ of memory and planned action increases? Geometrically this kind of leap would mean that CD becomes a sub- CD of a larger CD - either at the level of conscious experience or in absolute sense. The leap can occur in two senses: as an increase of the largest p-adic time scale in the personal hierarchy of space-time sheets or as increase of the largest value of Planck constants in the personal dark matter hierarchy. At the level of individual organism this would mean emergence of new lower frequencies of generalized EEG and levels of personal dark matter hierarchy with larger value of Planck constant.

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Figures

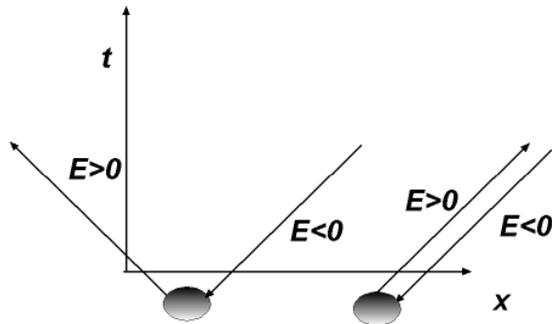


Figure 1: Time mirror mechanism

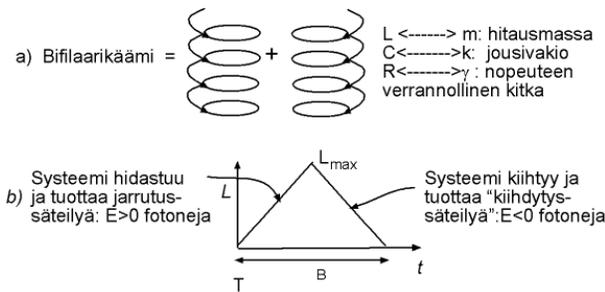


Figure 2: a) The structure of bi-filar coils and the mechanical analog of RCL circuit as a harmonic oscillator. b) The reduction of the mass of the harmonic oscillator at the second half of the magnetic pulse implies acceleration and generation of negative energy photons in order to get energy.

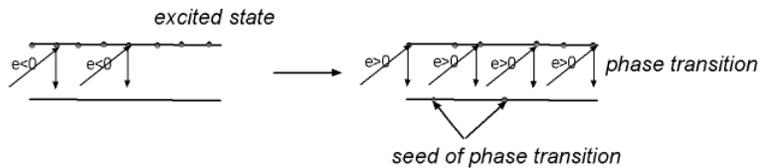


Figure 3: A mechanism of energy production based on negative energy topological light rays and population inversion.

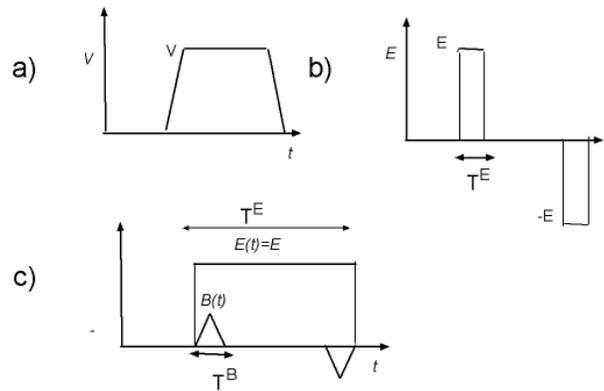


Figure 4: Constant voltage pulse (a) and the corresponding electric (b) and magnetic (c) pulses in the bi-filar coil.

$$p\text{-adic distance } |x-y|_p = p^{-n} \ll 1$$

$$\text{real distance } |x-y| = p^n \gg 1$$

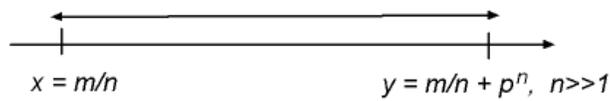


Figure 5: Rational valued points x and $y = x + p^n$, which are close to each other p -adically, are far from each other in real sense.

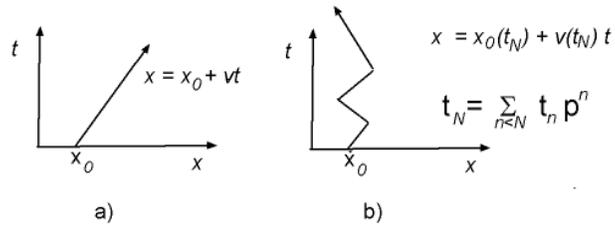


Figure 6: The non-determinism of p-adic differential equations in the case of a free particle. a) In real case the initial position x_0 and and velocity v determine the orbit. b) In the p-adic case x_0 and v are piecewise constant functions of time and the orbit resembles that associated with Brown motion.

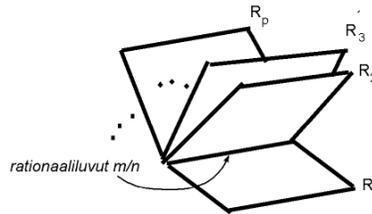


Figure 7: Rational numbers are common to both reals R and all p-adic number fields R_p , $p = 2, 3, \dots$. These number fields can be "glued" together along the rational numbers to form a book like structure. Rational numbers correspond to the rim of the book and different number fields to its pages.