Self and Binding

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Abstract

The quantum notion of self solved some longstanding problems of TGD inspired theory of consciousness and led to a breakthrough in quantum theory of consciousness. Self is identified as a sub-system able to not generate bound state entanglement during quantum jumps. Generation of bound state entanglement leads to a loss of consciousness. The concept of psychological time however remained poorly understood.

With the advent of the hierarchy of Planck constants realized in terms of generalized imbedding space and of zero energy ontology emerged the idea that self hierarchy could be reduced to a fractal hierarchy of quantum jumps within quantum jumps. It seems now clear that the two definitions of self are consistent with each other. The identification of the space-time correlate of self as causal diamond of the imbedding space -rather than space-time sheet- solved also the problems concerning the relationship between geometric and subjective time.

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

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

One could understand linear cognitive processes like thinking and language as self cascades in which self decomposes into subselves, which in turn decompose into subselves, which ... and self hierarchy implies connection with computationalism. Quantum entanglement provides a mechanism leading also to formation of irreducible wholes at the level of mental images.

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

like what physical death means from the point of view of consciousness: it could be that electromagnetic part of self hierarchy could survive after the physical death as a 'soul'.

1 Introduction

For a long time the basic hypothesis of TGD inspired theory of consciousness was that *single* quantum jump between quantum histories determines the contents of conscious experience associated with a particular moment of consciousness. It however became gradually clear that this hypothesis is subject to several objections, the most serious one being that genuine memories about previous conscious experiences (quantum jumps) are not possible if single quantum jump determines everything. These counter arguments served as a pressure forcing the discovery of the quantum notion of self. An essential prerequisite for the notion of self were parallel developments related to the p-adic aspects of quantum TGD.

The understanding of the notion of self did not emerge as an instantaneous flash but has been plagued by some mis-interpretations as the evolution of the new concepts usually is. The progress in the understanding of quantum TGD, initiated by 'TGD as a generalized number theory' vision, has been of importance also in attempts to achieve a more precise definition of the notion of self. The most central clarifications in the conceptual framework have been following ones. p-Adic physics is physics of imagination, cognition and intention and space-time has a genuine decomposition into regions with a local topology which is real or p-adic (what these p-adic regions really mean turned out to be highly non-trivial question!); quantum jump decomposes into a TGD counterparts of the unitary process followed by the state function reduction process followed by a TGD version of the state preparation process governed by Negentropy Maximization Principle; quantum measurement theory follows as a basic prediction of quantum TGD; the sequences of quantum jumps defining selves define what might be identified as fundamental statistical ensembles growing in size quantum jump by quantum jump; statistical physics becomes part of the theory of consciousness, in particular the theory of qualia.

Further steps in the progress were the observation that only bound state entanglement is stable in quantum jump so that the binding of mental images involves liberation of usable energy (quantum metabolism); the realization that sub-selves of two separate selves can entangle and that this corresponds to the fusion and sharing of mental images providing a fundamental mechanism of quantum communication; the realization that the sharing of mental images is only possible by adopting a length scale dependent definition of sub-system motivated the fact that topologically condensed space-time sheets resemble black holes in many respects; and the idea about how the formation of many particle bound states might allow sequences of quantum jumps to combine to single effective quantum jump making possible macro-temporal quantum coherence and quantum computation type processes for irreducible selves in a state of 'oneness'.

Ironically, the latest step in the progress means an almost return to where all began. The notion of self might be reduced to quantum jump after all by adding to it the attribute "fractal". The idea was motivated by two new concepts: zero energy ontology and the generalization of the notion of imbedding space predicting a hierarchy of Planck constants labeling a hierarchy of phases of matter identified as dark matter. It took some years to decide whether the reduction of self to a fractal hierarchy of quantum jumps within quantum jumps can be consistent with the earlier view about self. This seems to be the case. Also it took time to give a real meaning to the phrase "quantum jumps within quantum jumps". The new picture allows surprisingly quantitative answers to a long list of questions about the relationship of geometric and subjective time: this will be summarized later in the introduction and discussed in detail later.

There has been also a lot of pseudo progress. The understanding of the relationship between geometric and subjective time in TGD framework has been especially difficult challenge. By quantum classical correspondence the arrow of subjective time should be mapped to the arrow of geometric time at the level of conscious experience. In similar manner the asymmetry between subjective future and past should be correspond to an asymmetry between geometric future and past. What this means at the level of details has been far from clear and I have proposed many partial answers to the question about the arrow of geometric time. For instance: the geometric future inside light-cone contains much more room than geometric past so that the space-time region about which the contents of conscious experience are about tends to diffuse to the direction of the geometric future defined by light-cone proper time; perhaps the flow of geometric time corresponds to a wave front of intentional action identifiable as a phase transition changing intentions identified as p-adic space-time sheets transformed to real space-time sheets; maybe the space-time sheet assignable to self topologically condensed to a larger space-time sheet shifts in quantum jumps to the direction of geometric future some average temporal distance perhaps defined by CP_2 length scale. All these proposals have provided only partial answers, have led to paradoxes, and failed to give a firm quantitative grasp about the situation.

Also the original wrong view about the correspondence of real and p-adic numbers has generated a lot of confusion. The natural belief of topologist would be that p-adic space-time sheets are mapped to their real counterparts by a continuous map (some variant of what I called canonical identification making sense in p-adic thermodynamics). This map did not however respect symmetries and was inconsistent with field equations. Finally I was able to accept the natural belief of algebraist: reals and various p-adic number fields must be glued to together along rationals and common algebraic numbers to achieve generalization of the number concept and also that of imbedding space. What was difficult to accept was the highly non-intuitive implication that most points of p-adic space-time sheets are at spatial and temporal infinity in real (but not in p-adic) sense so that cognition and intentionality would be literally cosmic phenomena and only cognitive representations would be realized in a finite space-time volume in real sense (causal diamond) in terms of intersections

of real and p-adic space-time sheets consisting of rational and some algebraic points.

I have tried to tidy up the chapters so that they would not contain too many mammoth bones. Since I can use only a finite amount of time to documentation purposes, I have not been completely successful and this chapter as also others resembles a lab notebook rather than a Handbook of Consciousness and might contain statements which represent earlier archeological strata. I hope that reader could forgive this. Benevolent reader might even take these chapters as documents about how ideas have developed.

1.1 Self as a sub-system able to remain unentangled

The manner to circumvent the objections against quantum jump as a moment of consciousness identification is surprisingly simple and general and relies on the idea that selves are effectively their own sub-Universes,that is sub-systems able to remain unentangled in subsequent quantum jumps consisting of the unitary process U followed by TGD counterparts of state function reduction and state preparation. The hypothesis is that the self experience of a sub-system lasts for so many quantum jumps as sub-system avoids entangling with some other self. The highly nontrivial question is what defines the identity of the self as a physical system: it seems that the p-adic prime characterizing the space-time sheet serving as the geometric correlate of self characterizes self identity.

The unitary process U generates a maximally entangled state, a multiverse superposition of quantum potentialities. State function reduction step corresponds in the TGD framework to a localization in so called zero modes which thus behave as effectively classical variables. State preparation consists of a cascade of self measurements proceeding from long to short length scales and giving rise to maximally unentangled state. Essentially a conscious analysis is in question.

Space-time surface decomposes into real and p-adic regions and rational entanglement between regions corresponding to different number fields is in principle possible. Rational entanglement is allowed because rational numbers are in a well-defined sense common to both reals and p-adic number fields. This entanglement is reduced during the first step of the state preparation phase. The interpretation would be as a cognitive measurement. Selves can be identified as unions various real and p-adic space-time sheets of surface whereas irreducible self corresponds to single space-time sheet. Self can disappear only by a topological phase transition changing the number field associated with the self, if the space-time sheet disappears, or if a join along boundaries bond connects two space-time sheets and gives rise to a fusion of selves and formation of quantum bound state representing the fused self.

In the formation of a quantum bound state by join along boundaries bonds only overall zero modes remain zero modes whereas the remaining zero modes become quantum fluctuating degrees of freedom. The irreducible self (no sub-selves) generated in this manner has the property that state function reduction does not occur in the former zero modes and state preparation does not occur

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neither. This means that the entire sequence of quantum jumps during which bound state property is preserved, corresponds effectively to a single quantum jump. This means macro-temporal quantum coherence in the time scale of the duration of the bound state. Otherwise macro-temporal quantum coherence lasts only for the average increment of the geometric time associated with single quantum jump, which is about CP_2 time equal to 10^{-39} seconds. Macrotemporal quantum coherence makes possible for the self to act as a quantum computer type system. Also the experience of self, which is subjecto-temporal average over quantum jumps, contains in this case useful information since complete thermalization is avoided.

1.2   Is genuine subjective memory necessary?

For a long time the basic hypothesis of TGD inspired theory of consciousness was that the contents of conscious experience are determined totally by the initial and final states of *single* quantum jump. A heavy objection against this assumption is that the hypothesis makes it impossible to have genuine memories about previous conscious experiences. The concept of self however allows the possibility that the connected series of sequential quantum jumps performed by self after its last "wake-up" integrates to single conscious experience. This hypothesis realizes self as an extended object in subjective time allowing it to have memories about previous conscious experiences rather than only memories with respect to geometric time. An attractive additional assumption is that the conscious experiences of self are kind of subjecto-temporal statistical averages. This would make experiences reliable. In particular, sensory experiences can give objective reliable knowledge despite the fact that the outcomes of individual quantum jumps are not predictable. The undesired implication is that for long sequences of quantum jumps averaging leads to a total loss of information.

Geometric memory is made possible by the finite temporal duration of the mindlike space-time sheets. p-Adic space-time sheets are correlates of intentions, plans, desires,... whereas real space-time sheets correspond to ordinary memories. The phase transition front at which p-adic intentions transform to real actions defines psychological time. p-Adic (real) geometric memories are about geometric future (past) and serve as prophecies telling what would happen (would have happened) if quantum jumps were not constantly replacing macroscopic space-time with a new one. Subjective memory makes it possible to compare what actually happened with what was expected to happen. It might be that this comparison is one of the fundamental irreducible mental acts.

A natural identification of the subjective memory is as immediate short term conscious memory, or actually a hierarchy of short term memories corresponding to the hierarchy of selves. This identification requires that the subjective durations of our sensory selves are typically of a fraction of second, .1 second is suggested by various arguments relating to the ability to experience subsequence stimuli as separate ones and corresponds to the duration of psychological moment. The narrative character of the long term memories suggests their identification as geometric memories: long term memories could correspond to

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multitime experiences with contributions coming also from the geometric past (say childhood). It turns out that this identification explains basic facts about long term memories.

1.3 Binding of experiencers and quantum entanglement

How different components of conscious experiences, such as various sensory qualia and the active components of conscious experience involving thoughts, conscious selections and volition, integrate to single experience, is known as binding problem. In TGD framework one can distinguish between binding of *conscious experiences* and binding of *conscious experiencers*. Quantum entanglement provides a possible mechanism of binding of conscious *experiencers* to larger selves. At the level of mental images (sub-selves) this corresponds to the integration of parts to wholes. If the p-adic primes associated with the two p-adic sub-systems are different, the p-adic prime p of either system must change in topological phase transitions so that the local topologies (real or p-adic) are same.

The successes of p-adic physics suggest that it should be possible to label also real selves/space-time sheets by p-adic primes. Hence also real selves would form a hierarchy. If the entanglement with a higher level self is preceded by a phase transition changing local topology to that of the surrounding space-time region, it should lead to a loss of consciousness so that it is not possible to remember anything about the period of entanglement (sleep and trance would present basic examples of this).

Since only a bound state entanglement is stable against the state preparation process occurring in each quantum jump, the fusion of selves to a larger self means a formation of a bound state and the liberation of the binding energy as a usable energy. Thus quantum metabolism is predicted to accompany the binding of the mental images. Second aspect is a transformation of zero modes to quantum fluctuating degrees of freedom implying macro-temporal quantum coherence with a sequence of quantum jumps behaving effectively as a single quantum jump.

1.4 Binding of experiences and summation hypothesis

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

about the experiences of sub-selves X_{ij} of X_i representing what it is to be average X_{ij}, that is average over the mental images of X_i.

1.5 Some consequences

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

1.5.1 Infinite hierarchy of selves with God at the top

A rather dramatic prediction is a Russian doll like hierarchy of conscious experiencers having the entire Universe, God, at the top. The necessary localization in zero modes making the Universe of conscious experience classical together with the proposed concept of self allows to understand both active and passive aspects of consciousness and a general classification of various types of conscious experiences becomes possible. Summation hypothesis, sharing of mental images and 'enlightment' by entanglement (perhaps preceded by a phase transition increasing the value of p-adic prime of sub-self) hypothesis provide a general framework for interpreting various transpersonal experiences and altered states of consciousness as resulting from entanglement with larger units of consciousness.

1.5.2 Reducible and irreducible selves

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

1.5.3 Self-organization, ageing, death

Living systems are autonomous systems and selves, being effectively their own sub-Universes, are indeed autonomous. Selves define statistical ensembles in a natural manner and dissipation is naturally related to the ageing of self since the statistical ensemble in question grows quantum jump by quantum jump.

The cascade of self measurements serves as a kind of self repair mechanism and is necessary for self for self to retain its identity.

On the other hand, state function reduction and state preparation imply quantum decoherence and averaging over quantum jumps which means that the contents of consciousness of self thermalize with mental images becoming more and more fuzzy. Haken's classical theory of self-organization applies almost as such since time development by quantum jumps means hopping around the space of zero modes characterizing the size and shape and Kähler fields associated with the space-time surface $X^4(X^3)$.

Subjective ageing results from dissipation and is the price paid for having self. Very concretely, the mental image represented by self gets more and more entropic during ageing. One can also formulate questions about what happens in death in terms of physical concepts. Does only the bodily sub-self (mental image about body) cease to exist in the physical death so that only the field body consisting of magnetic flux tube structures and massless extremals (MEs, topological counterparts of light rays) remains? Can one identify the field body as the counterpart of what is called soul? Could the field body get interested of some new physical body and use it as sensory and motor organ (re-incarnation)? Is entanglement with some larger self generated after death (and during sleep)? Or does only the crucial p-adic-to-real phase transition for MEs (say) representing the transformation of intentions to actions cease during sleep and in death so that neither sensory mental images nor memories are formed but consciousness might still continue?

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

1.5.4   How psychological time and its arrow emerge?

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

The picture of self having mind-like space-time sheet with a finite time span motivated the first attempts to understand how psychological time emerges.

1. Psychological time might identified as the center of mass time coordinate for the mindlike space-time sheet and is zero mode so that each quantum jump localizes quantum state to a sharp value of psychological time (actually several values of psychological times). The local arrow of psychological time in turn can be understood as resulting from the diffusion and drift of

the mindlike space-time sheets in the future lightcone induced by quantum jumps. Diffusion and drift result from the facts that there is much more room in the future of the lightcone than in its past and the total probability for the transitions increasing the value of the light-cone proper time is slightly more higher than for those reducing it. For large values of the light-cone proper time the drift dominates and implies constant average increment of the light-cone proper time in quantum jump.

2. This picture is however not quite complete. The mirror model of long term memories implies that the contents of conscious experience are determined by the entire life cycle and that even the geometric future could contribute. This raises the question about what gives for the psychological now its special status. The identification of the psychological now as the time coordinate characterizing the position for the front of a p-adic-to-real phase transition (occurring for, say, massless extremals) proceeding in the direction of the geometric future could resolve the problem and also other paradoxes. p-Adic-to-real phase transition has an interpretation as a transformation of an intention to an action and psychological time corresponds to the center of mass time coordinate for the space-time region where the volition is concentrated. Simple arguments lead to the conclusion that psychological time is very probably common to the entire biosphere (p-adic hierarchy of psychological times is involved). Although the transformation of intentions to action is localized around sharp moment of geometric time, the proposed explanation involves the ad hoc assumption about propagation of conscious experience to the direction of geometric future.

Neither of these approaches led to quantitative success whereas the emergence of zero energy ontology and hierarchy of Planck constants allowed a picture allowing much more detailed answers to the questions posed in the beginning.

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

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

3. The simplest explanation for the arrow of geometric time assumes that the attention of self is directed to a fixed volume of imbedding space defined by the causal diamond. In other words, self has this causal diamond as a geometric correlate and conscious experience of self is about this causal diamond. The long lasting misconception causing all the fuss was that the regions of 4-D space-time surface rather than those of imbedding space serve as correlates for selves.

4. If the quantum superposition of space-time surfaces in the first approximation shifts in a given quantum jump to the direction of geometric past a distance given by T, the arrow of geometric time can be understood and T defines the lapse of geometric time in quantum jump. The hierarchy of quantum jumps inside quantum jumps corresponds to both p-adic and $\hbar$ hierarchies and the experience of flow of time can be understood in terms of sequences of sub-quantum jumps defining mental images. A more precise formulation allows also to understand why sensory experience is about narrow time interval. Absolutely essential elements of this explanation is the representability of the space-time as a 4-D surface of a higher-dimensional imbedding space, multi-verse picture and quantum coherence in macroscopic scales, as well as the assignment of unique space-time surface to given 3-surface required by General Coordinate Invariance. The original defining assumptions relate to the notion of self can be assumed to hold true for sub-selves identified as sub-quantum jumps.

A couple of comments about the relationship to the earlier visions are in order.

1. These visions need not be completely wrong. For instance, first vision might apply when one wants to answer the question whether the attention of self (position of causal diamond) can shift in quantum jump and whether this causal diamond tends to in the direction of geometric future. They however contain as an un-necessary ad hoc assumption the postulate of standard physics that consciousness corresponds to something moving towards geometric future in space-time.

2. The original belief was that mind-like space-time sheet with finite geometro-temporal size serves as correlate of self but that also space-time sheets with infinite temporal size are possible. This concept turned out to be an idea much before its time. In zero energy ontology all quantum states have this kind of space-time sheets as space-time correlates. The identification of mind-like sheet as a correlate of self was however wrong: only the realization that causal diamond - region of imbedding space - serves the space-time correlate of self allowed to achieve answers to the basic questions.

1.5.5 Quantum model for intelligent system

The concept of self provides justification for the assumptions behind the quantum model for intelligent systems [H7]. One can understand at very general level the mechanism for how universe forms abstractions about itself. Even the basic hierarchical structures of language could be identified in terms of Russian doll like structure formed by selves with phonemes possibly representing the lowest level selves in case of language.

The close connection with the computationalistic approach to psychology and consciousness is obvious. The hierarchy of selves is analogous to a hierarchy of higher level computer languages. Note also the analogy with the the hierarchy of the modules of a computer program. Selves could be interpreted as symbolic representations for the objects of external (and internal) world and cascades of selves generating selves inside selves provide a model for sensory experience and cognition. This model provides also a possible representation for logical implication sequences as temporally ordered sequences generating sub-selves. Quantum entanglement between selves is a good candidate for representing how wholes are formed from parts consciously as also for the formation of associations. Since bound state entanglement is necessarily involved, the formation of wholes involves the liberation of binding energy as a usable energy. Abstraction process emerges naturally as a formation of quantum average selves about the sub-sub-selves of self.

Quantum statistical determinism makes possible reliable thinking and sensory experiencing at the level of self and one could in principle model brain and sensory organs as ensembles of sub-sub-systems for which quantum measurement of certain observables occurs in quantum jump leading to the thought or sensory experience[H7]. What is especially nice is that temporal statistical averages become possible since mindlike space-time sheets can have also timelike distance: thus individual can learn form experience if temporal ensemble of cognitive space-time sheets is available.

1.5.6 Binding of sensory experiences

Different sensory qualia naturally correspond to separate sub-selves, whose individual experiences are separate but combine to form various qualia in our experience. In TGD framework they could correspond to sensory pathways or parts of them and perhaps containing also primary sensory organs. Quite generally, it seems that the reliability of the sensory experiences and the absence of experienced volition is guaranteed by the hypothesis about subjective memory. Experienced volition is most naturally related to the selection between different absolute minima of Kähler action rather than quantum jumps reducing the entanglement.

For instance, synchronous neuronal firing could be understood as a consequence of almost simultaneous wake-up of neuronal sub-selves near criticality for phase transition changing the local topology of the space-time sheets associated with sub-self. If neurons have sub-selves, also subneuronal quantum

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

2 Quantum self

Everyday experience suggest that consciousness is a property of the physical state and that self corresponds to a continuous stream of consciousness rather than quantum jumps occurring only now and then. On the other hand, it is not possible to be conscious of being not conscious: hence one cannot exclude the possibility that our consciousness might correspond to quantum jumps occurring occasionally in the sequence of quantum jumps. However, the idea that sub-systems participating in sequential quantum jumps possess self, very natural and the successes of this hypothesis is the best support for it.

2.1 Why the contents of conscious experience cannot be determined by the initial and final states of single quantum jump?

The quantum notion of self as a sub-system able to remain unentangled during subsequent quantum jumps emerged from four strong objections against the theory of consciousness relying solely on the identification of the quantum jump as a moment of consciousness.

1. The contents of conscious experience is determined by both the initial and final states so that it seems not possible to get any objective information about quantum states as such: we are doomed to live in the world of Maya, contrary to what mystics argue. One can consider a weaker form of objectivity for which state remains invariant in quantum statistical sense: this would suggest that sensory experiences involve ensembles of 'sub-observers' and that 'our' sensory experience is kind of mean experience, whose objectivity is guaranteed by statistical determinism.

2. If moments of consciousness correspond to quantum jumps between quantum histories, any conscious experience should involve a conscious selection between various outcomes of the quantum jump or at least experience of free will. Sensory experience does not certainly always involve this kind of selection.

3. The idea of self as a continuous stream of consciousness is very attractive and it seems difficult to imagine that our consciousness could be actually a sequence of moments of consciousness with gaps between. This argument is not so strong as it might sound: one cannot experience the gaps between moments of consciousness since it is not possible to be conscious of not being conscious. One could however argue that system possessing 'self' must be as near as possible to a continuous stream of consciousness: perhaps systems able to participate to sequential quantum jumps have self.

4. If the contents of conscious experience are defined by the initial and final states of only single quantum jump, it is impossible to have subjective memory, that is memories about previous conscious experiences.

For a long time these problems remained a challenge for TGD inspired theory of consciousness. The progress in the understanding of quantum TGD led however to a notion of self providing a beautiful resolution of these problems. The most important pieces of the puzzle identified during the last year are the following ones.

1. p-Adic physics can be identified as physics of cognition and space-time surfaces decompose into real and p-adic regions. If bound state entanglement between spaceetime regions belonging to different number field is not possible, selves are stable objects and can disappear only in a quantum jump inducing a topological phase transition changing the topology of space-time sheet associated with self to that of the surrounding space-time region.

2. Geometric matter-mind duality realized in terms of mindlike and matter like space-time sheets is crucial for understanding how cognitive and sensory mental images emerge. Infinite primes [O2] are very closely related concept: infinite primes could code in itself the decomposition of the space-time surface to matter and mindlike (cognitive) space-time sheets labelled by p-adic primes at lower level of infinity.

3. Dissipation can be regarded as a direct signature for the occurrence of quantum jumps between quantum histories (and, in fact, for the existence of real selves). More generally, entropy gradients, which are well defined also for p-adic selves, serve as a signature of consciousness.

4. Each quantum jump involves a localization in zero modes (associated with infinite-dimensional configuration space of 3-surfaces and characterizing the macroscopic shape and size of 3-surface), which implies the classicality of the universe of the subjective experience. The localization in zero modes together with the assumption that the unitary 'time evolution' operator U corresponds to effective flow in zero modes correlating measured quantum numbers with zero modes serving as macroscopic variables, means that state function reduction becomes part of the quantum jump. If the

localization in zero modes is followed by a cascade of self measurements leading to a completely unentangled state, state preparation becomes a part of quantum jump. The dynamics of self measurements is governed by Negentropy Maximization Principle.

5. A precise definition for the sub-system concept constrained by the requirement that the definition reduces to the quantum field theoretical definition in the QFT limit. This is achieved if sub-system concept is local at the level of configuration space and relies one the geometric definition of the sub-system at space-time level relying on the identification of self as a connected region of space-time corresponding to a particular number field. A highly nontrivial point is that standard identification of sub-system as a tensor factor does not seem to work. The reason is that a space-time sheet representing a sub-system is glued by wormhole contacts to the larger space-time sheet and these contacts are surrounded by so called elementary particle horizons at which induced metric becomes degenerate. Sub-system space-time sheet is information-theoretically more like a blackhole like object and ahierarchy of statespaces results with sub-system-system inclusion described in a more abstract manner taking into account that 'blackhole has no hair'.

6. Quantum-classical correspondence is a correspondence principle stating that subjective time development by quantum jumps and geometric time development at the space-time level must correspond to each other.

The notion of self allows rather detailed answers to some other deep questions related to TGD inspired theory of consciousness. Some examples of these questions are following.

1. How the components of conscious experience bind together to form experience and how to achieve general classification of conscious experiences to various types (volition, sensory experiences, thinking,...)?

2. How psychological time and its arrow emerge? How we are able to genuinely remember something about the previous moments of consciousness?

3. What is the precise relationship between various macroscopic quantum phases and consciousness?

4. What is the relationship of TGD inspired theory of consciousness to the computational approach to mind applied in neuro sciences and cognitive science?

2.2 Self as a sub-system able to not generate bound state entanglement

A natural identification of self is as sub-Universe behaving autonomously. Thus sub-systems able to remain un-entangled are natural candidates for selves. As

already described the identification of geometric correlates of selves as regions of space-time appearing in the decomposition of space-time into regions belonging to various number fields solves this problem: bound state entanglement does not simply occur between different number fields. If rational entanglement is allowed between different number fields, it must be reduced during the state preparation process. Entanglement probabilities and entanglement entropy are algebraic numbers in this case. If the entanglement entropy is interpreted as a real number, it is uniquely defined, and the real version of NMP forces self measurement to occur.

The sub-system representing self must have some characteristic property remaining invariant from quantum jump to quantum jump and the p-adic prime characterizing the space-time sheet representing self is an excellent candidate for this invariant.

The basic prediction is the existence of infinite hierarchy of selves and this has rather dramatic consequences. One can say that at the top of the infinite hierarchy is God, the entire Universe. This structure is not entangled with any larger structure of same kind so that this self can be said to live eternal life. God abstracts all experiences in the infinite hierarchy of sub-selves to single experience. If infinite primes are allowed, as required by simple physical arguments, God corresponds to infinite p-adic prime characterizing entire universe and since this prime grows, also God evolves.

2.3   Two kinds of sub-selves?

There is an interesting delicacy related the definition of sub-self due to the fact that there are two kinds of sub-systems: ordinary sub-systems identifiable as tensor factors and smaller space-time sheets glued to larger ones by wormhole contacts and analogous to black holes. Thus depending on the definition of self, self could have two kinds of sub-selves.

1. A self consisting of a set of quantum entangled disjoint space-time sheets is reducible and decomposes in self measurement to 'tensor factor type' sub-selves represented by these sheets and identifiable as mental images of self.

2. Space-time sheet can however contain smaller space-time sheets representing sub-selves of 'blackhole type'.

Can one say that space-time sheet containing space-time sheets represents an irreducible self? If so then irreducible self could have mental images. If not then it is difficult to imagine how irreducible selves are possible at all since any space-time sheets presumably contains smaller space-time sheets (say elementary particles). If there are several sub-selves these sub-selves become de-entangled in quantum jump and this means analysis and experience of separations at level of mental images.

These arguments suggest that self is in a state of oneness if the 'blackhole like' sub-selves represented by smaller space-time sheets are fused by join along

boundaries bonds to single one: there is only one mental image. This definition is consistent with the identification of the neuronal synchrony as a correlate for the bound state formation at neuronal level, with the idea about macrotemporal quantum coherence as a prequisite for the state of oneness, and with the idea that the fusion of sub-selves leads to a kind of stereo consciousness (as in case of the fusion of right and left visual fields).

One could quite well give up the assumption that self can consist of several disjoint space-time sheets entangled with each other. With this identification selves correspond to join along boundaries condensates of space-time sheets and irreducible self has only single sub-self (mental image) represented by similar join along boundaries condensate. The analysis process generating separations and distinctions would be equivalent with the existence of several sub-selves.

The sub-selves of different selves can entangle and this corresponds to the formation of join along boundaries bonds between corresponding space-time sheets. This is not possible if sub-self is identified as a tensor factor. This process gives rise to a fusion and sharing of mental images and is of crucial importance in understanding how conscious communications are possible.

An interesting question is what kind of experience self having to several sub-selves, each in state of whole-body consciousness, has: there is no averaging involved so that the mental images of self could be identical with the experiences of sub-selves. The absence of 'tensor factor type' sub-selves suggests that dissipation is anomalously small during 'whole-body consciousness' and could serve as a physical signature of this state.

2.4 Active and passive aspects of consciousness

When self has no sub-selves, the experience of self reduces to pure awareness without any mental images. This raises the question whether the basic structure of the quantum jump could allow the general identification of the passive and active aspects of the conscious experience. In the following two possible identifications of these aspects are considered. The first approach was developed when I still believed in standard positive energy ontology. Second approach emerges naturally in zero energy ontology. Many elements of the first approach are consistent with the latter one.

2.4.1 Passive and active aspects of conscious experience in positive energy ontology

The experienced volition must be kind of an average over the subjective history of self and thus quantum jumps reducing entanglement do not probably contribute to the experience of volition.

1. Active aspects of consciousness could be related to the localization in zero modes occurring in quantum jump, which implies that the world of conscious experience looks classical. In particular, the localization in discrete zero modes labeling various degenerate absolute minima of Kähler

action is a good candidate for experienced volition. That classical non-determinism corresponds to volition would conform with the quantum-classical correspondence. On the other hand, degenerate absolute minima lead to the notion of association sequence making possible to understand the emergence of symbolic representations and language.

2. It seems that the contribution of the quantum measurement part of the quantum jump reducing entanglement for a system with given values of zero modes need not involve conscious experience of volition or selection and could therefore be regarded as the passive aspect of conscious experience, such as sensory qualia.

3. Volition involves also intention. The first two identifications do not explain intentionality: only a selection between given alternatives is in question. Furthermore, selections of this kind are between a finite number of alternatives, which is however not the case for the first two options. A quantum jump in which p-adic space-time sheet is replaced with a real one is the natural candidate for volition transforming intention to action. The number of p-adic space-time sheets counts the number of intentions and the number of alternative choices is finite as it should be. Clearly, this option is the most realistic one.

Note that the passive and active aspects of conscious experience correspond directly to the Yin-Yang duality of the Eastern philosophies and might also corresponds to the basic sensory perception-reaction feedback loop appearing in the bio-systems.

These two types of quantum jumps provide a very general classification of conscious experiences and one can even understand at general level the differences between right and left brain. In particular, the allowance of self-generating quantum jumps is crucial for the model of cognition as cascades creating selves, sub-selves of selves,.... such that sub-selves can be interpreted as representations of symbols for the objects of external world.

2.4.2 Passive and active aspects of conscious experience in zero energy ontology

In zero energy ontology all physical states have vanishing total conserved quantum numbers. Zero energy states decompose into pairs of positive and negative energy states localizable at the boundaries of future and past directed light-cones defining causal diamond. In positive energy ontology zero energy states correspond to physical events -say particle scattering. Everything can created from vacuum so that one can avoid frustrating questions such as *What are the total conserved quantum numbers of the Universe?*.

The formulation of quantum TGD in terms of zero energy ontology forces to identify the counterpart of S-matrix of particle physics as M-matrix defining time-like entanglement coefficients between positive and negative energy parts of zero energy state. M-matrix need not be unitary and thermodynamics becomes

part of quantum theory if one assumes that M-matrix is a square root of density matrix expressible as a product of positive real square root of density matrix and unitary S-matrix. The notion of finite measurement resolution realized in terms of inclusions of hyper-finite factors of type II_1 leads to the conclusion that the S-matrix is highly unique and expressible in terms of Connes tensor product. This framework leads also to the understanding of p-adic length scale hypothesis and predicts that the time scale associated with the causal diamond corresponds to secondary p-adic time scale $T_p = \sqrt{p} L_p / c$. In particular, electron corresponds to the time scale of .1 seconds: the connection with the fundamental 10 Hz biorhythm is obvious.

What is important that M-matrix is a *property* of zero energy state. *M*-matrix does not make sense between different number fields so that it cannot be assigned with intentional action. Therefore M-matrix, which is indeed associated with quantum measurement in the most general sense of the world, naturally corresponds to the passive aspects of conscious experience.

In zero energy ontology U-matrix characterizing the unitary process part of quantum jump describes scattering between zero energy states: this is something totally new from the viewpoint of standard physics. Because of the zero energy property, U-matrix can have matrix elements between different number fields if it is expressible in terms of rational numbers or algebraic extension of rationals. Hence U-matrix can can be assigned to intentional action and can correspond to the active aspects of conscious experience.

2.5   Self as a statistical ensemble

The sequence of quantum jumps defining self defines also a sequence of completely unentangled quantum states resulting in the state preparation process governed by NMP. This set of states, which grows in size quantum jump by quantum jump, defines in a natural manner a statistical ensemble identifiable as the fundamental realization of the otherwise fictive notion of statistical ensemble fundamental in the formulation of statistical physics. There are actually two statistical ensembles: the first one being associated with the final states of quantum jump and the second one being associated with the values of zero modes resulting in quantum jump. As far as conscious experience is involved, it however seems that it is the increments of quantum numbers and zero modes which are the relevant statistical variables.

This observation anchors the theory of conscious experience to statistical physics [K3]. For instance, the increments of zero modes resp. quantum numbers are responsible for geometric resp. non-geometric qualia. More precisely, the gradients with respect to subjective time for the zero modes and for the net quantum numbers associated with selves correspond to qualia. One can classify non-geometric qualia to entropy type qualia (emotions in accordance with the fact that peptides are both informational molecules and molecules of emotion); kinestetic qualia (sense of pressure and force and, more generally, gradient of any conserved (with respect to geometric time) quantity associated with self with respect to subjective time); and generalized chemical qualia (rates for

the changes of numbers of particles with various quantum numbers). Various entropies associated with self and sub-selves in turn characterize the sharpness of the mental images, and one can relate concepts like attentiveness, alertness and the level of arousal to these variables.

CP_2 time provides a simple estimate for the average increment of psychological time per quantum jump. The occurrence of 10^{39} quantum jumps per second probably means that statistical averaging thermalizes sub-selves completely so that mental images contain no information. Decoherence is the physical counterpart of this process. The manner to achieve macrotemporal quantum coherence is the formation of bound states of several systems giving rise to a larger irreducible self. In this process the zero modes of the binding systems are tranformed to quantum fluctuating degrees of freedom and state function reduction and state preparation do not occur in these degrees of freedom. The sequence of quantum jumps defined by the duration of the bound state behaves effectively as a single quantum jump and no averaging occurs in these degrees of freedom so that the mental image represented by this kind of sub-self stays sharp.

The feed of the metabolic energy takes care that these bound states are destroyed sooner or later. If metabolic energy is not fed to the system, bound state could last for a very long time. Interestingly, there is a reported disease in which patient can live for decades in single frozen moment of consciousness. Perhaps the lack of metabolic feed of energy allowing mental images to last forever is what causes this sickness.

2.6 How to define measures for the information contents of conscious experience?

Despite the fact that one cannot write formula for the contents of conscious experience, one can define information measures for conscious experience as differences of the information measures for the initial and final quantum histories. Infinite number of different types of information characterized by information measures for single quantum jump can be found. For instance, the sum of the net entanglement negentropy gains over the steps of the self measurement cascade could define a quantity characterizing net information gain for a single moment of consciousness.

Contrary to the original beliefs, the information measures associated with single quantum jump are not probably very useful for characterizing the information content of self. Since self defines a statistical ensemble, one expects that the information gain of conscious experience should approach zero at the limit when self approaches thermal equilibrium. Thus it seems that the deviation of the average information gain over the quantum jumps defining self from the value of this quantity at the limit when self approaches thermal equilibrium, could be a relevant measure for the information gain of conscious experience. Furthermore, the sequence of quantum jumps defines distributions over zero mode – and quantum number increments, and the deviations of the entropies associated with these distributions from the corresponding entropies in thermal

equilibrium state could be used to characterize the information contents of conscious experience. The formation of bound states implies that the system does not thermalize and entanglement entropy in the real context stays small.

The definition above is somewhat problematic. The subtraction of the entropy of the maximally entropic state is somewhat adhoc procedure and need not be even well-defined. It might be that one must just accept that in the real sector the best one can achieve is empty mind free of illusions. The interpretation would be that sensory experience as such can only carry disinformation.

p-adic physics is the physics of cognition and one can wonder whether one might assign a positive entanglement negentropy to some cognitive systems. For p-adic systems for which entanglement probabilities are rational numbers for any sub-system-complement pair, p-adic entanglement entropy can be regarded as a rational number and can be identified as such as a real number when $log(p)$ is used as a unit of negentropy. With this definition entanglement negentropy can be positive and this kind of states can be seen as p-adic counterparts of bound states containing genuine cognitive information. In p-adic context also $S = 0$ states with vanishing entanglement entropy are possible. The systems with positive entanglement negentropy are ideal for the realization of cognitive quantum computer like systems [H2]. Perhaps frontal lobes have specialized to the generation of this kind of sub-selves besides generating p-adic intentions and transforming them to real actions.

p-Adic-real cognitive entanglement makes sense only if entanglement coefficients are algebraic numbers. In this case one can use a number theoretic definition of entropy and also states with negative entanglement entropy are possible. These states are stable against NMP, have positive definite information content, and give tise to experiences of understanding.

Entropy gradients with respect to subjective time could be used to characterize how the information gain of conscious experience of self changes. These gradients approach zero when self approaches thermal equilibrium. In TGD framework entropy gradients correlate with emotions, which means a somewhat counter intuitive connection between emotions and information gain or loss (consistent however with the fact that peptides are both informational molecules and molecules of emotion [35]). Note that the binding of information molecules to receptors means the formation larger bound states accompanied by the experience of oneness at molecular level (are sex and spiritual experiences present already at the molecular level?) and macro temporal quantum coherence so that quantum computer like operations might become possible.

2.7 How selves wake-up and fall asleep?

If the impossibility of entanglement between different number fields is what makes selves possible, the wake-up of the mental image most probably means generation of space-time region with topology different from that of surrounding space-time region. For instance, p-adic space-time regions surrounding real regions with different p could serve as shields allowing real space-time sheets to stay in self state and vice versa. Topologically the death of the mental image

would mean a phase transition in which the topology of the mental image becomes that of the surrounding space-time region or a fusion with a larger region when it forms an extrusion through the shielding region. If our sensory mental images are real this could be one of the mechanisms involved. For instance, falling asleep could involve either phase transition or fusion mechanism.

It seems that this characterization is un-necessarily restrictive. Also real space-time sheets are labelled by primes characterizing the p-adic length scale associated with the space-time sheet. The assumption that there is no bound state entanglement between real space-time sheets characterized by different primes is natural since the space-time sheets communicate only via wormhole contacts surrounded by elementary particle horizons (wormhole contacts have induced metric with Euclidian signature). With this characterization self corresponds to a set of disjoint space-time sheets characterized by the same prime and irreducible self corresponds to a set of space-time sheets characterized by same p-adic prime and fused together by join along boundaries bonds. In particular, real selves can topologically condense on real selves. With this definition the wake-up of an irreducible self can be due to the emergence of a new space-time sheet, the change of the number field characterizing the space-time sheet, or the splitting of the join along boundaries bonds connecting two space-time sheets leading to a decay of a bound state. Falling asleep corresponds to the reversals of these processes.

The function of sleep would be obvious: when mental image ages, its entropy grows and it becomes fuzzy. One manner to avoid this is a temporary death and re-incarnation as a brisk and young mental image. Of course, also we are mental images and the reason for why we die physically might be precisely this. This would encourage to believe that our bodily sub-self (also mental image!) has a duration determined by our lifetime. Second manner to achieve this is to somehow reduce the entropy growth rate or change its sign. The formation of bound states is the fundamental mechanism of this kind. Very probably biosystems are full of mechanisms tending to achieve this kind of state. For instance, de-differentiation of cells to stem cell stage would be an example of this mechanism. The basic function of metabolism would be to help this fight against second law. Note however that this war against second law could occur both at the level of mental images and the matter at atomic space-time sheets and it might be that a neglilible fraction of metabolic energy is needed to to keep our mental images sharp. An interesting possibility is that second law holds true at a given space-time sheet only in time scales longer than the corresponding p-adic time scale. This would mean that the typical duration of the bound state is of order of p-adic time scale (also secondary, tertiary, etc... p-adic time scales are possible).

2.8 Self has genuine subjective memory

That the contents of consciousness are determined totally by the initial and final states of the quantum jump was the basic assumption of TGD inspired theory of consciousness for a long time. A heavy objection against this assump-

tion is that, since the contents of consciousness are determined by the initial and final state of the quantum jump, it is not possible to have any genuine memories about previous quantum jumps. One could even argue that in this kind of universe it is not possible to discover the idea of quantum jump as a moment of consciousness. One can imagine a possible way out of this problem. The ensemble of mindlike space-time sheets performing quantum jumps with time dependent average outcome makes in principle possible to have memories about earlier experiences by re-experiencing the thoughts generated by them. Of course, only simulations are in question and one could argue that this is not enough.

The proposed identification of self however forces to reconsider this assumption. Nothing precludes the possibility that a connected series of the sequential quantum jumps performed by self after its "wake-up" integrate to single conscious experience, the subjective history of self. A natural additional hypothesis is that the integrated experience is kind of an average over the quantum jumps, possibly a weighted average such that weighting favours the latest quantum jumps. This hypothesis guarantees the objectivity and reliability of sensory experiences and thoughts despite the fact that the outcomes of the individual quantum jumps are not predictable. This hypothesis would provide strong realization for the idea about continuous streams of consciousness and realize self as an extended object in subjective time. The assumption is supported by the resolution time of the visual experience: if the interval between sequential pictures is shorter than .1 seconds, pictures are not experienced as separate ones. This is indeed expected to happen if given visual sub-self (mental image) contains experience about several pictures leading to temporal averaging.

A possible identification of the subjective memory is as immediate short term memory. Duration of immediate short term memories is typically fraction of seconds and this would suggest that the duration of self might be typically of the same order. This is of course in conflict with the intuitive view that our wake-up consciousness is continuous. Actually an entire hierarchy of subjective memories is predicted. Note that a conscious memory about our good and not so good deeds and great moments of life could live even after our physical death as an abstracted average self at the next level of the hierarchy as long as this higher self stays alive!

The sub-selves of self can form subjecto-temporal sequences. Since no averaging over these sub-selves is performed, it is possible to remember the digits of phone number. Therefore the temporal resolution of sensory experience of about .1 seconds does not pose any bound for the duration of our self (as I have erraneously claimed in some contexts). A periodic sequence of sub-selves defines a conscious clock and it seems that living systems are full of this kind of clocks. Examples of mechanisms probably inducing conscious (not necessarily conscious-to-us) clocks are retinal microtremor at frequency of 80 Hz, muscle tremor and presumably also EEG oscillations. Musical rhytms obviously create this kind of conscious clocks. Also a cat which is preparing to catch a mouse develops a rhytmic movement: the conscious clock presumably helps it to coordinate its own motions appropriately.

Mindlike space-time sheets which can also have timelike separations and ensembles of sub-selves in the geometric time axis are possible. A self containing these kind of sub-selves presumably experiences the sub-selves of the geometric past as memories. This mechanism provides very attractive realization of long term memory.

The temporal integration of the conscious experiences to single experience conforms with the quantum-classical correspondence principle in the sense that the integration corresponds to the necessary generalization of 3-surface to association sequence consisting of minimal number of spacelike 3-surfaces with timelike mutual separations. These 'association sequences' provide symbolic representations for the quantum jump sequences defining contents of consciousness of self and make possible organized view about space and time. They would also make possible self reference in the sense that it is possible to be conscious about.... p-Adic nondeterminism in turn allows cognitive representations about the contents of consciousness and also helps to build self model based on p-adic space-time sheets.

2.9   Self as an observer

In standard physics context observer is something external to the physical system. In principle physical theory should however also provide a natural description of the observer. System with self can be regarded as an observer. The hypothesis about subjective memory provides the observer with memory. Natural, but not absolutely necessary, hypothesis is that this memory performs kind of quantum average about the experiences of individual quantum jumps and hence stabilizes the experiences of observer. TGD based concept of psychological time implies that the entire space-time surface is populated by mindlike space-time sheets giving rise to observers.

This might mean that geometric future contains physicists who have long ago (with respect to subjective time) developed unified theories we are only dreaming about! Note also that these grand unified physicists could have subjective memory extending possibly to the moment of big bang! Whether this is really the case depends on wheter the p-adic-to-real phase transition front defining the value of the psychological time is universal or only local and restricted to our biosphere. Fractality of consciousness would suggests that there is a fractal hierarchy of these phase transition fronts inside phase transition fronts.

2.10   Self and the emergence of psychological time and its arrow

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

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

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

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

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

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

6. The model of geometric and subjective memories would not be modified in an essential manner: memories would result when "me" is connected

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with my almost copy in the geometric past by braid strands or massless extremals (MEs) or their combinations (ME parallel to magnetic flux tube is the analog of Alfwen wave in TGD).

This argument leaves many questions open. What is the precise definition for the volume of attention? Is the attention of self doomed to be directed to a fixed volume or can quantum jumps change the volume of attention? What distinguishes between geometric future and past as far as contents of conscious experience are considered? How this picture relates to p-adic and dark matter hierarchies? Does this framework allow to formulate more precisely the notion of self? Zero energy ontology allows to give tentative answers to these questions.

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

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

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

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

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

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

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

Let us make the following assumptions.

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

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

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

assumptions which will be discussed next - one would have just two quantum jumps: mental image appears, disappears or exists all the time. At the level of sub-sub-selves 4 quantum jumps and so on. Maybe this kind of simple predictions might be testable.

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

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

The contributions from lower the boundaries identifiable in terms of memories would correspond to different time scales and for a given value of time scale T the net contribution to conscious experience would be much weaker than the sensory input in general. The asymmetry between geometric now and geometric past would be present for all contributions to conscious experience, not only sensory ones. What is nice that the contents of conscious experience would

rather literally come from the boundary of the past directed light-cone along which the classical signals arrive. Hence the mystic feeling about telepathic connection with a distant object at distance of billions of light years expressed by an astrophysicist, whose name I have unfortunately forgotten, would not be romantic self deception.

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

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

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

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

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

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

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

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

2.12   Space-time as a 4-dimensional living being

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

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

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

2.13   Self, evolution and self-organization

The generalization of the notion of unitarity forced by the introduction of the p-adic numbers [H1] implies that time evolution by quantum jumps corresponds to a sequence of p-adic primes increasing in a statistical sense. This means that

the concept of nearness defining the effective topology becomes gradually more refined, the complexity of the universe increases, and the maximal information contents of the conscious experience increase in the long run (like $p \times log(p)$ or at least as $log(p)$ as a function of p-adic prime characterizing the system). This is nothing but evolution. NMP, which states that entanglement negentropy gain maximal for allowed quantum jumps, enhances this tendency.

Quantum jumps between quantum histories make also possible genuine quantum self-organization. The concept of self-organization gets quite new additional meaning in TGD framework. Self-organization means also evolution of self-hierarchies. Self-organization by quantum jumps can be regarded as a hopping in the zero modes characterizing the macroscopic aspects of the space-time surface. Each self is a dissipative system which ends up to some asymptotic self-organization pattern in the presence of the external energy feed (and even without it). Dissipation is the ultimate Darwinian selector picking up the winning selves as favored self organization patterns. Since sub-selves correspond to mental images, the immediate implication is that also memes are subject to similar selection. For instance, the formation of long term memories and habits could be understood as a formation of surviving sub-selves.

The TGD based realization of the quantum criticality, besides making macroscopic quantum systems possible, in a well-defined sense maximizes the intelligence and complexity of the universe [H7]. In biosystems a concrete realization of quantum criticality is in terms of magnetic flux tube structures and electret type space-time sheets representing solutions of field equations dual to each other and having opposite signs of Kähler action density.

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

This looks nice but one can ask whether the framework of standard quantum theory is all that is needed to formulate quantum TGD and the notion of quantum criticality. The original motivations for introducing the hierarchy of Planck constants and the generalization of the imbedding space to a book like structure having as pages the almost copies of the imbedding space were purely physical. Now it seems that this generalization is required by a need to have a proper formulation of quantum criticality of TGD Universe. The hierarchy of Planck constants leads to a whole bundle of ideas about quantum biology and evolution of consciousness and also to a detailed model for how living matter can perform topological quantum computation like activities [L5, L6, L7, J7].

2.14   Self as a moral agent

One could argue that the randomness of the quantum jump means that moral choices are impossible. Volition can however be associated with the selection of an intention realized in p-adic-to-real phase transition.

Evolution, both p-adic evolution and evolution as increase of the Planck constant, defines the fundamental value of the quantum ethics. The selections which tend to increase the value of the p-adic prime represent good deeds since they mean evolution. The values of this ethics are not in the physical world but in the quantum jumps defining the subjective reality.

Selves can make plans since they have 4-dimensional geometric memory (conscious experience contains information about a *four-dimensional* space-time region, rather than only time=constant snapshot, and p-adic space-time sheets give rise to a "prophecies", predictions for the future and past, which would be reliable if the world were completely classical). Selves can make decisions and select between various classical macroscopic time developments. Selves are able to remember their choices since they have subjective memories about the previous quantum jumps and also geometric memories providing representations of the past. Thus selves are genuine moral agents if they can experience directly that increase of p is 'good' and decrease of p is 'bad'.

3   Binding of experiencers and binding of experiences

One can consider two forms of binding: binding of *experiencers* and binding of *experiences*. The original hypothesis was that binding of experiencers by entanglement is all that is needed but it seems that the notion self leads to the self experiences its sub-selves as mental images and to the summation hypothesis stating that the experiences of sub-systems of sub-self sum up to single abstracted experience at the level of self. It must be emphasized that there is also a third meaning of binding in which various attributes are assigned with the object of the perceptive field: this binding however reduces to the entanglement of sub-selves (sub-experiencers). A concrete model for binding understood in this sense is discussed in [H4].

3.1   Binding of experiencers by entanglement

Quantum entanglement provides a mechanism for binding experiencers to a larger experiencer, and thus also a fusion of mental images to single mental image. Quantum entanglement was originally proposed as a solution of the binding of experiences but it seems that entanglement must form wholes from parts such that parts disappear in the process. Certainly this kind of binding is also an essential part of consciousness and direction of attention presumably corresponds to the division of entangled whole into 'figure and background'. In any case, entanglement 'kills' entangling sub-selves and change of the higher

level experience to a holistic experience with no divisions and separations. A possible example of the binding of sub-selves is the binding of right and left visual fields to single visual field. The visual fields can sometimes fail to bind: this should result from the failure of the corresponding sub-selves to generate mutual entanglement with sufficient rate.

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

3.2   Entanglement and altered states of consciousness

The succesful applications of p-adic physics give good reasons to believe that also real space-time regions can be a labelled by p-adic primes. This prime perhaps labels the local p-adic topology to which the real region can be transformed easily (, that is is near criticality against this kind of transition). If this is the case then also real space-time regions form a hierarchy labelled by p-adic primes.

The p-adic prime characterizing a real or a p-adic space-time region can change and this change might be interpreted as a phase transition. It however seems that in p-adic case this phase transition destroys the old self and creates a new self. In the real context the situation might be different and this transition might be experienced as a kind of enlightment experience.

The entanglement of sub-self with a sub-self of some higher level self means sharing and fusion of mental images and might provide a Golden Road to the understanding large number of altered states of consciousness. If self corresponds to a real space-time region, it can have a p-adic space-time region characterized by arbitrarily high p-adic prime p. If this cognitive sub-self entangles with a cognitive sub-self of some higher level self, it is possible to have mental images with an arbitrarily high positive entanglement negentropy. Certain kind of personal moral and intellectual evolution is believed to be a prequisite for enlightment experiences. The increase of the p-adic prime of sub-self meaning cognitive evolution indeed has interpretation as this kind of evolution.

Also the entanglement of a real sub-self with a real sub-self characterized by a larger p-adic prime can give rise to an enlightment experience. An alternative mechanism of self-extension in real case is simply the increase of the geometric size of self without entanglement with higher level self. This is quite possible and could also lead to an increased span of the geometric memory.

Examples of alterned states of consciousness are transpersonal experiences and enlightment experiences in which one identifies with some larger consciousness. For instance, prenatal experiences could result from the entanglement of sub-self with subsef having a temporal extension of order lifetime and having kind of abstracted experience about the period of life before birth. Experiencing the sorrow of all mothers of dead soldiers could involve the entanglement of

sub-self with a collective mental image resulting in the entanglement of mental images of very many mothers. If the notion of field body having size at least of order Earth size makes sense, this idea does not look so implausible anymore.

What happens for our self during sleep? There are several options.

1. We really lose consciousness during sleep.

2. Long term memory representations are not constructed during sleep so that we do not remember anything about sleep time consciousness except when we wake up from REM sleep: note that in this case the memories fade rapidly in accordance with the idea that long term memories are not constructed. Synchronous hippocampal theta is indeed absent during sleep.

3. We are able to remember what happened during sleep only if we are asleep. Perhaps synchronous theta and delta oscillations are involved with the construction of memory representations experienced only during sleep. The mirror mechanism of long term memories might allow this kind of possibility.

The first option is the 'obvious' one. Perhaps the function of sleep is to make possible formation of larger collective selves. During sleep our selves could entangle to form kind of a stereo consciousness representing human condition. This process could involve either phase transition changing local topology or a formation of join along boundaries contacts with much larger space-time sheets characterized by same local topology. This mechanism could make possible subconscious communication between the members of society and also establish conscience and moral. The topological field quanta associated with photons generated by EEG during sleep have frequency smaller than 7 Hz [L1]. This suggests that the higher level selves in question correspond to these topological field quanta and thus have a wake-up time of order .5 seconds during delta wave sleep. Therefore thoughs would not disappear but would become more abstract during sleep.

Physical death could mean the loss of sub-self representing body image and involve extension of the physical self: this would explain out of body experiences and near death experiences (person near death looking his body from outside). In fact, an attractive hypothesis, motivated by the quantum model of brain, is that the topological field quanta associated with photons generated by EEG currents having size of order Earth by Uncertainty Principle, could correspond to highest selves in our personal self hierarchy. Also magnetic flux tube structures associated with body and brain could have similar sizes and serve as a magnetic body [H4]. In physical death these ELF selves could continue to oscillate as Schumann resonances in the wave cavity between Earth's surface and ionosphere interacting with magnetic flux tube structures!

3.3 Summation hypothesis and binding of conscious experiences

The hypothesis about self leads immediately to ask how the experiences of self are determined. The geometric picture suggests strongly that self has sub-selves having their own experiences and these sub-selves correspond to space-time sheets or islands of different number field inside self. An attractive working hypothesis is that the experiences of sub-selves somehow sum up to a total experience of the entire self: various sub-selves would naturally represent separate mental images, such as various objects of the sensory experience and words and other substructures of linguistic though. The self Y containing self X would in turn form some kind of abstraction or average $\langle Z_i \rangle$ about sub-selves Z_i of X.

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

A possible problem for the hypothesis of self and summation hypothesis is provided by split brain patients. It seems that in most serious cases either right or left half dominates the behavior of the split brain patient and communication between brain hemispheres is lacking. It is known that brain hemispheres learn to communicate indirectly. Thus one can wonder whether the hypothesis about summation of the right and left selves to higher self consistent with the behaviour of split brain patients. there are several possibilities.

1. The dominance of either hemisphere is completely analogous to the dominance of a person over another one. This could partially explain why either left of right hemisphere dominates. The sudden changes of personality can be understood as result of different cognitive specializations of the two hemispheres. The lacking information transfer between hemispheres explains why right and left brain behave so differently (to the extend that they can have different future plans!). It is well known that in early childhood hemispheres behave as separate personalities and certain period in the learning of language seems to involve communication between brain hemispheres: left hemisphere comments what right hemisphere is doing. This kind of direct communication usually ceases, when the direct physical connection between brain hemispheres has developed. One can of course ask what 'dominance' means. A possible definition is based on the notion of self hierarchy. Dominant hemisphere has larger p-adic prime and dominated hemisphere entangles with some sub-self of the dominant hemisphere. The question is whether the join along boundaries bonds needed to achieve this entanglement are there in case of split brain patients.

2. The two hemispheres are not simultaneously awake in the sense of having self: this would mean also the absence of the higher self. The length of time-interval during which hemispheres are awake could be rather short. This might apply occasionally also to healthy persons. In fact, it is known that in case of dolphins the situation is just this. This kind of mechanism together with impaired communication between hemispheres could explain sudden changes of the personality.

3. For split brain patients the absence of physical connection between hemispheres makes impossible quantum entanglement binding the hemispheres together to form single coherent whole and the body of the patient is inhabited by two persons.

3.4   Binding geometrically

Quantum-classical correspondence principle suggests that the concept of binding should have counterpart at the level of space-time geometry. The gluing of the space-time sheets by topological sum to larger space-time sheets creates nested hierarchical structures. This suggests that the binding of the *experiences* that is mental images to mental images experienced by same self corresponds geometrically to the gluing of the material space-time sheets of sub-selves to the material space-time sheet of self by topological sum operation involving formation of 'wormhole contacts'. One could also require that sub-selves have p-adic prime smaller than that of self but this assumption is not absolutely necessary: certainly the local topologies must be different.

The binding of *experiencers* in turn would naturally correspond to the glueing of 3-surfaces together along their boundaries by join along boundaries bonds (actually topological sum for boundaries). In fact, join along boundaries mechanism has been identified as the mechanism leading to the formation of macroscopic quantum systems at the level of material space-time sheets. Join along boundaries bonding would make possible to get entangled with selves at the same level of the p-adic hierarchy of selves but not at different levels unless rational bound state entanglement between different number fields is possible. If experiencers are sub-selves, the formation of join along boundaries bonds means the fusion of mental images: basic example is the fusion of right and left visual fields to single visual fields and giving rise to stereo vision. Also the mental images of separate selves can fuse and this means sharing of the fused mental image.

The identification of the geometric counterpart of self with mindlike space-time sheet makes it possible to identify uniquely the subjective history of the self as induced by its space-time history. For instance, larger mindlike space-time sheets at the higher level of the hierarchy could contain or generate wholes making possible for smaller mindlike space-time sheets to form join along boundaries bonds. This mechanism would provide a concrete geometric realization for the communication between different levels of the hierarchy of selves. For instance, long term memories could become conscious through this kind of mechanism.

Also the question what happens for self after physical death could reduce to the question what happens to the mindlike space-time sheet of self. For instance, a fusion to some mindlike space-time sheet, whose p-adic prime characterizes the fate of the self in future (in the sense of subjective time) life, could take place.

There are several arguments supporting the importance of join along boundaries bonds between matter- and mindlike space-time sheets and also demonstrating that the two views need not be mutually conflicting. It is however clear that one should not take the idea about the importance of join along boundaries bonds to extreme.

1. The dynamical realization of the self hierarchy as a master-slave hierarchy of various kinds of super conductors [I4, I5] relies on the identification of the join along boundaries bonds between the space-time sheets belonging to various levels of hierarchy as Josephson junctions. The "biofeedback" made possible by the join along boundaries bond makes it possible for the selves at higher levels of the hierarchy to experience what it is to be lower level self. In particular, our immediate sub-selves are represented by topological field quanta of ELF em fields associated with EEG frequencies and thus have size of order Earth's circumference by Uncertainty Principle, whereas sensory experiences involve in essential manner entanglement with sub..sub-selves with size scale of neuronal circuits.

2. One could argue that mindlike space-time sheets become actually material space-time sheets in the gluing along boundaries process since energy and matter from the material space-time sheets flow to the mindlike space-time sheets freely through join along boundaries bonds. This objection can be circumvented. 'Free' mindlike space-time sheets could correspond actually to pairs of space-time sheets with opposite time orientations such that various classical fields are generated by rotating gauge charged wormhole contacts on the boundaries of these space-time sheets. These two space-time sheets have opposite classical energies so that the net energy for the system vanishes. If this kind of a pair is glued to a material space-time sheet by join along boundaries bonds connecting the mindlike space-time sheet with a positive time orientation to the material space-time sheet, continuity requires that classical fields on the two mindlike space-time sheets of the pair have similar strength. Thus a cognitive representation of the material space-time sheets by a direct mimicry results [J5]! In this view mindlike space-time sheet pairs would realize phycisist's version of the computer scientist's universe as consisting of Turing machines emulating other Turing machines.

3. If one regards the mindlike space-time sheet with a positive time orientation as a part of the material space-time sheet, one can also regard negative energy mindlike space-time sheet as a mindlike space-time sheet glued near to the boundary of the material space-time sheet by topological sum contacts! Mindlike space-time sheets would obtain classical information only about the *boundary regions* of the material space-time sheets. As

a matter fact, our conscious experience actually does just this: whether this is mere coincidence, must be left open here. One could argue that this kind of restriction is not consistent with the idea that the universe is maximally intelligent. Of course, mindlike space-time sheets appear in all length scales so that this restriction is perhaps not a problem. An open question indeed is whether cell membranes could be regarded as two-sheeted structures glued by join along boundaries bonds to the space-time sheets representing cell interior and exterior. If this is the case then cell membrane space-time sheet would represent space-time sheet with negative time orientation and negative classical energy.

4. The localization of cognition to boundaries, if taken to extreme, might force to modify the basic ideas about the identification of the quantum correlates of the sensory qualia and thought. For instance, the idea that cognitive neutrino pairs would correspond neutrino and antineutrino space-time sheets glued to the boundaries of a material space-time sheet does not seem to make sense. Rather, the members of the cognitive neutrino pair are both glued to material space-time sheets of a positive time orientation and cognitive antineutrinos are delocalized in the entire cell membrane space-time sheet. Note that this argument does not bite if one assumes that the members of cognitive neutrino pair do not entangle with material space-time sheet at which they topologically condense.

3.5 General structure of conscious experience

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

3.5.1 Experiences of self as abstractions and averages

Summation hypothesis means that self forms abstractions about experiences of its sub-selves: this means that the separate experiences of sub-sub-selves are replaced with some kind of average experiences. NMP states that the experiences of sub-systems and sub-selves are maximally interesting in the sense that each step in the cascade of self measurements representing state preparation yields maximal entanglement negentropy gain. Self is an ideal 'boss' since it forms abstractions about the most interesting potential experiences. Note that abstraction hierarchy is analogous with the hierarchy of higher level computer languages and with the hierarchy of modules of a computer program.

If subjective memory is possible in the sense that self integrates to single experience all the conscious experiences after the the moment when it 'wake-up', one could expect that self performs automatically also time-averaging: in biologically interesting time scales of about one second the averaging would mean use of 'temporal' ensembles with something like 10^{38} experiences! Thus the reliability and stability of experiences is reached already at the level of single irreducible self. Subjecto-temporal sequences of sub-selves experienced as

separate mental images in turn make it possible to have structured experiences so that one can remember digits of a phonenumber.

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

3.5.2   Parts, wholes and entanglement

The basic feature of higher level cognition is formation of wholes from parts. Quantum entanglement between selves representing parts provides an attractive model for this process. Selves represent symbolically the components of conscious experience, say letters of the word: in absence of entanglement between these 'letter' selves the sum experience is set of letters whereas higher level experiences is about average letter. If sub-selves get entangled, there are no sub-self-experiences and sum-experience is about the word as is also the higher level experience. The application of this hypothesis to the modelling of music experience will be considered later. The hypothesis will be also applied to explain paradoxal result of certain experiment testing righ-left brain differences.

3.5.3   What is the most general structure of the self hierarchy?

Self hierarchy need not be a simple nested hierarchy represented by a tree or a union of disjoint trees. On the other hand, arbitrary connections between the levels of the hierarchy imply paradoxal situations. Simple questions help to get a grasp on the problem. What happens if the branches of a given tree or separate trees are connected? What kind of connections are allowed without ending up with a paradoxical situation in which one cannot tell which one of the two selves is the sub-self of another self. The appearance of loops in the self hierarchy certainly leads to this kind of paradoxal situations since self can become its own sub-self.

This kind of paradoxal situations are avoided if only those selves which belong to the same level of the self hierarchy can fuse so that one has a collection of trees which can have horizontal connections (both intra- and inter-tree) between the nodes belonging to the same hierarchy level. The presence of a horizontal connection means that two separate selves share the mental image resulting in the fusion. Of course, the same mental images could be shared by an arbitrary number of selves, and this could be one of the mechanisms making possible both social behaviour and the propagation of memes. Also a genuine communication might necessitate sharing of the mental images rather than being only active sending and passive receival. Sharing of mental images might occur also in hypnosis and various remote mental interactions and identification phenom-

ena ('experiencing the sorrow of all mothers lost their son in war'). Long term memory could also involve the sharing of the same mental image by the selves of the geometric past and geometric now.

The paradox-free situation is achieved if the selves are arranged according to the local space-time topology so that all p-adic selves with given prime are at the same level in the hierarchy and real selves ($p = \infty$ formally) are at the top of the hierarchy. Sub-selves must always have smaller p than self and real selves are at the top. Quantum entanglement allows only fusion of selves at the same level of the hierarchy and thus having the same local topology labelled by the p-adic prime p. Algebraic extensions of p-adic numbers presumably bring in more refined sub-hierarchies for a given value of p and they could correspond to various levels of mathematical cognition. This hierarchy is represented by a collection of trees which can have horizontal connections joining nodes at the same level. The sharing of mental images by the fusion of sub-selves is thus possible. The level of the self in the hierarchy can change and is induced by a quantum jump in which the local number field (p-adic or real) associated with the space-time sheet representing self changes from R_{p_1} to R_{p_2}.

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

This might have a trivial explanation: the change in the direction of the gaze could be too small to be perceived. But also quantum entanglement might be involved. What must be crucial is that the change of the orientation of the eyeball is caused by brain itself rather than some external agent as in the case of a moving object belonging to the external world. The changing orientation of an external object of the perceptive field is consciously perceived by comparing it with the orientations of other objects of the perceptive field. That is, self compares its sub-selves (mental images) with each other. When the direction of the gaze is changed, quantum entanglement between self and the visual-cognitive mental image representing eyes is generated to achieve the needed motor response. The visual-cognitive sub-self representing eyes is temporarily lifted to a higher level in the self hierarchy and becomes part of higher level self (the change of the local number field is involved). The other sub-selves at the same p-adic level cannot anymore serve as a reference against which the changing orientation would be perceived. Since self cannot compare itself with itself, it cannot perceive visually the changing direction of the gaze.

3.5.4 Objectivity of conscious experiences

Understanding the objectivity of conscious experience has been longstanding problem of TGD inspired theory of consciousness. The contents of conscious experience can depend on both initial and final states of the quantum jump. Quantum theory does not necessarily tell how the contents of conscious experience are determined.

1. Are the contents of sensory experience defined by the final state of the quantum jump?

The most optimistic assumption is that the contents of the conscious experience depends on the final state only or contains precise information about both initial and final state simultaneously. The standard quantum measurement theory would suggest that the measured quantum numbers of the final state could determine the contents of conscious experiences but this is obviously purely formal guess. Quantum jump involves localization in zero modes and thus quantum measurement of zero modes. If the localization is complete (in discrete zero modes this need not be the case), the information about the position of the Universe in configuration space zero modes is maximal. Hence the information gain in zero modes defined as the difference $I(\Psi_f) - I(U\Psi_i)$ [H7] is certainly nonvanishing even for states remaining invariant in quantum jump ($\Psi_f = \Psi_i$).

Hence one could say that quantum jump can give objective information in zero modes and that the information contained by geometric aspects of the sensory experiences might be information about the zero modes of the final state. This conclusion would be in accordance with the fact that zero modes correspond to order parameters characterizing the classical features of the space-time surface. The contents of the geometric aspects of the experience might be determined by the location in zero modes for ordinary vision, sense of touch and sense of smell: of course, the location would occur simultaneously for a large number of neurons and our experience would be averaged over these experiences.

Consider now the objections against this hypothesis. Zero modes form an infinite-dimensional space analogous to symmetric space and its should be possible to experience only their increments since configuration space geometry by no means distinguishes between various values of zero modes. Also the very notion of subjective experiencing as associated with quantum jumps favours the idea that it is only increments which are experienced. This principle could be seen as some kind of principle of relativity at the level of conscious experience.

2. Are the contents of conscious experience determined by both initial and final states of the quantum jump?

A more pessimistic, and presumably realistic, assumption is that only some kind of comparison of initial states Ψ_i and final states Ψ_f, or more probably, comparison of the zero mode localization $Loc(U\Psi_i)$ of the state $U\Psi_i$ and the state Ψ_f is in question. This would suggest that information about initial and final states is only relative information, information about differences, and that absolute information about state is impossible to achieve. This would mean that the increments of quantum numbers in quantum phase transitions and increments of zero modes determine consciousness experience. Certainly this is in accordance with the view that subjective existence corresponds to quantum jumps and objective existence corresponds to quantum states.

Considerable support for this line of thinking comes from the model for the quantum correlates of the sensory qualia [K3] in which various geometric and

nongeometric sensory modalities are characterized by the increments of various quantum numbers and of zero modes in quantum jumps. In particular, magnetic transition frequencies correspond to the differences of the initial and final state energies and indeed depend on both the initial and final states of the quantum jump.

Consider now various definitions of objectivity.

1. The strongest form of objectivity requires that sub-system state remains essentially unchanged both in the informational "time evolution" U and in quantum jump. This kind of ideal situation might be realized in 'that-which-is' experiences. The fact that various information gains for conscious experiences are differences for information gains associated with the initial and final quantum histories and vanish at the limit when state remains unchanged, supports the conclusion that the knowledge provided by 'that-which-is' experiences cannot be regarded as information but means only direct experiencing of what it is to be that particular state. This would suggest that we are doomed to live in Maya basically. In accordance with this pessimistic view one could interpret information gains as measures for how much illusions are reduced in the experience.

2. The requirement that state remains invariant in statistical sense provides a weaker form of objectivity. If one assumes that all the experiences of self after wake-up integrate to single subjective time-continuum, quantum statistical determinism is automatically achieved in biologically interesting time scales of order second and statistical objectivity is achieved since the number of quantum jumps can be as high as 10^{38} per second. If one does not assume subjective memory, one must assume that self consists of subensembles of identical sub-selves. One can represent an objection also against this view: at the limit when the statistical ensemble representing self is thermalized the experience does not fluctuate but the price paid for this is that mental image is completely thermalized and has no information content. Thus it would seem that there is a competition between information content and reliability of conscious experience associated with self. Too short time series is not reliable, too long time series does not give information at all. Formation of bound states allows to effectively bind large number of quantum jumps to single quantum jump with duration of the bound state so that information is not lost totally.

4 Some applications at brain level

4.1 A simple model for cognition

The hierarchy of selves and summation hypothesis allows to construct a very general model for cognitive processes including as a special case thinking, analysis of visual experience, and language. In nutshell: cognitive process could be regarded as cascade like process leading to a generation of selves followed by

generation of sub-selves for these and so on. Quantum jump becomes the building block of cognition and thought but is not sufficient alone. p-Adic space-time sheets as fundamental cognitive representations providing geometric correlates for thoughts, intentions, plans, etc.. are a fundamental element of cognition. In the following considerations, which date back to the time when I had not yet realized the proper meaning of the p-adic physics, this aspect is not taken into account. It is of course a matter of definition what one regards as cognition.

4.1.1 Two modes of consciousness

Self can be in two modes of consciousness. Irreducible self having just single mental image in a state of oneness must experience 'whole-body consciousness', state of one-ness. These states of consciousness might correspond to the mystic experiences described by mystics like Krishnamurti. The life long training of yogis and meditators could help to achieve skill to induce phase transitions eliminating the sub-selves representing mental images representing sensory input and thoughts. There are no dissipating sub-selves during these experiences and hence one might argue that neurons, etc... do not get older nor suffer irreversible changes. Reduced dissipation during meditation provides a test for this prediction. The binding energy liberated in the formation of bound state of sub-selves in turn could be used as metabolic energy: metabolic energy would be however needed to destroy the bound state. Whole body consciousness, if it could be generated artificially, could have obvious medical applications and even save lives. For instance, entangling the brain of a victim of brain infarct with his body could hinder irreversible neuronal changes otherwise caused by bleeding in brain!

It seems that these two modes of consciousness could explain wide range of dichotomies of consciousness like rational/mystic, left brain/right brain, masculine/feminine, Western/Eastern, etc... A self consisting of sub-selves, which are dominantly in these opposite modes could form representations about external world as a summary from two highly different world views and perhaps cope better in the survival for fittest. If this is the case, evolution would favour selves which find their opposites attractive: this could be the origin of the sex. Binary systems are abundant in biology. Examples are pairs of microtubules, DNA double helix, lipid layers of cell membrane and cell layers of epithelial sheets in skin and various organs. A possible explanation is that these structures correspond to selves consisting of sub-selves in analytic and holistic modes of consciousness.

4.1.2 Quantum criticality of TGD and existence of selves

The model of cognition provides a new view to the role of quantum criticality of TGD. One consequence of the quantum criticality could be the existence of a lot of sub-systems which are near the critical line at which phase transition changing the local topology (real or p-adic) occurs. TGD universe would be in a state of maximal alertness ready to generate cascades of selves representing cognitive acts. Our cognitive acts would be only part of the cognitive acts of the entire

Universe proceeding from top to bottom as infinite trees with branches representing new selves and nodes representing moments of wake-ups for the selves. Or expressing it in the terminology of AI: we would be like subprograms of infinite program represented by entire universe. The presence of higher level selves means that cognitive acts can proceed from the level of even entire biosystem to the level of DNA. This encourages to interesting speculations: for instance, the ideas of Sheldrake about learning at the level of species and even biosphere might find justification [I1].

4.1.3 Thoughts, perceptions, cognitions as sequences of awakenings

Before the discovery of the notion of self, the idea was that thought corresponds to single quantum jump. The idea was that the experienced temporal duration of thought results from the time nonlocality of the contents of thought made possible by temporal duration of the mindlike space-time sheets. One could however claim that temporal extension of mindlike space-time sheets need not explain the experienced time duration associated with thoughts. The time duration of thought is subjective time duration whereas mindlike space-time sheets have geometric time duration.

Furthermore, it is subjective rather than geometric time which has natural arrow and the arrow of psychological time reflects the arrow of subjective time. Taking also into account that the average increment of psychological time in single quantum jump is extremely small, perhaps only 10^4 Planck times on the average, one must give up the idea that single quantum jump could correspond to single thought. This leaves only one conclusion: single thought cannot correspond to single quantum jump but to a sequence of very many quantum jumps.

Basic cognitive act, identified as a generation and subsequent development of self, corresponds to a cascade like process in which new selves are generated as sub-selves of already generated selves. Thus cognitive act can be characterized by a dynamically generated tree in which each node corresponds to generation of sub-selves of self represented by the branch leading to the node. This leads naturally to a modular structure of cognitive acts analogous to the modular structure of a computer program: starting of subprogram means wake-up of sub-self. Sub-selves cannot wake-up before the self containing them has woken-up and this gives natural time ordering for the execution of these 'program modules'. The decomposition of the sensory experience to modular pieces corresponds directly to the decomposition to sub-selves. Subjective memory makes it possible for main program to experience the entire subjective histories of subprograms as abstracted experiences.

1. The dynamically generated nested inclusion of selves inside selves is crucial for cognitive acts. The most natural interpretation of this process is as analysis, in which initial experience gradually sharpens and gets more and more structured during the decomposition into sub-selves. Sub-selves could be thought as symbols of language or as logical statements or objects

in picture: interpretation depends on what kind of cognitive process is in question.

2. In this picture basic elements of conscious experience are sequences of awakenings. In each step several sub-selves of given self can be created. What would happen could be something like follows:

    i) Self A wakes up and begins to perform quantum jumps (perhaps something like 10^{38} per second!).

    ii) Sub-self B of A is generated by a topology changing phase transition.

    iii) Cognitive process proceeds in a cascade like manner starting from the root of tree and going downwards along the tree choosing at each node some branches. For instance, understanding of a sentence would correspond to waking up of large self A representing sentence in its entirety, words its sub-selves B_i, phonemes to sub-selves C_{ij} of B_i, etc... waking-up in this order. Similarly, the act of decomposing the figure to objects and of objects to sub-objects would correspond to a temporal sequence generating selves within selves. Background would be the largest conscious self and objects would correspond to a sequence of selves. Selves C_{ij} and further sub-selves can be generated before generation of next C_{i+1}: this should occur in case linguistic mental image: generation of word self would be followed by the generation of syllables and phonemes and only after this would next word be generated. Time nonlocality of self experience with respect to geometric and subjective time would be essential.

3. Statistical determinism implies reliability if there is ensemble of 'big' selves. If sub-selves make with high probability the same matter-mind type quantum jump repeatedly and if the process of self generation is more or less deterministic, thoughts are reliable. This is certainly possible. Learning as habituation could be possibly understood as a gradual development of highly predictable cascades of selves.

4. The sequential quantum jumps performed by self need not be identical. Quantum statistical determinism in temporal domain could be at work and it is enough that some state is favoured as final state of quantum jump for long enough periods of time. Note also that self experience must be kind of statistical average if subjective memory is possible.

At formal level one could consider the self cascade as a realization of logical implication sequence $A \to B$ as inclusion of sets: $B \subset A$. This would be standard set theoretic realization of Boolean algebra: A implies B when the self representing B is sub-self of self representing A. $A, B, ...$ are experienced simultaneously as sub-selves of entire self sub-selves of A and B are created later than their predecessors. Logical causation would also correspond to temporal causation. The objection against this idea is that self experiences only its sub-selves directly. A more plausible interpretation of the self cascade is as a representation for an abstraction process representing thoughts about thoughts

about... Our poor ability to form statements about statements about ... would correspond to the fact that self experiences only its sub-selves directly. A more plausible realization for logical thinking is as learned associations in which sub-self representing premises of logical statement wakes-up sub-self representing the conclusions of the statement and belonging to the *same* level of self-hierarchy. Neural circuits would represent typically linear sequences of selves waking up in linear order: TGD based model for brain cognition indeed favors this option [H7, L1].

4.2 Differences between left and right brain hemisphere

The differences between left and right brain hemisphere are a challenge for any theory of consciousness. In TGD framework one can imagine several mechanisms contributing to the differences between right and left brain hemisphere (these mechanisms need by no means be mutually exclusive). The differences could be related to the number, size and wake-up time of the sub-selves, to the nature of self cascades and even to the manner the sub-selves wake-up. Also the time span and temporal and spatial resolutions of the geometric memory could be different for left and right brain. Linguistic cognition represented by cognitive antineutrinos is in a well-defined sense critical phenomenon and could be more dominant in the left brain hemisphere: one could even say that left brain talks while right brain sings. p-Adic cognitive representations might be more dominating on the left hemisphere: of course, it could also be that the character of p-adic representations depends on hemisphere.

It seems however that the most fundamental characteristic explaining all the listed differences derives from the fact that for MEs in time scales of long term memory right brain hemisphere possesses a reversed arrow of geometric time whereas left brain has a normal arrow of geometric time. For the right brain hemisphere long term memories are episodal memories, re-experiences involving a time-like entanglement with the geometric past and a direct sharing of mental images. Negative energy Z^0 MEs are excellent candidate for the space-time correlates of this entanglement. Left brain generates positive energy MEs and the very low value of the effective phase velocity allows it to communicate non-episodal memories classically.

4.2.1 Linear/parallel dichotomy

The model of cognition [L1] suggests that left brain decomposes to many sub-selves which reside on linear brain circuits and wake up each other sequentially, whereas right brain contains only few sub-selves which correspond to larger brain regions. This would explain linear/parallel and analytic/holistic dichotomies. At the level of subjective experience this means long subjecto-temporal sequences of sub-selves (say words of a sentence) in case of the left hemisphere, and large number of longlived subjectively parallel sub-selves in case of the right hemisphere (say separate items of a picture).

Linear/parallel dichotomy could physically correspond to the dominance of propagating (resp. nonpropagating) EEG waves in left (resp. right) brain hemisphere [M4]. Nonpropagating EEG waves are possible for large brain regions whereas propagating EEG waves are possible only for linear circuits. During nonpropagating EEG phase nerve pulse activity associated with Boolean mind would be be supressed which is consistent with the observation that right brain is less verbal. Also the Combinatorial Hierarchy model for the memetic code suggests that 'Boolean' cognition involving sub-selves which correspond to linear circuits, is more prevalent in the left brain hemisphere.

Left brain seems to be skilled in forming mental images about structures consisting of well defined components whereas right brain can grasp the general shape and size of the structure. This could be understood if left brain represents structures linguistically as associative linear structures consisting of parts represented as sub-selves. Thus structure could be realized as a reverberating neural circuit in which sub-selves representing parts of the structure keep each other awake.

4.2.2 Why right brain hemisphere is less analytic?

The requirement that the number of right brain sub-selves does not require that the depth for the cognitive cascades is small. Thus the notion that right brain is analytic than left brain requires the additional assumption that right brain self cascades are short. The sub-selves of right brain avoid decomposition into smaller sub-selves if they remain for sufficiently long time in a state of 'whole-body' consciousness. This requires that the entanglement between sub-systems is genereted rapidly enough, perhaps event resonantly, during sequential time developments U.

'One-ness' requirement implies that linear information processing is not possible for right brain below the length scale at which enlightened state endures. Of course, linear processing of information with generation of hierarchy of sub-selves could become possible after the state of one-ness ceases unless sub-selves in question fall asleep. This would mean that sub-self begins to analyze its 'enlightment' experience, when the stimulus giving rise to the experience of one-ness ceases. Note that this picture implies that the metaphor describing states of one-ness as a resonance like phenomenon is more than metaphor. The interpretation for two kinds of cognitive modes is as ordinary analytic intelligence relying on linear information processing and as emotional, holistic intelligence relying on parallel information processing (the states of one-ness in each level of hierarchy are indeed purely emotional since analytic thought is completely absent).

4.2.3 Why left brain talks and right brain sings?

That left brain talks whereas right brain (almost) sings is more than a loose metaphor: it is known that people who have left brain injury and cannot talk can sometimes express themselves by singing. Linear-parallel dichotomy would

suggest that left brain is specialized to subjecto-temporal sequences of parallel small-sized mental images of short duration (say words of speech) whereas right brain is specialized to large selves formed by the fusion of parallel sub-selves formed by, say, separate notes of music which can last long time and have no linguistic content. Although the notes of song are heard one in time, they would continue to live in right brain as parallel mental images and make possible to experience the melody as sad or joyful.

This could be due to a neuronal specification: according to the model of cognition [L1], in the left brain the cognitive inputs from the auditory pathway to the association regions could consist of memetic codewords with fixed Z^0 magnetic transition frequency corresponding to the frequency defined by the duration of the nerve pulse. In the right brain hemisphere the inputs from the auditory pathway to the associative region could correspond to varying Z^0 magnetic transition frequencies. These frequencies could be above or below the audible frequency range.

At the deeper level the difference between right and left brain hemispheres could reflect their different roles in the mechanism of the long term memory. Talking-singing dichotomy could correspond to the classical-quantum dichotomy for communications.

1. Negative energy Z^0 MEs sent by right brain hemisphere would generate a timelike entanglement and a sharing of the mental images with the geometric past. This alone could give rise to an episodal memory. The mechanism would not however be very flexible, and it is questionable whether it might allow active memory recall at all. In this case individual Z^0 MEs need not carry any information since their sole role is to entangle. Hence monochromatic Z^0 MEs would be enough. The frequency pattern of various Z^0 MEs however could however carry emotional information as in music so that there would not be any absolute need for the individual Z^0 ME to entangle with a complex mental images. Right brain would sign in multisono.

2. In the case of non-episodal memories active memory recall could be realized in the same manner but now the quantum answer would be only a statement that the question has been received. The left hemisphere would provide the real answer by classical communications by sending positive energy Z^0 MEs with extremely slow effective phase velocity $v = L/T$, where L is an appropriate distance inside brain and T is the time span of the long term memory. Ca^{++} have extremely wide velocity spectrum and would most naturally be associated with these Z^0 MEs. For the classical communications a modulation at single carrier frequency to realize memetic codewords is enough. Presumably this frequency is 1260 Hz corresponding to the bit of the memetic codeword. Left brain would talk.

4.2.4 Why right brain has a poor time resolution and is more emotional?

If right brain sub-selves have time like entanglement to form temporal wholes, the time resolution is poor. Time resolution requires a sequence of separate sub-selves and in left brain the duration of the sub-selves is short. For instance, the cognitive antineutrinos of the right hemisphere could entangle both in spatial and temporal directions to form spatio-temporal wholes whereas in left brain they would behave as separate sub-selves. This would indeed mean poor spatial and temporal resolution as a price paid for temporal holism. Also the mechanism of episodal memories based on time-like entanglement is consistent with this view.

One could consider also the possibility that the spin flips of cognitive antineutrinos which correspond in one-one manner to nerve pulses are more frequent in left brain: this would obviously increase the information content of the memetic codewords. The average temporal distance between spin flips would define the time resolution of the sensory experience so that the typical number of nerve pulses per time in given axon could be larger in left brain hemisphere.

Is also spatial holism characteristic of right brain information processing? Right brain has better skills in recognizing and expressing emotions and in grasping spatial shapes and has worser ability to recognize temporal order. If emotions are qualia having entropy gradients as their correlates and give information about what happens for the entire system, one could perhaps understand this. Large sub-selves formed by fusion of sub-selves would give rise to large entropic gradients and coherent emotions whereas a large number of unentangled sub-selves in left brain would not give rise to any coherent emotion just as left brain vision does not give rise to any coherent picture (say face) but only a collection of features.

4.2.5 Holism and reductionism: why we have two brain hemispheres?

One of the basic features of conscious experience is the formation of wholes and parts. As already described, quantum entanglement provides a quantum description of this process. Sub-selves represent the components of experience and in the absence of entanglement between selves the net experience is sum of the parts without an idea what the whole is. If sub-selves get entangled, the sum experience represents the irreducible whole without any idea about parts. This gives rise to reductionism-holism dichotomy which seems to characterize all cognitive activity.

This tension between holism and reductionism suggests a general explanation for why we have two brain hemispheres. There are two basic cognitive representations: reductionistic and holistic corresponding to the knowledge about parts without knowledge of the whole and vice versa. Single self (and presumably also brain hemisphere) cannot provide these representations simultaneously. Two brain hemispheres can however achieve this and this might be one the most important reasons why we have two hemispheres! If this hypothesis is correct,

then information processing in brain involves co-operation of and communication between the brain hemispheres so that the special skills of the hemispheres are used in the optimal manner. The hemisphere more skilled in dicriminating geometric, linguistic, etc.. details provides a representation or parts in terms of unentangled sub-selves whereas the less skilled brain hemisphere provides simultaneous representation as an entangled whole and entire brain has reductionistic and holistic representations as its simultaneous sub-selves.

This hypothesis can be tested by applying it to explain a rather paradoxal experimental result which is in conflict with the idea about the differences between right and left brain. In [30] there is report about two experimental situations testing right-left differences.

1. Subject persons saw figure S consisting of smaller figure F:s. It was found that left brain seemed to recognize smaller F:s whereas right brain seemed to recognize the entire figure S: just as expected.

2. For control purposes figure S consisting of small F:s was replaced with a figure of anchor consisting of small cups. What happened was that left brain recognized the anchor and right brain recognized the cups! It was conjectured that the smallness of cups might have something to do with the unexpected result.

The result provides a challenge for left-right brain dichotomists and also for the proposed conceptual framework. The idea about division of labour to build reductionistic and holistic representations suggests an explanation of the paradox.

1. A plausible assumption is scale invariance in the sense that the recognition of a particular linguistic symbol or geometric shape cannot depend on its size above some resolution scale. This resolution scale depends on the brain hemisphere. Zooming could be involved and correspond to a formation of cognitive representation about part of figure and involving same neuron group as the representation of the entire figure.

2. Since right (resp. left) brain hemisphere is more skilled in the recognition of shapes (resp. linguistic symbols), one would expect that it is able to recognize smaller shapes (resp. linguistic symbols) than left (resp. right) brain hemisphere by directing attention to a small part of the figure. This dictates the optimal division of labour. Since the first (resp. second) figure consists of linguistic symbols (geometric shapes), left (resp. right) brain hemisphere takes care of details and right (resp. left) brain hemisphere takes care of the whole.

An alternative explanation is based on the observation that the figure in the first case is letter consisting of letters whereas in the second case the figure is geometrical shape consisting of geometrical shapes. This would suggest that it is left/right hemisphere which recognizes the figure in the first/second

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case. Just the opposite seems however to occur! Could it be that the neural activity observed is not associated with recognition but with the receipt of a message about the recognition actually carried out by the opposite hemisphere? This would suggest that recognition itself is quantum level process not involving neural activity at all! 75 per cent of cortical projections in human brain are inhibitory: for monkey the corresponding number is 45 per cent. This is consistent with the idea that large part of conscious activity might not manifest itself as neural activity.

4.2.6 Dr. P. and twins who saw primeness

Oliver Sack's book 'The man who mistook his wife for a hat' [38] contains fascinating stories about those aspects of brain and consciousness which are more or less mysterious from the view point of neuroscience. There are two stories which relate very closely to reductionism-holism tension of conscious experiencing.

The first story is about Dr. P. who suffered visual agnosia and could not recognize concrete objects, say faces unless some nonvisual association was involved. He could however recognize abstract symbols or objects containing some symbolic details making possible the recognition (he recognized Einstein's face, which has indeed become a symbol of wisdom!). Sacks tells about how his patient tried to recognize glove. 'A curved shaped containing five small bags' was his abstract analysis: he could not identify the glove as a glove unless he got it in his hand! He could however define glove as an abstract geometric shape allowing simple linguistic description. Dr. P. could identify abstract shapes and symbols like letters and geometric objects but could not recognize real world objects. Amazingly, Dr. P. used musical associations as a manner to cope with the complexities of everyday life. He singed through all his everyday activities and lost control totally if this was for some reason not possible. He could also continue teaching of this music class. For instance, he could recognize his music students only when they moved by recognizing their 'body music'.

As discussed, reductionism-holism duality provides the deep reason for why we have two brain lobes. This allows to understand what might be possibly involved with Dr. P:s case. Dr. P:s right visual areas had been damaged and he could not recognize faces and concrete objects of the visual field. Left visual areas were in good condition and he could identify abstract objects. Other than visual areas were still in good condition in both hemispheres and he could perform recognition using musical associations, associations created by smells, etc... Sacks notices also a deep analogy with Dr. P.:s case and neuroscience. Expressing rather freely what Luria said, entire neuroscience up to seventies provided analytic description of left brain about left brain. It had indeed turned out very difficult to assign any easily identifiable cognitive dysfunctions with localized right brain injuries and Luria's opinion was that this necessitated completely different approach which he called 'romantic' (stories of right brain about both right and left brain!).

In fact, one can formulate new kind of Uncertainty Principle, perhaps it

might be called Uncertainty Principle of cognition. Same mental image cannnot be both holistic and reductionistic simultaneously. The combination of reductionistic and holistic descriptions (and all possible intermediate descriptions combining parts to subwholes in various manners) to single description is impossible even in principle! Science and Art as descriptions of the world are very much like mutually incompatible observables of Uncertainty Principle!

Sacks tells also about twins, John and Michael, who had mysterious ability to 'see' large numbers. For instance, matchbox was dropped from the table and its contents were spread along the floor. Both twins shouted immediately '111!'. Then John mumbled '37', Michael repeated it and John said '37' third time. Obviously this was their cognitive representation for the decomposition 111=3x37 of number 111 to a product of primes!

How John and Michael did these numerical feats? The first thing to notice is that twins had intelligence quotient of about 60 and could not perform even simplest arithmetical operations. They did not even understand what the concepts of prime and decomposition into prime factors mean conceptually. They however experienced primes as especially interesting numbers and even played a game in which they invented new primes. One can safely assume that they did not consciously calculate the decomposition of number 111 to a product of primes. When asked how they were able to tell the number of matches, they told that they 'saw' it. In fact, their eyes moved in strange manner always when they were performing numerical tasks and stopped when the solution was found. Also the decomposition of 111 to a product of 3 primes '37' seemed to occur completely spontaneously 'in front of their eyes'.

The mysterious ability of twins is not a mere curiosity but could provide a crucial clue to the problem of understanding of how numbers are realized as mental images. Indeed, also ordinary human beings are able to experience directly 'N-ness', when the size of N is small. The natural working hypothesis is that the difference between ordinary human being and numerical genius is only quantitative. Thus the problem transforms to a more general question 'How integers are experienced?'.

In TGD framework the answer to the question is obvious. Experiencing of 'N-ness' means experiencing 'N' separate objects as a single whole and corresponds quantum physically to the generation of entanglement between the cognitive representatives of individual objects. If the resulting mental image associates automatically with a linguistic expression for 'N-ness', say '$N = 5 \leftrightarrow five$', reportable recognition of 'N-ness' occurs. 7 ± 2 law suggests that this entanglement and association usually occurs only for maximal number of objects not larger than $N = 7 \pm 2$. In case of a numerical genius this number seems to be drastically higher. The generation of this entanglement should be spontanous self-organization process in either brain hemisphere and entangled objects could correspond to separate neuron groups or neurons.

The decomposition of integer $N = N_1 \times N_2$ to a product of integers must in this picture correspond to the spontaneous formation of identical 'sub-wholes'. This process must be a quantum self-organization process. It could favour the decomposition of $N = N_1 \times N_2$ objects to N_1 'sub-wholes' consisting of N_2

entangled basic objects or decomposition of N_2 sub-wholes consisting of N_1 basic objects or something else depending on factors of N. This kind of final states of self-organization are natural since they are very symmetrical consisting of a repetition of an identical basic unit. This kind of self-organization patterns are analogous to the lattice-like self-organization patterns of Benard flow.

The model also explains the ability of twins to see whether a given number is prime or not. Primes are stable against decomposition into sub-wholes and are therefore 'elementary particles of cognition'. Hence primeness is a 'visible' property: primes are numerical mental images stable against decay to a set of identical numerical mental images. Note that this dynamical process breaks the symmetry between the factors of integer. This clearly occurred in 111= 3x37 example. Twins did not 'see' '3': they saw only some 37's and did not explicitely tell that there were precisely three 37:s!

In [K4] a more concrete model for how real space-time sheets could represent integers and their prime factorization by their effectively p-adic topology, is discussed.

4.3   Music and summation hypothesis

Music experience provides an interesting testing ground for several ideas:

1. Summation hypothesis stating that self is sum of abstracted experiences of sub-selves and thus representing kind of averages about the experiences of sub-sub-selves.

2. The idea of subjective memory.

3. The idea about entanglement creating wholes from parts.

4. The idea about cognitive act as a cascade like generation of selves having sub-selves having... providing symbolical hierarchical representations and cognitive analysis of the experience into objects.

5. The idea that there are two modes of conscious existence. The first mode creates a burst of parallel small-sized sub-selves forming linear subjecto-temporal sequences creating reductionistic experiences. The second mode creates fusions of large number of parallel sub-selves having short temporal duration creating holistic experiences. Information processing in left and right brain might correspond to these two modes respectively in some important length scales below cell membrane length scale.

6. The idea that there are two basic types of cognition depending on whether self is in a state of whole body consciousness (emotional, holistic intellect) or decomposes into hierarchy of sub-selves (analytic intellect). This applies in all length scales.

7. The idea that canonical identification map with pinary cutoff maps 'reality' to the personal 'p-adicity' of the experiencer.

4.3.1 Simple model for music experience

The following simple model tries ot abstract the idea that the dominantly parallel nature of right brain information processing is crucial for music experience.

1. Assume that there is ensemble of potential 'frequency selves' sensitive to wake-up by frequencies in a frequency range around some mean frequency characteristic for a particular frequency-self. The quantum model for hearing indeed allows to identify 'frequency selves' as associated with axons specialized to hear sound with a particular frequency [K3]. In accordance with the idea about parallel information processing in right brain, assume that these selves are located in right brain. Hence each frequency wakes up its own frequency-self provided the intensity of Fourier component associated with that frequency is above some threshold value. In some cases, the overall frequency scale of the frequency-selves could be temporally stable, perhaps due to the temporal stability of the Z^0 magnetic fields involved with hearing [M6]. This could explain the phenomenon of the absolute music ear.

2. An interesting possibility is that frequency self is in a state of whole-body consciousness and having experience of one-ness. This guarantees that information processing is not possible during experience.

3. There are several options as to what happens when the stimulus ceases. Frequency self could either fall asleep or it could just continue its existence by analyzing its enlightment experience by generating a hierarchy of p-adic sub-selves. It could also transform to p-adic self so that sensory experience would transform to thought about it.

4. One of the mysteries of the music experience is the ability of the listener to remember the basic key and the desire for the piece to end to the basic key even when several intermediate keys appear. If frequency selves stay awake as p-adic susselves during entire music experience, one could understand this phenomenon in terms of memories with respect to subjective time. Note however that the presence of mindlike space-time sheets whose duration is longer than the duration of music piece could explain this ability as the duration of memories with respect to the geometric time.

5. Discretization of frequencies, or rather the division of frequency range to subranges occurs. In p-adic context the ranges might well be disjoint since p-adic distance function defines naturally decomposition of p-adic axis to disjoint intervals ($N_p(x-y) \leq p^n$ defines this kind of decomposition). The inverse of the frequency gives lower bound for the duration of mindlike space-time sheets resonating with given frequency. Note that on left brain the selves would not resonate for incoming frequencies but would wake-up by a generation of large quantum entanglement followed by quantum jump and not depending much on the frequency of the incoming sound wave.

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The selves relevant for information processing should not be 'enlightened' selves since they must have ability to rapidly generate further sub-selves.

4.3.2 Harmony and self-organization

The phenomenon of harmony should be somehow related to quantum self-organization: perhaps the often used metaphor of harmonious co-existence could be turned around. Various notes correspond to sub-selves in the population of sub-selves and it might be that self-organization favours simultaneous conscious existence of sub-selves corresponding to subsets of frequencies defining basic chords. One could even consider some kind of co-operation between the frequency selves belonging to same basic chord.

The simplest model for the phenomenon of harmony relies on the identification of the chords as 'chord selves' formed by entangled 'note selves'. The listener is self having as sub-selves (mental images) note selves and chord selves which correspond to the same level of the self hierarchy. The entanglement between note selves could occur even at the level of ear between the mind-like space-time sheets sensitive to various frequencies. Topologically it would correspond to the formation of join along boundaries bonds between the note selves. The ability of the 'note selves' of the chord to have stable join along boundaries bonds between themselves should depend crucially on the fact that the frequencies of the notes of the basic chords have simple rational ratios so that the oscillations involved are commensurate and match together. Hence a resonance phenomenon ins spirit of classical physics involving rational ratios of frequencies would be in question. During listening the chord self continually decomposes into sub-selves when listener consciously concentrates attention to some notes in the chord.

The ability of the music to occasionally create thrills in spine could correspond to whole-body consciousness in unusually large length scale. It presumbly involves a resonant fusion of also other than note sub-selves to larger sub-selves by the formation of stable join along boundaries bonds. The ability of certain sounds ('Om') to promote the emergence of whole-body consciousness could be due to the ability to very effectively generate entanglement and stable join along boundaries bonds. Perhaps the frequency spectrum of 'Om' contains resonant frequencies of several sub-selves and induces large sub-selves. Also the healing effect of music and sounds could rely on this mechanism.

Focusing attention to some instrument producing melody creates kind of figure-background relationship. This requires that entire instrument playing the melody is represented by 'instrument self'. An interesting possibility is that various instruments give rise to their own ensembles of frequency-selves. Note that the model makes it easy to understand why experienced performance is not simply the sum of invididual performances. Music experience is a complicated self-organization process in which parts compose to wholes by quantum entanglement and vice versa according to how the listener directs his/her attention.

4.3.3 Why octaves are experienced similarly?

The model should explain the basic features of music experience. There are many interesting questions related to this. One of the most important is why frequencies which are 2^k- multiples of the fundamental frequency, notes differing by octaves, are experienced as identical notes.

1. p-Adic length scale hypothesis and octaves

Real selves are labeled by p-adic primes labelling the p-adic topology to which the real topologies of the corresponding mindlike space-time sheets can transform. Thus the phenomen of octaves could relate to the p-adic length scale hypothesis, which implies that physically preferred p-adic primes corresponds to primes near prime power powers of two. For instance, this implies that the massless extremals (MEs) associated with physically important p-adic primes have fundamental frequencies which are octaves of each other. Therefore a classical resonance via the formation of join along boundaries bonds becomes possible and real space-time sheets corresponding to preferred p-adic primes can form larger resonant structures. This universal resonance could explain why octaves are experienced similarly.

2. Is sensory experience 2-adic in some sense?

A stronger hypothesis for the phenomenon of octaves is that cognitive music selves are 2-adic or that real music selves can transform easily to 2-adic selves. One might even consider the possibility that the phenomenon is much more general. Music metaphor has indeed turned out to be of crucial importance for the theory of qualia. Thus music metaphor could reflect the underlying 2-adicity of the sensory experience (at some level of self hierarchy). Perhaps at least some aspects of our experience result from a mimicry of the lowest level of the p-adic self-hierarchy. Taking 2-adicity seriously, one is forced to ask for the possible consequences of 2-adicity. For instance, could it be that at the level of primary qualia the intensity of sensation as function of stimulus depends on the 2-adic norm of the 2-adic counterpart of the stimulus and is thus a piecewise constant function if sensory input?

An observation supporting this speculation is following. When overlearning occurs in tasks involving temporal discrimination, the intensity of sensation as a function of stimulus deviates from smooth logarithmic form in small scales by becoming piecewise continuous function [28] such that the plateus, where response remains constant are octaves of each other.

This observation suggests a generalization inspired by 2-adic version of music metaphor. Primary quale has a multiple of cyclotron frequency as its correlate and, being integer valued, is essentially 2-based logarithm of the 2-adic norm for the 2-adic counterpart of the intensity of the sensory input. Hence the increase of intensity of the sensory input by octave correspond to a jumpwise replacement of the n:th harmonic by n+1:th one and should be seen in EEG. Our experience usually corresponds to the average over a large number of this kind of primary experiences so that underlying 2-adicity is smoothed out. In

case of overlearning or neurons involved act unisono and the underlying 2-adicity is not masked anymore.

At the level of ELF selves this would mean generation of higher harmonic when the number of nerve pulses per unit of time achieves threshold value allowing the amplification of corresponding frequency by the mechanism discussed already earlier. This certainly would mean that cognition is an important part of music experience. The strongest assumption is that the real note selves are able to transform to 2-adic selves by a phase transition changing local topology from real to 2-adic. Note however that p-adic length scale hypothesis might be enough.

3, Octaves appear at the level of fundamental formulation of quantum TGD

Octaves might have much deeper significance than I thought originally and seem to emerge at the level of fundamental formulation of quantum TGD rather than characterizing only a very special kind of sensory experience. In the recent formulation of quantum TGD using zero energy ontology [C2, C3] one uses zero energy states which have their positive and negative energy parts at the light-like boundaries of causal diamonds consisting of future and past directed light-cones.

Physics as a generalized number theory vision, in particular the assumption that real physics and various p-adic physics result as algebraic completions of rational physics, motivates the hypothesis that the temporal distance T between the tips of the causal diamond is quantized and corresponds to powers of 2 using time scale defined by CP_2 size as a basic unit. This assumption allows to deduce p-adic length scale hypothesis ($p \simeq 2^k$, k integer), and to identify T as a secondary p-adic time scale. For electron this time scale is .1 seconds and corresponds to the fundamental 10 Hz biorhythm. For non-standard values of Planck constant T is scaled by a factor $\hbar/\hbar_0$. Thus octaves become a key element of fundamental physics. One can say that causal diamonds as space-time correlates of self appear naturally as octaves. Also rational multiples of fundamental frequency emerge via the hierarchy of Planck constants: in principle all rational scalings of the basic hierarchy are allowed.

4.3.4 Basic scales and 2-adicity

A further fascinating question is why 5-tone scale (pentatonic), 7-tone scales (say Cmajor) and 12-tone (chromatic scale used in atonal music) scales seem to be so fundamental. A part of answer is certainly the fact that the ratios of the frequencies of the musical scale are relatively small rational numbers so that the note selves can form join along boundaries bonds and generate resonating chord selves. Dissonance would mean that chord self is rarely formed. For two nearly identical frequencies the ratio of the corresponding periods $T_i = n_i T_0$ is a ratio n_1/n_2 of large integers n_1 and n_2 having no common factors. Hence the period of the superposed signal is $T = n_1 n_2 T_0$ and can be even longer than the duration of either note. Thus resonance making possible fusion of note sub-selves to chord sub-self is expected to be weak and even impossible.

One can consider this problem also from p-adic viewpoint. In p-adic case genuine rationals correspond to p-adic integers which are infinite as real integers but for which pinary cutoff is finite real integer. Thus rational harmony in the real context would correspond to superposition of harmonic multiples in p-adic context.

1. Canonical identification and 2-adic harmony

Interestingly, the mapping of the real frequencies to p-adic frequencies by canonical identification maps the preferred frequencies to *integer valued p-adic frequencies*: in particular rational frequencies are mapped to integers (infinite as real integers for genuine rationals), which converge rapidly as p-adic power series $f = \sum_n x_n p^n$. Thus all real frequencies correspond to p-adic harmonics trivially and harmony in the precise sense of the world would be achieved p-adically. Obviously one must make some natural restrictions to integers in question. The natural requirement is smallness of the normalized p-adic frequencies as ordinary integers. Part of the explanation is 7 ± 2 rule of psychology, which suggests that the number of cognitive sub-selves (now 'note selves') which can be simultaneously awake, is limited by this number.

It is well known [36] that basic scales corresponds to multiples of the basic frequency divided by a suitable power of two such that result is between 1 and 2, that is in single octave normalized to range $[1, 2]$. Even integer multiples give redundant results so that one can restrict the consideration to odd integers. This could be understood 2-adically. The crucial observation is that real frequencies can be obtained as canonical images of odd integers regarded as 2-adic numbers and mapped to real numbers by canonical identification

$$\sum_i x_k 2^k \to \sum_k x_k 2^{-k} \ .$$

If p-adic number represents odd integer the image has unit p-adic norm and is always in the range $[1, 2]$ and hence in the basic octave.

In light of 2-adic fractality, scaling invariance under scalings by power of 2 commuting with canonical identification, it would not be surprising if the 2-adic images of frequencies differing by power of 2 were equivalent from the point of view of subjective experience. Of course, p-adic length scale hypothesis alone might be sufficient to explain this as already found. This would explain why notes differing by octaves are experienced as similar. 2-adic fractality might be a property of experiencer also: the temporal durations of sub-selves could come as powers of two and perhaps realize the idea about hologram memory. This observation, together with the observation that our engineering feats resemble remarkably 2-adic fractals, suggests that at least some of our sub-selves represent the lowest level of intelligence in the hierarchy of intelligences! An interesting question is whether $p > 2$-adic music is possible and is it only for higher level intelligences! One could do experimentation with this kind of music and listen the result with 2-adic ears.

A counter argument against two-adicity is that the overall frequency scale (basic tone) and hence basic p-adic time scale can be chosen freely whereas

p-adic length scales are completely fixed. The objection can be circumvented if the p-adic time scale is related to genuine p-adic length scale by equation $T_n = p^{n/2} L_p / v$, such that v is some characteristic velocity, which adapts to different value depending on key. n defines which level of p-adic fractal is in question. For $p = 2$ $n/2$ must be about $M_{127} = 2^{127} - 1 \simeq 10^{38}$ to yield correctly the frequency 64 Hz of basic C for $v = c = 1$. It could also be that p-adic length scale itself is dynamical in some sense, at least at the level of cognitive experience.

2. Concrete model for the canonical identification map

The mapping of reals to 2-adics by canonical identification maps all frequencies above the basic frequency setting the scale to odd 2-adic integers and it is of interest to find how naturally the basic scales emerge.

i) The range $n = 1, 3, 5$ gives the notes of the basic major chord, say (C, E, G). The appearece of three smallest odd integers supports the idea about basic chords as self-organized ensembles of p-adic frequencies.

ii) The integers $C = 1, G = 3, E = 5, D = 9, A = 11$ corresponds to the pentatonic scale used in Chinese music.

iii) The integers $C = 1, G = 3, E = 5, (Bb = 7), D = 9, A = 11, F = 13, H = 15$ give good fit to 7-tone scale. Integer $n = 7$ is absent from both scales. For even scale a better fit for the note A is $A = 27$ instead of $A = 11$. The note $(Bb = 7)$ added to the 7-tone scale corresponds to the 'blue' note. $Eb = 25$ which is second blue note. $F\# = 19$ and $G\# = 29$ adds to the scale the additional notes appearing in A minor scale.

iv) The integers $C = 1, G = 3, E = 5, Bb = 7, D = 9, A = 11, F = 13, H = 15, Db = 17, G\# = 19, Eb = 25, F\# = 29$ give 12-tone or chromatic scale. Note that the integers $n = 21, 23, 27$ are not present in the set. A slightly better fit is given by the integers $1, 3, 5, 7, 9, 13, 15, 17, 19$ and $25, 27, 29$: now the integers $11, 21, 23$ are lacking from the set. All keys are obtained as subscales using chromatic scale although the ratios of the frequencies are not exactly the same since canonical identification does not commute with scalings: in practice instruments use this scale and this cause pains for the people having absolute ear.

One could of course criticize this representation: by using sufficiently rough resolution one can arrange that p-adic integers corresponding to notes of the basic scale are reasonably small. One could also claim that good explanation for the lacking integers is needed. This picture is however consistent with the general ideas about p-adic self-organization. Integer valued harmonic oscillator energies (when suitable units are used) appear always when one approximates system as a collection of harmonic oscillators. Integer valued spectrum of Hamiltonian is also a necessary ingredient for the existence of p-adic thermodynamics since Boltzman weights $exp(-E/T)$ are replaced by $p^{E/T}$, which exists only provided E/T is integer so that E itself must be integer valued in suitable units. Note that p-adic thermodynamics leading to the predictions for elementary particle masses involves in a crucial manner the fact that the spectrum of Virasoro generator L_0 taking the role of energy is integer valued.

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A further criticism concerns the use of the canonical identification map. Canonical identification makes sense for probabilities (p-adic thermodynamics) but one cannot map p-adic space-time surfaces to their real counterparts or vice versa by canonical identification. Hence the mapping of frequencies by canonical identification need not make sense.

5 Whole-body consciousness: physical evidence and tests

Whole-body consciousness is one of the most dramatic predictions of the proposed theory and anomalously low dissipation can be regarded as the most dramatic physical signature of whole-body consciousness. This prediction provides a manner to test the theory.

5.1 Dissipation and consciousness

In TGD framework dissipation can be regarded as a signature for the presence of consciousness and selves, which are identified as sub-systems able to remain unentangled in sequential quantum jumps. Anomalously low dissipation in turn can be regarded as a signature for the states of 'one-ness' in which self does not decompose into sub-selves. In the following I describe the basic ideas, and suggest some experimental evidence and tests for the picture.

5.1.1 Dissipation as a signature of consciousness

In TGD framework dissipation caused by quantum jumps is signature of consciousness and can be interpreted as a direct evidence of quantum jumps between quantum histories concept: dissipative irreversible quantum history can be interpreted as kind of envelope for the sequence of reversible quantum histories. This makes also sense at the level of the classical space-time since quantum jumps involve localization in zero modes characterizing space-time surface classically.

Self decomposes in general into sub-selves which in turn decompose to subsubselves which..., and a model of cognitive phenomena based on cascade like process in which selves of sub-selves wake-up in a cascade like manner, suggests itself. Selves can provide conscious representations for objects of picture, for basic structures of language, etc.. and are analogous to modules of a computer program with a hierarchical structure. Probably the range of modes of consciousness between calmness and anxiety could be characterized partially by the degree of the decomposition into sub-selves (also the entropy of sub-selves is important factor since it measures the fuzziness of the mental images).

The generation of selves by quantum jumps would presumably lead to a cascade of small sub-selves of short duration whereas second mechanism could lead to a generation of only few large sub-selves having long duration. One can wonder whether these two mechanisms have something to do with the linearity of left

brain information processing and parallel nature of the right brain processing in some length scales, presumably longer than cell membrane thickness. TGD inspired model for EEG and nerve pulse predicts, not only propagating EEG waves associated with neural circuits, but also non-propagating EEG waves associated with entire regions of brain (say gap junction connected cell groups). These two kinds of EEG waves could correspond to linear (resp. parallel) information processing modes dominating in left (resp. right) brain [M4].

It must be emphasized that it is not all obvious which corresponds to which.

1. The synchrony-holism association would suggest that holism corresponds to non-propagating EEG waves, synchronous neuronal firing and formation of wholes via entanglement of sub-selves. The model of synesthesia in which left brain works much like right brain and synchronous firing is observed, supports this view.

2. Computationalism would seem to suggest a different picture. Standing EEG wave makes the group of neurons to behave in unisono and to form single sub-self. Information processing would be sequential rather than parallel with the entire neuron group behaving a choir singing in unisono. In this picture the decomposition into axonal sub-selves defined by the propagating EEG MEs would mean a large number of separate sub-selves and parallel information processing. Furthemore, the coding of the nerve pulse patterns to lightlike vacuum currents of stationary MEs would occur naturally in this state and the interpretation as representation of thought seems reasonable.

What is the correct option? It would seem that 1). The basic counter argument against the option 2) is following. The fusion of sub-selves into single sub-self gives rise to holism and the fusing sub-selves give each their own parallel contribution like notes in a chord: information is not lost although firing takes place in unisono: different features are only bound together in accordance with the model for the sensory representations [H4]. Fusion of the right and left visual fields to single visual field with is excellent example of what happens in this process. Something qualitatively like 3-dimensional shape emerges in this process.

5.1.2 Reduced dissipation and absence of decoherence as a signature of whole-body consciousness

As noticed, both irreducible and reducible selves are possible. The dissipation rates in these two states of consciousness can be quite different since the entanglement involved is of quite different type. It would not be too surprising if the net dissipation rate for irreducible selves would be smaller than for reducible selves having several dissipating sub-selves. In p-adic context the notion of dissipation must be defined more generally: intuitively dissipation means that self gets more and more entropic and the distributions of zero mode and quantum number increments thermalize and mental images get fuzzier and fuzzier.

The absence of decoherence is also a correlate for the formation of state of oneness. This means that quantum jump sequence effectively binds to single quantum jump. This state lasts as long as bound state endures. In the time scale defined by the duration of the bound state the second law of thermodynamics is broken and serves as a signature for the effect. In this state the zero modes of the binding systems transform to quantum fluctuating degrees of freedom and the state is kind of multiverse state.

Enlightment by entanglement mechanism provides a mechanism binding selves to larger selves and disappearance of component selves. This mechanism does not inhibit the formation of smaller sub-selves of entangled selves unless the higher self is in state of whole-body consciousness. The small net dissipation rate in states of whole-body consciousness would be a rather dramatic effect supporting TGD based view. For instance, it could lead to lowering of body temperature or cell temperature since thermal energy would be gradually lost from the system!

Note that the state of whole body consciousness need not be whole-timely even in meditative state. It is enough that sub-selves are short-lived. The artificial generation of quantum entanglement between some part of body with larger sub-system in a state of whole-body consciousness could have medical applications some day. Perhaps entangling brain with body (be it physical or electromagnetic!) could even hinder irreversible effects caused by the lack of oxygen or by the bleed caused by brain injury.

5.1.3 Evidence and tests for reduced metabolism as concomitant of whole-body consciousness

Consider now possible evidence and tests for the reduced metabolism as a signature of whole-body consciousness.

1. In synesthesia different sensory modalities are associated with a regular manner just as thoughts are associated with speech. A dramatic signature of synesthesia is the lowering of the metabolism by as much as about 18 per cent from average in left brain (synesthete should become blind or paralyzed if standard wisdom would hold true!). This is what is expected if entire left brain gets entangled with, say parts of limbic brain and with sensory organs associated with coupled sensory modalities, or possibly with electromagnetic body of much larger size. The extended self in state of oneness does not dissipate significantly since there are no sub-selves performing quantum jumps.

2. The metabolism of trained yogis provides a test for the hypothesis: measure some signatures for neuronal or cellular dissipation occurred during the meditative state and find whether the dissipation is reduced during meditation. The lowered dissipation rate could even lead to the lowering of the body temperature or the temperature of nearby region.

3. There are even anecdotal claims about the ability of the dead bodies of gurus to resist natural decay. I am not certainly trying to convince any sceptic and, still having very living personal body, I have no personal opinions about the reality of the claimed phenomena. It would be however good to be open-minded.

4. There is (I believe well documented) phenomenon in which persons in trance are able to dance on burning charcoals without any disastrous consequences. Certainly there are standard science explanations for this. A possible nonstandard sicence explanation is that state of a whole-body consciousness is involved and no dissipation in cellular scale occurs. Since dissipation is not possible, the irreversible effects caused by the heatflow from burning charcoals are not possible and only reversible and curable effects can occur.

5. The reduction of the dissipation rate in some length scales should occur also during sleep, which is one example of this kind of state (obviously reduction of metabolism occurs).

6. Also hypnosis might involve quantum entanglement between some part of the brain of subject person and hypnotizer: the fusion of some sub-self with sub-self of hypnotized could explain the effect of hypnosis. This could reflect itself as correlations between EEGs of hypnotized and hypnotized.

5.2 Synesthesia

Synesthesia [27] is a phenomenon, which seems to give direct experimental evidence for a reduced rate of metabolism in 'holistic' states of mind. Synesthesia provides an excellent counter argument against the idea that sensory organs are primary experiencers unless one is ready to believe that cross-modal associations involve macroscopic quantum systems formed by the primary sensory organs involved and parts of brain.

TGD based quantum model for EEG and nerve pulse suggest that synesthesia is a natural by-product of the holistic states of mind involving enchanced EEG in large regions of brain. Coherent large amplitude EEG induces synchronous neural firing in memory circuit containing hippocampus and thalamus. This leads to a 'leakage' or nerve pulse activity in lateral thalamic nuclei from inducing sensory pathway to the indced sensory pathway An interesting possibility is that the non-propagating EEG waves predicted by TGD [M4] and possibly explaining the ability of right brain hemisphere to process information in a parallel manner are involved in synesthesia: the left brain hemisphere of synesthetes would be like right brain hemisphere during synesthesia.

5.2.1 Does synesthesia involve left cortex whole-body consciousness?

The following aspects of synesthesia suggest that left cortex whole-body consciousness might be involved with it.

1. Synesthesia depends on left brain hemisphere only. A dramatic signature of synesthesia is the lowering of the metabolism in the left cortex by about even 18 per cent compared to the baseline (synesthete should become blind or paralyzed if standard wisdom holds true!). This leads to relatively enhanced limbic expression. Hippocampus, which is believed to be crucial for long term memories, is critical for synesthetic experience.

2. Synesthesia is emotional: the experiences are accompanied by a sense of certainty ('this is it') feeling. This is in accordance with the observation that limbic brain expression is enhanced.

3. Holism is an important aspect of synesthesia. Synesthetes can precisely remember entire passages of text, re-experience entire episodes of previous life, remember precise locations of various objects in a room. Synesthetic experiences are emotional. Synesthetes also tend to have 'unusual experiences' like deja vu, clairvoyance and pre-cognitive dreams. This kind of personality constellation characterizes temporal-limbic epileptics.

4. Synesthetes have un-even cognitive skills. Dyslexia, dyscalculia in some degree, inability to transform words to digits, right-left confusion, etc.. Synesthetes are also non-right-handed.

A possible TGD based interpretation is that part of the left cortex is in whole-body consciousness so that there are very few, sub-selves (mental images) in the left cortex and these sub-selves have long duration so that temporal resolution is poor. In this state left cortex does not dissipate as much as usually since in state of 'one-ness' there are no sub-selves performing quantum jumps and dissipating. Since left cortex would contain very few sub-selves (mental images), limbic brain would dominate as far as mental images are considered: this would be consistent with the emotionality of synesthesia.

Whole-body consciousness (and also consciousness with very few mental images resulting from the fusion of smaller mental images) is accompanied by the generation of bound state entanglement and thus also by a liberation of the binding energy as a usable energy. This superfluous energy might partially explain why the metabolism can be reduced during synesthesia below the level causing death under normal circumstances. Thermal noise destroys this bound state sooner or later and one can say that buy now-pay later mechanism is at work: the system actually loans thermal energy. This mechanism resembles somewhat the Brownian ratchet mechanism [18] discussed in [K6].

The exceptional episodal sensory memories could perhaps be understood if the formation of large irreducible self in a state of one-ness has also large temporal extension so that long sequences of events of geometric past are re-experienced. In [H4] a model for long term episodal memories as questions sent to the geometric past inducing entanglement with the self of the geometric past making possible episodal memory as a shared sensory experience is discussed. The question sent to the geometric past is coded to the lightlike vacuum current associated with a stationary ME, usually in right brain but in left brain in case

of synesthesia. The time like entanglement of the mindlike space-time sheets located in geometric now and past (or future in case of clairvoyance) makes possible the episodal memory. States of one-ness are emotional since holism implies emotionality. The explanation for cognitive dis-abilities is that holistic left brain does not generate temporal sequences of sub-selves of short duration so that there is averaging over very many quantum jumps implying pure temporal resolution: a good temporal resolution is however essential for the mentioned cognitive skills.

The extraordinary memory achievements could also involve the temporal absence of the highest abstraction level of consciousness leading to abstraction and averaging implying highly symbolic verbal representations. This kind of mechanism is extremely useful for filtering of the conscious sensory information in order to cope with the practicalities of the everyday life. The mechanism might also explain both the extraordinary memory feats of some autistic persons and their difficulties with the challenges of the everyday life. Dramatic example is a person able to draw from memory an area of London with size of several square kilometers as seen from air. The same person draws from memory a building having hundreds of windows and the number of windows comes out correctly although this same person is not able to count corretly the number of three objects. Also in case of synesthetes cognitive impairments could be necessary prequisites of the extraordinary gifts. These impairments could be also due the fusion of a large number of mental images in left brain replacing the analytic view with a holistic one. Although the person cannot count how many windows the mental image of the building has, he can draw them correctly just by drawing along the image he sees in full concreteness.

5.2.2 Basic observations

The following observations provide a valuable information making possible to construct a more detailed model of synesthesia.

1. Synesthesia is in-voluntary and usually uni-directional: for instance, auditory experience creates visual association but not vice versa. Cross-modal associations, just like ordinary associations, do not change in the course of time. It has not been possible to find any rule telling which kind of associations are possible. It seems that cross-associated experiences are however generic and simple so that one can speak of form invariants which are kind of primitive building blocks of perception: for instance, visual associations tend to be blobs, lines, spirals and lattice shapes.

2. Synesthesia is projected: synesthetes experience their secondary sensory experiences in the space in the immediate surroundings of the body, never at large distances as is in principle possible in case of vision and hearing. For instance, visual associations are seen on screen near to eyes.

3. The reduction of the metabolism is concentrated in the cortical regions whereas relatively enhanced metabolism occurs in the limbic brain, in

particular hippocampus. Seizure discharges in hippocampus induce synesthesia in non-synesthetes: associations are simple experiences and become more complicated if seizures spread to the temporal lobes. The fact that exceptional activity of hippocampus is involved, correlates the exceptional ability to have precise episodal memories.

4. According to [27] it is very rare that taste or smell is a synesthetic response or trigger of it. In fact that author of the articles knows no case in which smell alone would be the inducing sensory modality. This could relate to the fact that olfactorion is exceptional sensory modality in the sense that there are two olfactory pathways: the first one projects directly to amygdala whereas second projects to cortex via thalamus as do also the sensory pathways associated with order sensory modalities [29]. Furthermore, the olfactory pathway to the thalamus projects to the medial dorsal nuclei whereas other sensory pathways project to the lateral dorsal nuclei.

5. Synesthesia can also generate sensory-motor associations. For instance, visual input can generate well defined motor outputs and synesthete can express sensory experiences by dancing!

5.2.3 Memory coordination circuit and Papez circuits as brain circuits possibly involved with synesthesia

Hippocampus is believed to be crucial for the formation and experiencing of long term memories. This suggests that an enhanced activity in some neural circuits involving hippocampus in a form of increased EEG amplitudes (at theta frequencies) is essential for generating the sensory leakage between neural circuits and sensory pathways leading to synesthesia. For this kind of mechanism synesthetic mode need not be the only mode of experiencing: ordinary and synesthetic modes could also alternate. If synesthetic and non-synesthetic periods alternate, synesthesia cannot interfere radically with the real experience. This is clearly the safest option and perhaps favoured by natural selection. The ability to control theta wave amplitudes in hippocampus could make possible an artificial generation of synesthesia.

There are two important circuits going through hippocampus [37]. The first circuit is memory coordination circuit having the following structure:
1. Lateral dorsal nucleus and anterior nuclear group of the thalamus
2. Cingulate cortex
3. Subiculum and the rest of the hippocampal formation with input via entorhinal cortex and output via the subiculum and fornix
4. Back to 1.

Fornix is known to be the circuit responsible for slow theta rhytm of about 3-7 Hz, which does not correspond to a conscious experience: thus memory coordination circuit is believed to be unconscious to us under normal circumstances [37]. Temporal cortex contains a region which projects to hippocampus and receives input from all sensory modalities. Memory circuit is believed to

somehow to provide a handle to the memory constellations believed to reside in the temporal lobes. That the EEG amplitude associated with the fornix would be exceptionally large during synesthesia is in accordance with the fact that that synesthetes tend to have personal constellation of limbic-temporal epileptics. Also the abnormal episodal memories (Nabokov is one of the best known synesthetes with miraculous memory) supports resonance in this circuit. Only memory circuit projects to the thalamic nuclei receiving both sensory and motor input. Hence also the occurrence of the motor synesthesia supports the view that the sensory leakage occurs in the thalamic nuclei contained by the memory circuit.

Papez circuit is second circuit containing hippocampus. Papez circuit has following structure:

1. Anterior nuclear group of the thalamus
2. Cingulate cortex
3. Hippocampal formation
4. Hypothalamus
5. Back to 1.

The enhanged activity of the Papez circuit induced by the hippocampus could correlate with the emotionality of the synesthetic experience.

5.2.4   The general picture about the sensory leakage

These observations and facts suggests the following general model for synesthesia.

1. Contrary to the original expectations, the hypothesis that the primary sensory qualia are associated with the sensory organs can be be defended against various objections if one assumes that brain and sensory organs quantum entangle so that a fusion of sensory mental images with cognitive mental images occurs. The hypothesis explains elegantly the differences between imagination, dreaming, hallucinations, and ordinary sensory experience. Dreams and hallucinations would involve a back projection from brain to sensory organs giving rise to a "qualiafication" of the cognitive mental images represented by the nerve pulse patterns. In the case of synesthesia the back projection would assign to a sensory input from the inducing sensory modality an artificial sensory input in the induced sensory modality.

2. If the cross-modal communication between sensory organs occurs through thalamic nuclei common to the cross-associated sensory modalities, one can understand why smells alone are never the inducing sensory modalities. Lateral dorsal thalamic nuclei would be the sites of the sensory leakage. Furthermore, in the case of hearing, vision, and tactile senses it is easy to produce artificial sensory experience than in case of chemical senses (molecules attaching to the sensory receptors would be required).

3. The possibility of the sensory-motor synesthesia suggests that the back-projection involves artificial sensory input to the motor organs inducing a motor activity, which in TGD framework corresponds to a geometric time reversal of the sensory perception starting from the level of motor organs and proceeding in a time reversed direction. Only memory coordination circuit involves thalamic nuclei receiving both sensory and motor inputs. Memory coordination circuit involves lateral dorsal nuclei (all modalities except olfaction) but not medial dorsal nuclei (olfaction). This leads to the hypothesis that the exceptionally high activity of the memory coordination circuit induces a sensory leakage in the lateral dorsal nuclei of the thalamus belonging to the memory coordination circuit.

4. The mechanism giving rise to the episodal memories would be following. If the net metabolic feed to the left brain stays constant, a reduced metabolism in some areas results. As an emergency reaction to the reduced metabolism, the neurons in these areas send negative energy Z^0 MEs to gain metabolic energy by buy now-let others pay mechanism. Negative energy Z^0 MEs generate time-like entanglement with the geometric past by the mirror mechanism of long term memory, and episodal memories result as shared mental images. Also the life review experience during NDEs would be based on the same mechanism since the reduction of the metabolic energy feed would occur also now. Rather paradoxically, long term episodal memories would require a neuronal starvation and the over-activity of the memory coordination circuit would force this activity. This mechanism could also explain why the damage of some left brain regions can induce the ability to have sensory memories.

5.2.5 Synesthesia as a sensory leakage between thalamic nuclei common to the memory coordination circuit and primary sensory pathways

Synesthesia could be a byproduct of an abnormally large EEG amplitude in the memory coordination circuit and possibly also Papez circuit inducing a 'leakage' of nerve pulses between sensory pathways in thalamus in turn giving rise to synesthetic crossmodal associations. That synesthetic associations are projected, is consistent with the sensory leakage hypothesis.

The resonant EEG amplitude associated with the thalamic nuclei of the resonating memory coordination circuit spreads out to the primary sensory or motor pathways in the physical vicinity of the resonating pathway and generates a sensory leakage and a back projection to the sensory organs of the induced modality thus inducing synesthesia. The structure of the synesthetic association is determined by the pattern of neurons activated and thus creating the virtual sensory input backprojected to the sensory organ of the induced sensory modality. One can imagine each neuron as a pixel of a sensory picture and the pattern of activated pixels determines the synesthetic association.

The model makes testable predictions.

1. The assumption that the sensory leakage occurs in the thalamus could be tested. One could study whether the crossmodal associations change, when the sensory input from right or left side of body is lacking. For instance, one could find what happens if audio-to-visual synesthete blocks left/right ear during audio-to-visual synesthesia.

2. The generation of artificial sensory experience by back-projection to the sensory organ of the induced sensory modality means that a permanent or an artificially induced temporal loss of the induced sensory modality (by a local anaesthesia of the axons of the sensory pathway) should lead to the loss of the synesthesia.

5.2.6 How to understand the memory feats of synesthetes and the reduced metabolism in the left hemisphere?

Negative energy Z^0 MEs can be interpreted as classical signals sent to the geometric past, and they should be crucial for an active memory recall involving a question sent to the geometric past. There are reasons to believe that right-left dichotomy corresponds to the negative energy-positive energy dichotomy for MEs in ULF range. This suggests that the question to the geometric past is sent by the right brain hemisphere as a negative energy Z^0 ME. Episodal and verbal memories would correspond naturally to quantum and classical communications.

1. Episodal memories and mirror mechanism

Mirror mechanism is the simplest quantum mechanism of episodal memories and involves only a sharing of mental images by entanglement. The brain hemisphere sends a negative energy Z^0 ME to the geometric past reflected at a large distance and returning back to the hemisphere. The question and answer fuse to a single mental image shared by the hemispheres of the geometric past and now. Usually only the right brain hemisphere would have episodal memories but in the case of synesthetes also left brain hemisphere would be forced to have this ability.

The generation of negative energy Z^0 MEs would involve a phase transition to a state in which the positive Z^0 MEs propagating along axons with a subluminal effective phase velocity transform to negative energy Z^0 MEs leaving the brain and reflected back. Synchronous membrane oscillations could accompany negative energy Z^0 MEs [M2]. If negative energy MEs are sent by the region of the left brain hemisphere, it gains some energy by pay now-let others pay mechanism.

This would not explain the reduction of the metabolism by 18 per cent during synesthesia. Rather, the generation of the negative energy Z^0 MEs would be forced by the starvation of the neurons induced by the over-activity of the neurons of the memory coordination circuit. The miraculous ability of synesthetes to remember episodally could be understood to result as a by-product of a neuronal emergency reaction. The starving cortical neurons of the left hemisphere send negative energy Z^0 MEs to the direction of the geometric

past inducing entanglement bridges by the mirror mechanism with the brain of the geometric past in turn inducing episodal long term memories by the sharing of the mental images. The same mechanism might work also in the normal situation but involve a less dramatic artificial starvation.

2. Non-episodal memories

Also in the case of non-episodal memories the question to the geometric past could be communicated by the mirror mechanism using negative energy Z^0 MEs and the sharing of mental images but the immediate answer would be more like a statement that the question has been received. The real answer would be communicated classically by the left brain hemisphere using positive energy Z^0 MEs with an extremely low effective phase velocity and accompanied by some neuronal excitation. The classical signal sent by the left hemisphere of the geometric past to the left hemisphere of the future would propagate a finite distance L within brain in a time interval T defining the temporal span of the memory (say years) so that the Z^0 ME would propagate with an effective phase velocity $v = L/T$.

The velocities of Ca^{++} waves span an extremely wide spectrum and provide a natural candidate for the physiological excitations associated with ultraslow MEs involved with the long term verbal memory. One can wonder whether the right hemisphere communicate the question classically to the geometric past using negative energy Z^0 MEs with superluminal effective phase velocity. If Ca_{++} waves are correlates for these Z^0 MEs they should "propagate" with superluminal velocity and would look like collective excitations with a slowly varying spatial phase.

6   Higher levels of biological self hierarchy

Am important question concerns about actual biological realization of the self hierarchy predicted to begin already at elementary particle level and continuing indefinitely. TGD indeed leads to rather concrete ideas about how this hierarchy is possibly realized.

6.1   General ideas about biological self hierarchy

Neurons are only one level of selves in the hierarchy starting from the level of body and sensory organs (or possibly from much higher level) and ending up to the level of 64 basic DNA triplets via neurons and microtubules and all between (or probably continuing even further downwards as suggested by the estimate for the duration of self as p-adic time scale associated with the system).

Buddhists classify fundamental experiences to 64 basic types in I Chin. Thus one can wonder whether they have achieved in meditation the level of DNA selves and recognized its presence clearly? I have proposed very simple model of abstraction process reproducing the basic numbers of genetic code [L1] and

in this framework DNA:s might provide a physical realization for selves representing basic mutually consistent statements of simple formal system.

The model for abstraction process also predicts higher levels of hierarchy and the identification of the next level as 'memetic code' leads to correct prediction for the duration of psychological moment as well as to a correct prediction for the time scale of nerve pulse duration. It turns out that these levels could involve also electromagnetic selves with size of entire Earth: the conclusion follows using only Uncertainty Principle and topological field quantization.

6.2 Higher level selves in biological self hierarchy

The basic inputs for the speculations about the higher levels of the biological self hierarchy are topological field quantization, the idea of memetic code and the observations about the effects of EFL em fields to brain suggesting that the higher levels correspond to em selves with sizes of order wavelength of photons generated by EEG currents having size of order of Earth and realized as topological field quanta. The general view about symbiosis of hierarchies of massless extremals (MEs) and superconducting magnetic flux tube structures with the ordinary matter at atomic space-time sheets provides strong constraints on the speculations. The general vision about sensory representations realized in terms of magnetic flux tube structures outside brain [H4] and having sizes of ELF wavelengths leads to rather concrete ideas about the self hierarchy and about our position in it.

6.2.1 Topological field quantization

Topological field quantization [D7] implies that various notions of quantum field theory have rather precise classical analogies. Topological field quantization provides the correspondence between the abstract Fock space description of elementary particles and the description of the elementary particles as concrete geometric objects detected in the laboratory. In standard quantum field theory this kind of correspondence is lacking since classical fields are regarded as a phenomenological concept only. Topological field quanta define regions of coherence for the classical fields and classical coherence is the prequisite of the quantum coherence.

The energies and other classical charges of the topological field quanta are quantized by the absolute minimization of the Kähler action making classical space-time surfaces the counterparts of the Bohr orbits. Feynmann diagrams become classical space-time surfaces with lines thickened to 4-manifolds. For instance, "massless extremals" [J4] representing topologically quantized classical radiation fields are the classical counterparts of gravitinos and photons. Topologically quantized non-radiative nearby fields give rise to various geometric structures such as magnetic and electric flux tubes.

The virtual particles of quantum field theory have also classical counterparts. In particular, the virtual particles of quantum field theory can have negative energies: this is true also for the TGD counterparts of the virtual particles. The

fundamental difference between TGD and GRT is that in TGD the sign of energy depends on the time orientation of the space-time sheet: this is due to the fact that in TGD energy current is vector field rather than part of tensor field. Therefore space-time sheets with negative energies are possible. This could have quite dramatic technological consequences: consider only the possibility of generating energy from vacuum and classical signalling backwards in time along negative energy space-time sheets [G1]. Also biosystems might have invented negative energy space-time sheets: in fact, so called "massless extremals" provide an ideal manner to generate coherent motions as recoil effects caused by the creation of negative energy massless extremals [I3]. An interesting possibility is that quantum entanglement has the formation of the join along boundaries bonds as its geometric correlate.

The hypothesis of topological self-referentiality stating that the topological field quanta of classical fields form a symbolic representation for the system's properties, provides a strong interpretative tool. For instance, bound state entanglement is represented by negative energy MEs and the generation of macroscopic bound states essential for the binding of the mental images is accompanied by the liberation of the binding energy as a usable energy. Hence the ability of the system to behave as a single coherent whole and nonlocal quantum metabolism are different sides of the same coin. The concept of field body (or electromagnetic body) consisting of the topological field quanta is also of central importance. Field body could be seen as a 'manual' for the system providing a classical, topological representation for the quantum aspects of the material part of the system. The size of this field body is much larger than the material body of the system.

Topological field quanta (field bodies) could serve as templates for the formation of the biostructures. Thus topologically quantized classical electromagnetic fields could be equally important for the functioning of the living systems as the structures formed by the visible biomatter and the visible part of biosystem might represent only a dip of an ice berg.

6.2.2 Topologically quantized classical fields as templates for self hierarchy?

The web like structure formed by topological field quanta representing classical fields, in particular em fields, is remiscent of structures formed by microtubules and collagens forming the connecting tissue of living systems. It has been already earlier suggested that magnetic flux tubes and other topological field quanta serve as templates for various biostructures in the sense that ordinary matter is topologically condensed on the flux tube like structures. This would mean that living systems would be only part of much larger web formed by Earth's classical em field forming one particular sub-self of Mother Gaia.

The thickness for the flux tubes of Earth's magnetic field is about $2/\sqrt{eB} \simeq 4 \times 10^{-6}$ meters for $B = .5 \times 10^{-4}$ Tesla. If magnetic flux tubes of Earth have direct geometric coupling with brain one could perhaps understand the miraculous ability of birds and bees to navigate using Earth's magnetic field. The proteins

navigating along microtubules, cells navigating along collagen fibres and birds navigating along Earth's magnetic field lines would all be guided by higher level self! One could see also humans and the societies formed by them as continually self-organizing organs in the body of electromagnetic Mother Gaia. In this picture the so narrow wave cavity of radius 80 km between Earth's surface and ionosphere could be like brain of Earth, which is very sensitive to the conditions of ionosphere and biosphere and has "biofeedback" coupling with living systems. The effect of oscillatory phenomena (sound, radiations and magnetic fields) at frequencies Schumann resonances on brain to be discussed below supports also the direct interaction of our brain with Mother Gaia via Earth's electromagnetic field.

It is interesting to notice that the ratio of the thickness of solar corona (10^6 m) to the radius of Sun (5×10^8 m), the height of the wave cavity of Earth (80 km) to Earth radius (7×10^6 m), the ratio of the thickness of grey matter of cortex (1 mm) to the size of human brain lobe (10 cm) as well as the the ratio of the thickness of cell membrane (10^{-8} m) to the radius of neuron (2.5×10^{-6}) have roughly the same value of order 10^{-2}. Thus it seems that cell membrane, cortex, electromagnetic cavity of Earth and solar corona might have similar role in the self hierarchy.

The web formed by topological field quanta of the classical em and Z^0 fields continues to arbitrary long length scales. For instance, the flux tube structure of solar magnetic field provides an explanation for the anomalously high temperature of solar corona and a model for solar spot cycle [D6]. Perhaps also Sun is a conscious self forming part of "Indra's net" representing electromagnetic and other classical fields of cosmos. Since the four CP_2 coordinates are the primary dynamical variables, one must consider the possibility that topologically quantized classical gauge fields and classical gravitational field could form rather independent sub-selves.

6.2.3 Identification of mindlike space-time sheets as massless extremals

So called 'massless extremals' (MEs) are basic solutions of field equations associated with Kähler action [J4]. MEs describe propagation of one-dimensional nondispersive wave with light velocity and are accompanied by lightlike vacuum current generating coherent photons. Since the vacuum current behaves in nondeterministic manner at given point of ME, it is ideal for the coding of information. MEs can appear also as pairs of space-time sheets such that the two space-time sheets have opposite time orientations and hence also energies so that the net energy of ME pair vanishes. MEs define a fractal hierarchy starting from elementary particle length scales and extending up to cosmic length scales.

The natural identification of MEs as building blocks of cognitive structures leads to rather concrete model for long term memory and forces the hypothesis that MEs define an infinite hierarchy of electromagnetic life forms living in symbiosis with each other and biomatter. The model allows to understand EEG as a direct physical correlate of mindlike space-times sheets (MEs) associ-

ated with ELF selves and provides a general vision about the electromagnetic organization of brain as sensory and motor organ of higher level self. Also so called RF (radiofrequency) and MW (microwave) MEs representing our mental images are crucial for the model. MEs are also crucial in the model of qualia. MEs are present also below cellular length scales and even at molecular level.

MEs can also serve as Josephson junctions and this could explain the observed intensity windows in the interaction of ELF em fields with biomatter [24]. The model of qualia leads to rather detailed view about the sizes of the hierarchy of various MEs defining what might be called our electromagnetic body. It took long time to answer the question whether we should identify ourselves with the self associated with brain; with the entire body; with ELF ME having size at least of order Earth circumference; with ULF ME having size of order order light years from the fact that we have long term memories in time scale of lifetime; or with self having literally infinite size. The last two options seem to be more plausible than the first three: the illusion that we are nothing but our physical bodies is created by the fact that during wake-up state sensory input is about the region surrounding our body.

MEs are accompanied by so called exotic representations of p-adic Super Virasoro and Super Canonical algebras generated by subalgebra of generators for which conformal weights vanish modulo some integer power p^n of p ($n > 0$) (the prime p characterizes the p-adic number field in question). The properties of these extremely light states, in particular, their gigantic degeneracy, make them ideal candidates for lifeforms and one ends up with nothing less than a general classification of lifeforms! This idea seemed too good and too big to be taken seriously but it indeed seems that one could understand life as symbiosis of these exotic Super Virasoro representations ('spirit') interacting with each other and 'matter' via classical gauge fields associated with MEs. For instance, primary sensory organs could be accompanied by lifeforms of this kind and the quantum transitions of the exotic Super Virasoro representations are crucial in the model of non-geometric qualia described in [K3].

6.2.4 Estimate for the "wake-up time" of sensory sub-selves from p-adic length scale hypothesis and from a model of memetic code

p-Adic length scale hypothesis suggests that the typical duration of a self characterized by p-adic prime p is given by the p-adic time scale $T_p = L_p/c$, where $L_p \simeq 10^4 \sqrt{p}$ Planck lengths is the p-adic length scale. The duration of our immediate memory of about .1 second would correspond to a p-adic length scale of the order of the circumference of the Earth! Either the estimate is based on wrong assumptions or our picture about brain as a seat of consciousness is quite not correct! TGD predicts entire self-hierarchy so that it is not all obvious which option is correct.

Amazingly, .1 second time scale comes as a prediction from the model of abstraction process leading to the prediction of Combinatorial Hierarchy characterized by a sequence of Mersenne numbers $M(n+1) = M_{M(n)}$, $M_2 = 3$. This

gives rise to the hierarchy $3, 7, 127, 2^{127} - 1,...$ the first members of which are known to be primes. Genetic code corresponds to the level $M_7 = 127$. The natural question is whether a counterpart of the genetic code could make sense for memes. Combinatorial Hierarchy model for abstraction process that memetic code should correspond to the level M_{127} of the hierarchy. This leads to a precise realization of the memetic code in terms of binary sequences. Codewords correspond to 126 digit sequences.

Combined with p-adic length scale hypothesis this leads to the prediction for the duration of memes identifiable as our cognitive sub-selves as the secondary p-adic time scale $T_p^{(2)} = \sqrt{p}L_p$ associated with M_{127}. The prediction for the duration is .1 seconds! Bit sequences should correspond temporal sequences of mindlike space-time sheets and the neutrino realization of Boolean mind leads to idea that each binary digit corresponds either to spin degree of freedom for cognitive neutrino or to neutrino-antineutrino cognitive pair or absence of it. If this time scale corresponds to a sequence consisting 126 bits, the duration of single bit is about one millisecond, which happens to correspond to a definite p-adic time scale and is of same order of magnitude as the duration of nerve pulse! It must be emphasized that this estimate does not allow to conclude anything about the duration of our self which could be much longer.

6.2.5 Cyclotron resonances as key to quantum consciousness

The estimate for the thickness of the magnetic flux tubes of Earth's magnetic field based on the quantization of the magnetic flux is about cell size. There is direct evidence for the hypothesis that ions in the magnetic field of .2 Gauss (Earth' magnetic field has nominal strength of $B_E = .5$ Gauss) form quantum states with the characteristic energies of order 10^{-14} eV and size of the orbit being of order $2/\sqrt{eB}$, that is cell size: in fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic field corresponds to the length scale $L(169) \simeq 5$ μm rather precisely. This length scale is indeed the p-adic length scale which seems to correspond to our sensory consciousness and various macroscopic quantum phases seem to reside at $k = 169$ space-time sheets probably forming join along boundaries condensates. The work of Blackman and other pioneers of bioelectromagnetism concerning the effects of ELF (extremely low frequency) em fields on brain [46] provides dramatic support for this idea and also a concrete view about how brain manages to act as macroscopic quantum system.

The discovery of Blackman means that frequencies having special effect on biomatter correspond to cyclotron resonances for ions like Ca_{++}, Na_+, K_+ and Cl_- in magnetic field $B = 2B_E/5 = .2$ Gauss. The cyclotron frequency for Ca_{++} is 15 Hz whereas the remaining frequencies are in the range $7 - 13$ Hz (theta waves) at which also the most important Schumann resonances lie. The cyclotron frequency 5.5 Hz of iron is also a bio-active frequency and is the lower edge of theta region of EEG. Also lower frequencies resonant frequencies such as 2.4 (Iodium ion) are present. Even more remarkably, the pattern of data forces to conclude that the interaction occurs at quantum level. This conclusion is is dramatic conflict with the predictions of the standard quantum theory and

with the standard view about space-time but consistent with the many-sheeted space-time concept of TGD.

A confession is in order: for years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking Ca^{++} cyclotron frequency 15 Hz as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for Ca^{++} is .2 Gauss and thus slightly smaller than the minimum value .3 Gauss of B_E. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of B_E at distance 1.4R, R the radius of Earth.

Dark matter hierarchy leads to a 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 $p = 2^{127-1}$, $k = 0, 1, 2, ...$ [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. Number theoretical arguments suggest a general formula for the allowed values of λ [C7] as $\lambda = n$ where n characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [C6]. The values of n for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers n expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. $n = 2^{11}$ obviously satisfies this condition. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \rightarrow h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \rightarrow nL(k)$ and $B \rightarrow B/n$.

$B = .2$ Gauss would corresponds to a flux tube radius $L = \sqrt{5/2} \times L(169) \simeq 1.58L(169)$, which does not correspond to any p-adic length scale as such. $k = 168 = 2^3 \times 3 \times 7$ with $n = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 25$ μm, size of a large neuron. However, $k = 169$ with flux $2h_5$ would be must more attractive option since it would give a direct connection with Earth's magnetic field. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux h_5. Note that $n = 5$ is the minimal value of n making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [E9].

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field in the direction of axon carrying $B = 2B_E/5 = .2$ Gauss , is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron

frequency of Ca_{++} ion. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. This can be understood as resulting from parity conservation for the simplest transitions induced by that part of the interaction Hamiltonian which does not depend on the longitudinal coordinate of the axon. The reason is that odd and even values of n for harmonic oscillator states have opposite parities and the interaction hamiltonian describing the transition has odd parity. The simplest possibility is that these transitions occur in second via intermediate virtual intermediate state and correspond to second order in perturbation theory. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

These observations are consistent with the following interpretation. Ions with charge Z, spin S and mass m in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as multiples of

$$
\begin{aligned}
E &= (n + \frac{1}{2})\omega_c + \frac{S_z}{S}\omega_L \ , \\
\omega_c &= \frac{ZeB}{m} \ , \quad (\hbar = 1, c = 1) \ , \\
\omega_L &= \frac{gS\omega_c}{4} \ .
\end{aligned}
\tag{1}
$$

Here S and S_z denote total spin and its projection to the direction of the magnetic field. The contribution to energy coming from longitudinal motion has not been written explicitly. Here g is so called Lande factor which for free elementary fermions equals to $g = 2$. The experimental findings suggests strongly that external em field induces resonant transitions from between magnetic states. By the quantization of the magnetic flux, predicted by TGD also classically, the minimal size of the magnetic flux tube for the magnetic field of Earth is of order cell size. An attractive hypothesis is that the magnetic field in question is associated with axon and is parallel to it.

It must be emphasized that this vision is forced by hard experimental facts and is in dramatic contradiction with the standard physics view about brain. The wave functions of ions in magnetic field are confined in a region of size of order

$$
r_n \sim \sqrt{n/eB} \ ,
$$

which is of the order of cell size for B=.2 Gauss: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the length scale $L(169) \simeq 4$ μm rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ (S

denotes the area of the flux tube) and $Z = 2e$. $L(169)$ seems to correspond to our sensory consciousness and various macroscopic quantum phases seem to reside at $k = 169$ space-time sheets probably forming join along boundaries condensates.

The binding energies of ions in Earth's magnetic field are extremely small: of order 10^{-14} eV, which is ridiculously small energy when compared with the natural energy scale of one eV and corresponds to a temperature of order 10^{-10} Kelvin. According to standard quantum physics, Earth's magnetic field should have absolutely no detectable effects in hot, wetty and noisy environment provided by brain. Many-sheeted space-time concept provides the solution to the riddle. Ions are not on the molecular space-time sheets but have dropped to the cellular space-time sheet and it is indeed very cold, dry and silent here: an ideal place for the formation of macroscopic quantum phases. The energy scale implies the upper bound $T < 10^{-10}$ Kelvin for the temperature at cellular space-time sheets.

A further empirical input of crucial importance were the observations challenging the cherished notions of ionic pumps and channels [23]. These findings lead to a concrete view about biosystems as three-levelled structures involving massless extremals (MEs), super conducting magnetic flux tube structures, and atomic space-time sheets containing the ordinary matter. MEs control the dynamics of the superconducting ions inside magnetic flux tube structures. Magnetic flux tubes in turn are in a many-sheeted ionic flow equilibrium with the atomic space-time sheets and thus control the ionic concentrations at these space-time sheets.

This general framework leads to a rather detailed model for the generation of nerve pulse and EEG; to a model of sensory representations based on the notion of sensory canvas realized in terms of magnetic flux tube structures outside body with MEs serving as projectors of the cortical sensory representations to this sensory canvas; to a model of cognition including the realization of the memetic code in terms of cognitive antineutrinos and a physical mechanism translating nerve pulse sequences to the 126 bit long codewords of the memetic code; and finally, to a model for the quantum correlates of the sensory qualia and to what deserves to be called spectroscopy of consciousness.

6.2.6 Electromagnetic selves

Rather remarkably, the time scale of .1 seconds predicted by the model of the memetic code and also the time scales of the photons associated with the magnetic transition frequencies, in particular cyclotron frequencies, of ions correspond to the time scale of EEG. The currents generating EEG certainly create weak electromagnetic radiation fields which in TGD framework correspond to topological field quanta of size of Earth: the lowest Schumann frequency is roughly $c/2\pi R$, R radius of Earth, and equal to $\omega \simeq 8$ Hz. It is known that EEG frequencies are in the same frequency range as so called Schumann frequencies 8, 14, 21 ,... Hz [16] associated with the resonances of the electromagnetic fields in the 80 km thick wave cavity between Earth surface and ionosphere.

The higher EEG frequencies seem to correlate with higher Schumann resonance frequencies: in particular,, the frequencies 13 and 39 Hz which are also cyclotron resonance frequencies of Na_+, are very near to Schumann frequencies. Schumann frequencies vary in time and it has been found that also the variations of EEG frequencies correlate with this variation. Magnetic perturbations near Schumann frequencies are known to have profound effects on human brain inducing altered states of consciousness and cortical instabilities such microseizures and epilepsies [41]. The photons generated by Josephson currents associated with macroscopic ionic BE condensates have wavelengths of order Earth size and the topological field quanta representing classically the radiation field have size of Earth.

These observations suggests the identification of the relevant selves in our self-hierarchy are electromagnetic selves having the size of Earth and correspond to EEG frequencies! What happens is that Josephson currents generate classical ELF em fields represented by topological field quanta of this size (by uncertainty principle alone) which in turn couple resonantly to ions. These observations raise the question whether our "physical" body is only a dip of an iceberg and formed by the topological condensation of the biomatter around electromagnetic topological field quanta serving as templates for the biostructures [I3]. There is also neuropsycological evidence for the importance of ELF fields. In particular, the work of Michael Persinger is especially important [44, 39, 40, 41] [L1].

One possible scenario inspired by these observations is following.

1. The magnetic transition frequencies for the superconducting ions at the flux quanta of magnetic field B=.2 Gauss correspond to personal sensory consciousness. The magnetic flux tubes emanating more or less vertically from brain and accompanied by massless extremals could act as projectors defining personal sensory representations at the magnetic sensory canvas formed by the flux tubes (or possibly shell like topological quanta) of Earth's magnetic field.

2. Schumann frequencies associated with the oscillations of the flux tubes of Earth's magnetic field would in turn correspond to transpersonal aspect of consciousness. Schumann resonances could indeed induce a synchrony of the vertical magnetic flux tube structures associated with separate brains and even entangle them during sleep. This view is supported by some observations. In hypnagogic states (states between wake and sleep) EEG is peaked near the lowest Schumann frequency 7.8 Hz. During these states it is possible to experience hallucinations and identification experiences (I have now and then fleeting but completely 'real' experiences of being someone else). The so called sleeping spindles correspond to EEG patterns at 14 Hz which is the second Schumann frequency. A possible interpretation is that during sleep collective consciousness begins to dominate and brains form a highly synchronous whole. It would be interesting to test whether there are correlations between EEGs of different persons during sleep.

6.3 Quantum entanglement with higher level selves

Quantum entanglement with higher level selves has been one of the 'Eastern' ideas in development of TGD inspired theory of consciousness. The evolution in the very notion of 'self' however has been accompanied by the evolution of the notion of 'higher level self', and the views about the role of quantum entanglement have been fluctuating (and a tedious updating of the material related to this concept).

6.3.1 What 'higher level self' means?

When talking about quantum entanglement with higher level selves the first question is what 'higher level self' means. There are several manners to define this notion.

1. Self can correspond to space-time region of a given local topology contained inside larger region of different local topology. The larger region is in this case the 'higher level self'.

2. p-Adic hierarchy of the local space-time sheet topologies defines a hierarchy of selves and real selves are at the top of this hierarchy.

3. Real selves are expected to be near criticality against topological transitions to some p-adic selves and it should be possible to assign to each real self a p-adic prime characterizing its position in the hierarchy of real selves. Also p-adic selves could be near criticality against transition to some other p-adic topologies and again a hierarchy of selves with fixed p becomes possible.

The quantum entanglement with a self containing self as a region of different local topology (option a)) should always lead to the loss of consciousness since the phase transition changes the local topology of sub-self to that of self. Lower level self not only becomes unconscious but also loses its topological identity. This kind of phase transition could, but not need, occur for our self during sleep. The entanglement of sub-self understood in this sense need not be a completely passive state but higher level self could use lower level self as its instrument: trance could be an excellent example of this kind of situation.

An interesting question is what happens when sub-self entangles with a self of external world having same local topology (real or p-adic, option c)): this involves the formation of join along boundaries bonds fusing the two selves in question. Does sub-self remember anything about this period when it is subself of some other self? Could sub-self experience this period as an extended state of consciousness when the real self outside is characterized by a larger p-adic prime (option c))? In the sequel these questions and mechanism leading to entanglement with higher level self and signatures of this entanglement are discussed.

6.3.2 Possible geometric correlates of entanglement?

The geometric correlate for the entanglement between sub-systems is the generation of join along boundaries bonds combining the corresponding 3-surfaces to single 3-surface: this is nothing but the direct touching of the 3-surfaces. Actually, all that is needed is the fusion of the space-time sheets of same local topology (real or p-adic) to single sheet. The entanglement generated in this manner can be preserved even when direct geometrical contact between 3-surfaces is not present anymore. In TGD based model for brain these bonds are formed between parts of brain and sensory organs.

One can consider several models for join along boundaries bonds. Topological field quantization providing general description of classical gauge and gravitational fields in TGD framework implies that magnetic and electric flux tubes and "massless extremals" (MEs) are the basic building blocks of classical em fields. All these structures can serve as join along boundaries bonds.

MEs are especially interesting candidates for join along boundaries bonds. MEs are very general solutions of field equations of TGD and have properties making them ideal for realizing basic functions of biosystems.

1. MEs represent propagation of classical gauge fields with light velocity and can carry non-vanishing vacuum em currents and hence give rise to coherent photons. A tentative identification is as biophotons of Popp [43]. The hypothesis is that MEs make possible generation of quantum entanglement between brain and sensory organs. In this manner they provide a realization for neuronal window idea generalizing the idea about hologramic brain [H7]. MEs could make possible both classical (quantum) communication by the propagation of classical fields (coherent photons) along them and neuron could literally have a window to external world via sensory organ.

2. In TGD framework space-time sheets with negative time orientation are possible and carry negative classical energies (in General Relativity this is not possible). The generation of negative energy MEs provides "buy now, pay later" type mechanism for energy production. Generation of negative energy ME is classical counterpart for the generation of virtual particle and it is to be expected that the subjective lifetime of negative energy MEs is finite number of quantum jumps. Thus organism must eventually "pay", that is to compensate for the dissipation of the energy gained by the generation of the ME by metabolism. Therefore metabolism is still needed. Even more, organism must be able to give guarantees that it can pay! The ability to provide these guarantees is perhaps one of the great achievements of the biological evolution.

3. MEs carry large momentum since all Fourier components of the gauge fields have parallel lightlike momenta. Since classical 4-momentum is lightlike, the amount 3-momentum per energy is maximal. Thus, if the system is able to generate ME by quantum jump, it gains automatically large

recoil momentum. Hence MEs could provide the fundamental mechanism making possible the coherent macroscopic motion of living systems. Negative energy ME of this kind might be identifiable as a mindlike space-time sheet representing the geometric correlate for the conscious decision to move.

4. MEs represent dispersionless propagation of a pulse preserving its shape and are thus ideal for classical communication. If negative energy MEs are possible, one can imagine a mechanism of "real subjective time" communication between selves of either geometric past or future having arbitrarly large timelike distance. This idea is not conflict with standard classical causality at given space-time sheet. Needless to say, this kind of possibility would realize concretely the idea about four-dimensional society and revolutionize our view about universe: living beings separated by billions of light years could in principle have "real subjective time" chat.

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

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

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

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

side brain at the sensory canvas provided by the magnetic flux tube structures which can be even of the order of Earth size. This option is discussed in [H4].

6.3.4 Semitrance mechanism

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

The entanglement of the right or left brain hemisphere (or some part of it, perhaps the linguistic regions with respect to which human brain has highest asymmetry) with a collective self could be the basic mechanism making it possible to communicate the commands of the collective self to left and/or right hemisphere as 'hallucinations'. This leads to a TGD variant of the vision of Jaynes about bicamerals and schizophrenics as persons who differ from the average modern man in that they are able to receive commands and advice from collective levels of consciousness as hallucinations [34]. The notion of semitrance leads to very general views about how various societies (cells as societies of proteins, organisms as societies of cells, societies of various animals) develop and allows also to understand various altered states of consciousness [N5, N6].

The semitrance mechanism involves the generation of a bound state entanglement accompanied by the liberation of the binding energy as a usable energy. This non-metabolic energy might have something to do with the miraculous architectural feats of the ancient bicameral cultures (consider only pyramides) and the unusual physical strength of schizophrenics discussed in [34].

6.4 Dark matter hierarchy and higher levels of self hierarchy

The identification of dark matter as phases having large value of Planck constant [D6, J6, C6] led to a vigorous evolution of ideas still continuing while I am writing this addendum to the original text. Entire dark matter hierarchy with levels labelled by increasing values of Planck constant is predicted, and in principle TGD predicts the values of Planck constant if physics as a generalized number theory vision is accepted [C6]. Also a good educated guess for the spectrum of Planck constants emerges. The implications are non-trivial already at the level of hadron physics and nuclear physics and imply that condensed matter physics and nuclear physics are not completely disjoint disciplines as reductionism teaches us. One condensed matter application is a model of high

T_c superconductivity predicting that the basic length scales of cell membrane and cell as scales are inherent to high T_c superconductors.

6.4.1 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.

6.4.2 Jones inclusions and quantization of Planck constant

The Clifford algebra spanned by gamma matrices of infinite-dimensional space defines standard example of a von Neumann algebra known as hyper-finite factor of type II_1. The characteristic property of this algebra is that unit matrix has unit trace. Jones inclusions of hyperfinite factors of type II_1 combined with simple anyonic arguments turned out to be the key to the unification of existing heuristic ideas about the quantization of Planck constant [C7].

1. Quantum TGD emerges from the infinite-dimensional Clifford algebra extended to an analog of a local gauge algebra with respect to hyper-octonionic coordinate [C6]. In particular, the notions space-time as a hyper-quaternionic four-surface of imbedding space emerges.

2. One can understand how and why Planck constant is quantized and gives an amazingly simple formula for the separate Planck constants assignable to M^4 and CP_2 and appearing as scaling constants of their metrics as integer multiples of standard value $\hbar_0$ of Planck constant: $\hbar(M^4) = n_a \hbar_0$ and $\hbar(CP_2) = n_b \hbar_0$. This in terms of a mild generalization of standard Jones inclusions [C6]. The emergence of imbedding space means that the scaling factor of these metrics given by the scaling factor of Planck

constant have spectrum: their is no landscape as in M-theory. Also the fusion of real and various p-adic variants of imbedding space along common rational (algebraic) points is involved.

3. In ordinary phase Planck constants of M^4 and CP_2 are same and have their standard values. Large Planck constant phases correspond to situations in which a transition to a phase in which quantum groups occurs. These situations correspond to standard Jones inclusions in which Clifford algebra is replaced with a sub-algebra of its G-invariant elements. G is product $G_a \times G_b$ of subgroups of $SL(2,C)$ and $SU(2)_L \times \times U(1)$ which also acts as a subgroup of SU(3). Space-time sheets are $n(G_b)$-fold coverings of M^4 and $n(G_a)$-fold coverings of CP_2 generalizing the picture which has emerged already. An elementary study of these coverings fixes the values of scaling factors of M^4 and CP_2 Planck constants to orders of the maximal cyclic sub-groups. Mass spectrum is invariant under these scalings.

4. This predicts automatically arbitrarily large values of Planck constant and assigns the preferred values of Planck constant to quantum phases $q = exp(i\pi/n)$ expressible using only iterated square root operation: these correspond to polygons obtainable by compass and ruler construction with integer n expressible as $n = 2^k \prod_i F_{s_i}$, where $F_{s_i} = 2^{2^{s_i}} + 1$ are distinct Fermat primes: the lowest Fermat primes are given by $3, 5, 17, 127, 2^{16} + 1$. In particular, experimentally favored values of $\hbar$ in living matter should correspond to these special values of Planck constant. This model reproduces also the other aspects of the general vision. The subgroups of $SL(2,C)$ in turn can give rise to re-scaling of $SU(3)$ Planck constant. The most general situation can be described in terms of Jones inclusions for fixed point subalgebras of number theoretic Clifford algebras defined by $G_a \times G_b \subset SL(2,C) \times SU(2)$.

5. These inclusions (apart from those for which G_a contains infinite number of elements) are represented by ADE or extended ADE diagrams depending on the value of index. The group algebras of these groups give rise to additional degrees of freedom which make possible to construct the multiplets of the corresponding gauge groups. For $\beta \leq 4$ the gauge groups A_n, $D_2 n$, E_6, E_8 are possible so that TGD seems to be able to mimic these gauge theories. For $\beta = 4$ all ADE Kac Moody groups are possible and again mimicry becomes possible: TGD would be kind of universal physics emulator but it would be anyonic dark matter which would perform this emulation.

6.4.3 Dark matter hierarchy and the notion of self

The introduction of dark matter matter hierarchy forces to also reconsider the definition of self and in the following the original definition and modified definition are discussed. The vision about dark matter hierarchy as a hierarchy

defined by quantized Planck constants leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [J6, M3].

The hierarchy of dark matter levels is labelled by the values of Planck constant having quantized but arbitrarily large values. It seems that the most important hierarchy comes as $\hbar(k) = \lambda^k \hbar_0$, where $\lambda \simeq 2^k$ is integer. 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 a modification of the notion of self, in fact a reduction of the notion of self to that of quantum jump alone. Each self involves a hierarchy of dark matter levels, 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. This indeed looks extremely natural and the hypothesis that self remains un-entangled for a longer duration than single quantum jump un-necessary. It is perhaps un-necessary to emphasize that the reduction of the notion of self to that of quantum jump means conceptual economy and somewhat ironically, would also a return to the original hypothesis but with a quantized Planck constant.

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.

If one accepts the hypothesis that CP_2 time defines the typical geometric duration of quantum jump then moments of consciousness with duration longer than CP_2 time would be associated with dark matter. This would require quite huge value of n for human consciousness and does not seem a plausible option since the time scale of .1 seconds corresponds to integer $n \simeq 2^{256} \simeq 10^{38}$. A more reasonable looking option is that n-ary p-adic time scales $T(n,p)$ for a given value $\hbar = m\hbar_0$ define the typical geometric duration so that for a given prime p one would have the hierarchy $T(m,n,p) = mT_p(n) = m\sqrt{p}^n T_{CP_2}$ of geometric durations of moment of consciousness, with favored values of m given by $m = 2^k \prod_i F_{s_i}$: as already explained, $F_{s_i} = 2^{2^{s_i}} + 1$ are distinct Fermat primes and the lowest Fermat primes are given by $3, 5, 17, 127, 2^{16} + 1$. $m = 2^{11}$ seems to be favored in living matter [M3]. T_{CP_2} corresponds to CP_2 time about 10^4 Planck times. The geometric durations give a natural first guess for the duration

of long term memories. Second interpretation is as the increase of geometric time coordinate in single quantum jump in the drift towards geometric future which should accompanying quantum jump making possible to understand the experience about flow of time.

6.4.4 Higher levels of self hierarchy as levels of dark matter hierarchy

Higher levels of dark matter hierarchy provide neat quantitative view about self hierarchy and its evolution. The integer $n = 2^{k11}$, $k = 0, 1, 2, ...$ seem to define favored values of Planck constant in living matter. This means a hierarchy in which time and length scales are zoomed up by a factor of 2048 in the transition to the next level of hierarchy. This integer represents also fundamental constant in TGD Universe [D6].

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

The emergence of these levels must have meant evolutionary leap since long term memory is also accompanied by ability to anticipate future in the same time scale. This picture would suggest that the basic difference between us and our cousins is not at the level of genome as it is usually understood but at the level of the hierarchy of magnetic bodies [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.

7 Ageing and death

One can interpret the world ageing in two senses. The ageing with respect to geometric time and the ageing with respect to the subjective time.

Geometric ageing might correlate closely with entropy growth due to the non-determinism of Kähler action. Basically this classical non-determinism would gradually spoil the functioning of the physical body. In particular, the non-determinism of Kähler action implies that there is fractal hierarchy of MEs (massless extremals) inside MEs. The lightlike boundaries of MEs can be iden-

tified as an important instance of 3-surfaces identifiable as geometric correlates of selves. Geometric ageing could thus be closely related to the entropy growth associated with the emergence of MEs inside MEs.

What interests us mostly is obviously the subjective ageing: What ageing person experiences? Is there a continuity of subjective experience and what follows after physical death?[1] How our deeds affects to the experiences after the physical death? The situation is complicated by the fact that we possess entire hierarchy of selves. The selves associated with the physical body do not certainly survive with respect to the geometric time in the physical death whereas electromagnetic selves and field body could quite well do so. The second complication is that selves contain sub-selves located in various values of the geometric time, even childhood. The question is about what sub-selves dominate during ageing: are these selves electromagnetic selves or bodily selves and do sub-selves of geometric past, now or future dominate. Subjective ageing could proceed in many manners depending on these factors.

The basic problem involved is the identification of the after life self. Universe is full of selves and one cannot say anything definite about the fate of self after death unless one can decide which self can be regarded as the continuation of self before death. Since selves and mindlike space-time sheets are firmly associated with each other, the question about the reality of physical death reduces to the question about the fate of the 'personal' mindlike space-time sheet(s) during ageing and after death and the identification of the personal mindlike space-time sheet.

The notion of electromagnetic body, when combined with the view about psychological time as the value of the geometric time defining the front of the p-adic-to-real phase transition at which intentions are transformed to deeds, allows a general answer to these questions. Magnetic body certainly survives the physical death, and since it serves as the sensory canvas, there are all reasons to expect that consciousness continues after the physical death. The contents of consciousness would be determined by the 4-dimensional physical and electromagnetic bodies and the dominating contribution creating the illusion about reality as a time=constant snapshot would be absent. Kind of timeless consciousness would be in question in accordance with the life review experiences associated with NDEs.

7.1 Ageing as a price for having self

Self can be regarded as a statistical ensemble defined by the unentangled final states of the quantum jumps. Since the size of this ensemble increases quantum jump by quantum jump, the approach of this ensemble to thermal equilibrium is unavoidable although living matter has probably invented manners to fight against the second law of thermodynamics. In real context the ageing of self means dissipation. In p-adic context the notion of energy dissipation need not be especially useful. Rather the gradients of various entropy type variables

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[1] 'Physical' means here 'bodily' or 'material'.

associated with self with respect to subjective time variables are the proper variables to characterize what happens in dissipation understood as gradual thermalization of distributions of quantum number increments and zero mode increments.

Each p-adic length scale defines its own characteristic dissipation. In case of a self decomposing into sub-selves the rate of dissipation is sum over the real dissipation rates associated with the nested system formed by the self, its sub-selves, their sub-selves, etc.... The dissipation associated with states of whole-body consciousness can be anomalously small since only the highest level contributes to the dissipation rate. If the system is a join along boundaries condensate formed from a large number of sub-systems whose sizes are characterized by a p-adic length scale, especially low dissipation rate results. A possible test for this is the study of total rate of metabolism during meditation.

Dissipation implies thermodynamical arrow of time and this is directly related to the arrow of the psychological time, which can be understood as resulting from drift of the mindlike space-time sheets in the future lightcone occurring also when the sheets do not define separate selves. The interpretation of the psychological time as a zero mode and localization in zero modes in each quantum jump is absolutely crucial for this argument. The continual drifting of mindlike space-time sheet is supported also by the fact that psychological time grows steadily also during sleep.

Dissipation can be interpreted as the ageing of self: getting old is the price for having self. More concretely, the entropies associated with various distributions of quantum number and zero mode increments increase during ageing so that mental images are gradually blurred. Note that also our self which defines a mental image of a higher level self is blurred. Also physical death, or at least death experience, seems to be unavoidable fate of self. An open question is what happens for the mindlike space-time sheet carrying self after death. Could the mindlike space-time sheet be called soul? Does this soul continue drift in lightcone and get attached to some new material system so that reincarnation would occur? "Ontogeny recapitulates phylogeny" principle suggests that the evolution of an individual is image for the evolution of the entire universe. This would mean that "physical" death would be only a metamorphosis to some new form of existence, perhaps as topologically quantized classical fields associated with the physical body. Massless extremals (MEs) and magnetic flux tube structures having sizes measured in scale of light lifetime are especially promising candidates for the components of electromagnetic body surviving in the death of what is usually identified as the physical body. Some experimental facts lead to rather precise ideas about the geometric representation of our selves and also suggest that our existence continues in electromagnetic form after death [I3].

7.2 Death as disappearance of the mental image representing the physical body?

If one takes seriously the following two assumptions behind the TGD based model of quantum control and coordinate based on the symbiosis of MEs, magnetic flux tube structures, and matter at the atomic space-time sheets, one ends up with rather concrete view about what happens after the bodily death.

1. Our mental images actually correspond to ELF and even ULF MEs of size of order $L \sim \lambda = c/f$, where f is the frequency in question (not above EEG range), so that the sizes of these mental images are measured using Earth size as a unit. Sizes of MEs of order lightlife are possible.

2. The ultimate sensory representations are realized on the sensory canvas provided by magnetic flux tube structures of similar size, so that we have magnetic body providing sensory representation of the physical body and external world [H4]. Our magnetic self very probably survives in the physical death by the conservation of the magnetic flux.

Under these assumption our afterlife body would consists of the magnetic body plus MEs possibly surviving the death of the so called physical body. The only difference as compared to the life before death would be that the sensory and cognitive mental images representing the physical body (sub-selves) would disappear and the attention of our self would be directed to something else. Near death experiences indeed support this view [I3]. In this picture re-incarnation is possible and even plausible and means only that the magnetic flux tube structure representing our bodily self turns its attention to some other physical body and uses it as a sensory and motor organ. This new physical body could be plant, animal, human, or perhaps something else. In this picture the metaphor about physical body as a cloth becomes very concrete.

Since self has an extension with respect to geometric time, it has memories about its earlier history and one could perhaps identify the continuation of self after the death as that self which has the memories of self with respect to geometric time before death. In this extended state of consciousness self could experience the subjective past of self's mindlike space-time sheet and associate it with self's recent mindlike space-time sheet. Note that this kind of mechanism could also explain why it is possible that I regard it obvious that I existed yesterday although my bodily self slept over night. This picture is consistent with the reported ability of some children to remember their past lives.

7.3 Ageing and death from the point of view entanglement generation

Ageing could be seen also as a process analogous to the process of getting drowsy and falling asleep but in much longer time scales. The process would involve generation of temporal entanglement of bodily sub-self with larger selves involving phase transition changing the topology of the space-time sheet representing self

to that of the surrounding world. Bodily sub-self would not remember anything about these periods of different local topology. Our sub-self would not have no mental image about body during these periods. Also sleep could represent a similar conscious state without bodily mental image and the impossibility to remember anything about this period of consciousness might be simply due to the fact that one can remember something about sleep state only in sleep state.

An alternative option is that space-time sheet representing the bodily self preserves its local topology but fuses to a space-time sheet of similar local topology outside the physical body. Generation of join along boundaries bonds could be the geometric correlate of this process. During ageing bodily sub-self would spend more and more time near the critical line at which this transition occurs. If bodily sub-self ceases to be our self in this process we do not remember anything about these periods.

Perhaps the process of ageing could be a process of personal growth (in rather concrete sense!). The temporal entanglements generated with larger selves would give rise to larger temporal selves and the metaphor 'awakening' would thus be much more than a metaphor. Person would spend more and more time in extended state of consciousnesss and in death finally leave the confines of the physical body. Note that person need not, and probably doesn't, remember anything about the periods of entanglement in which the local topology of self changes. This would make possible the evolution of selves continuing after death to higher levels of conscious existence. This picture is rather optimistic: one must also consider the possibility that the evolution of self is not continuous growth! The fact that the individual development of most people seems to be a process of continual abstraction indeed that physical death is only one step in the process of abstractions and that our self consciously experiences the final transition to higher level of existence in death.

In death the space-time sheet representing bodily sub-self would get so far from the critical line for the phase transition of the local topology back to original one that wake-up becomes impossible for the sub-selves associated with the physical body. For instance, the effect of electric shocks on patients who have suffered heart attack and lost consciousness could be understood as a large enough perturbation able to bring the bodily sub-self back to the critical line.

7.4   Why childhood memories are recalled so intensely?

The first manner to see ageing is as a subjective experience: as ageing with respect to subjective time. Our self contains sub-selves representing our memories, sensory input from the geometric now and future plans. At the old age it often happens that childhood memories begin to dominate whereas the recall of more recent memories is gradually lost. Of course, the contribution of future plans becomes also gradually negligible. This suggests that the contents of consciousness for our self can suffer a gradual transformation such that the childhood begins to dominate: of course, this need not happen always. That the childhood dominates is not easy to understand if the memories of the past are stored in the geometric now as assumed in the standard brain science. In TGD

framework the very fact that the childhood consciousness is very intense and un-conceptual, explains the dominance of the episodal memories of childhood.

Who is the subjective experiencer in this kind of situation? Is it the old person with vivid memories or a child with some very diffuse ideas about future? The view about psychological time would suggest that the general experience gradually becomes some kind of a 4-dimensional life review such that the very intense childhood memories dominate but that the person in the psychological now is still the only one who can transform intentions to actions effectively whereas the 4-D body of the past is more or less frozen.

7.5 What after physical death?

In TGD framework physical body is accompanied by magnetic body and radiation body which provide representation for the physical (or better to say, material) body. The latter consists of radiation selves (massless extremals representing topologically rays of light) representing classically the ELF radiation fields generated by EEG currents, one is led to ask what happens for these em selves in physical death. Some of them correspond to resonant frequencies of the em fields in the 80 km thick wave cavity between Earth surface and ionosphere known as Schumann frequencies and one can consider the possibility that that something which might be called soul remains after the physical death and is represented as Schumann resonances.

The most plausible hypothesis is that both ULF MEs and magnetic flux tube structures remaining after physical death together with the 4-dimensional body of geometric past define our self after the physical death. This leads to the following speculative vision about consciousness after the physical death.

1. The transformation of intentions to actions as p-adic-to-real transitions ceases in the physical death so that the dominating contribution of the psychological now to the experience disappears and conscious experience becomes kind of four-dimensional life review in which also the contributions from other bodies (say deceased relatives) appear as unmasked.

2. The geometric past, or rather experiences about it, can be gradually refined but no big changes are possible, so that a totally new life based on different decisions does not seem to be possible. The assumption about totally new life would also lead to paradoxes. On the other hand, the unstability of the long term memories suggests that the memories about the past life could be edited. The conscious experience contains also the contribution of the magnetic body continuing to exist.

3. The surviving magnetic body could attach to some new organism which it begins to use as a sensory and motor organ. The re-incarnation would have the memories of the past life as an unconscious background masked strongly by the sensory input and coming clearly conscious only in some altered states of consciousness. The reports about children remembering they previous life could be understood in this conceptual framework. This

of course makes one wonder whether young children could remember their past lives. Perhaps someone should ask!

There is a lot of subjective evidence consistent with life after death. Near-death experiences are not the only manner to get convinced for life after death. So called eye-movement desensitization and reprocessing (EMDR) discovered by Francine Shapiro [45, 25] induces what could be interpreted as after-death communications. The experiences of subject persons can be induced by this therapy in highly reliable manner: according to [25] 98 per cent of patients willing to participate the therapy had after death communication experience It does not matter what the religious convictions of the subject person are and the experiences are actually rather easy to induce. It does not matter if the loss is traumatic or not or whether it is recent or occurred for decades in past. The experiences resemble near death experiences (light tunnels, beautiful landscapes) and involve spiritual contact with the deceased. The EMDR technique involves getting the patient to move his or her eyes in a particular rhytmic fashion while at the same time attending to a particular aspect of the traumatic memory. How EMRD works is poorly understood as yet: possibly the fact that the shifting of eyes leads to increased brain processing is of importance. Notice that rapid eye movements REM are also involved with dreams. A possible explanation is that EMDR experiences could involve communication with the recent selves of the deceased ones located possibly in the geometric recent or past and represented by magnetic flux tube structure and MEs interacting with them.

Indirect support for the survival of mindlike space-time sheets after death comes from rather unexpected direction. The phenomenon of phantom DNA suggesting that mindlike space-time sheets associated with DNA remain in the chamber which contained DNA: in the experiments of Poponin [42] the signature of phantom DNA is its interaction with laser light at visible frequencies. Phantom DNA would be represented by mindlike space-time sheets with size of at least the wavelength of visible light (10^{-7} meters). The em selves remaining after our death would have consirably larger size! One can however consider the possibility that some detectable interaction between EFL frequency em fields and 'phantom brain' ('em soul') could be possible and make it possible to prove experimentally the presence of em soul!

The claimed successes of homeopathy (For phantom DNA and homeopathy see [J5] and [K5]). could also have explanation in terms of the mindlike space-time sheets. Homepathic drugs are fabricated by a repeated dilution of the active drug so that the concentration of the drug in solution becomes extremely low. The method of fabrication could however imply that final product contains quite many mindlike space-time sheets of the drug molecules. These mindlike space-time sheets might be able to affect the sickness since the mindlike space-time sheets provide a cognitive representation for drug and this mimicry could 'cheat' the patient to cure. The law of similarities could have something to do with the mechanism involved.

More concretely, a given quantum transition frequency characterizing the medicine would be represented as ME with length equal to the wavelength asso-

ciated with the transition frequency. The electromagnetic body of the molecule could be mimicked by liquid crystal water blobs producing similar transition frequencies and thus containing similar MEs in their electromagnetic bodies. The effect of the medicine would be mediated by the electromagnetic body so that the 'fake' medicine could indeed cure.

7.6   Near death experiences

Near death experiences provide a testing ground for the general ideas about what might happen in the physical death. Experiences resembling near death experiences can be produced now in controlled manner in laboratory circumstances for people well and alive and irrespective of their belief structure subject persons tell about light tunnels and meeting of deceased relatives [25]. These experiences have been found to be therapeutic and are indeed used as therapy to cure severe psychic traumas. Therefore the materialistic explanation as a hallucination associated with dying brain seems to be excluded. Near death experiences involve experiences like being in light tunnel, seeing beautiful and rich landscapes and meeting dead relatives. Also out-of-body experiences are involved. The model of NDEs are discussed in detail in [H9] and here only some brief comments are represented.

The proposed picture about physical death allows a lot of room to interpret these experiences. For instance, OBEs allow two explanations.

1. The first explanation is based on the fact that in TGD based model of sensory representations the magnetic sensory canvas far outside body basically sees the brain in ELF light. This light usually comes from brain and provides a sensory represention for the external world. TGD predicts also a mechanism producing background ELF radiation from the entire body at magnetic transition frequencies and this background would make possible to see the body 3-dimensionally from outside when the sensory input is absent and does not mask this weak contribution. NDE OBEs might correspond to this kind of vision reported also by yogis.

2. The experience looking one's body from outside could mean that some higher level self corresponding to slow EEG waves and higher em selves formed physically by the personnel of hospital in the hospital room begins to dominate. This self could perhaps see patient's body with the combined eyes of the hospital personnel. Indeed, since the sensory input from the physical body ceases, the illusory identification of 'me' with the physical body ceases and attention can be directed to this higher level sensory input.

Geometrically the em bodies of our dead relatives would exist in the geometric past and now, perhaps already in a re-incarnated form. This allows several explanation for the experience of meeting dead or living relatives. A very concrete model would be based on electromagnetic bridges formed by mag-

netic mirrors and connecting us with our relatives and friends. This would make possible for us to see them in ELF light just like we would see ourselves.

The experience about meeting deceased relatives could be also understood as a special kind of geometric memory. Generation of the long term memory means classically looking to a magnetic mirror at classical level and seing the me of the past in the mirror. It is however possible to see someone else in the mirror since the magnetic fluxtube from the mirror could continue to the body of the deceased relative of friend instead of my body. In the usual states of consciousness the sensory input from the psychological now dominates and this contribution is masked. In near death experiences sensory input from the geometric now is diminished and the transpersonal background contribution becomes unmasked.

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