

# Biological Realization of Self Hierarchy

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## Abstract

Self-hierarchy is the basic prediction of the TGD inspired theory of consciousness and the biological realization of the self-hierarchy is the basic theme of this chapter. Space-time sheets, in particular mind like space-time sheets having finite temporal duration and providing cognitive representation of the material world, are geometrical correlates of selves and biological self hierarchy reduces geometrically and topologically to the hierarchy of space-time sheets. Crucially involved is the notion of the topological field quantization, which among other things implies that photons have as their classical geometrical correlates so called topological field quanta. One interpretation for the topological field quanta of em field is as classical/quantal coherence regions of classical/quantum em field and electromagnetic (em) fields and their topological field quanta are expected to be especially important in bio-systems. One can assign vacuum quantum numbers to topological field quanta and these quantum numbers are expected to be carriers of a biologically relevant information.

In principle the self hierarchy starts already at elementary particle level but the atomic length scale serves as a natural length scale for length scale at which biological relevant part of the self-hierarchy starts.

a) The assumption that various bio-molecules are selves allows to understand the miraculous abilities of living systems as outcome of quantum self-organization process in which dissipation selects very limited repertoire of self-organization patterns identifiable as survivors in Darwinian selection. For instance, one can understand protein folding and DNA replication as self-organization processes.

b) The fact that bio-systems are liquid crystals, makes them ideal for the realization of the self hierarchy. The reason is that liquid crystals have ability to self-organize to very complicated structures and are ideal for communication purposes: for instance, mechanical signals can be coded to electric signals and vice versa. Liquid crystals are also electrets: the presence of electric fields is indeed an important prerequisite of cognition in TGD as discussed in the chapter "Information and consciousness". In fact, one could identify various bio-structures such as micro-tubuli, cell organelles and cells as generic outcomes of the self-organization of the liquid crystals. An especially important level of the self hierarchy is provided by collagen networks which could give rise to what might be called 'body consciousness'. Central nervous system is only one, although very important level in the self hierarchy, and TGD approach allows to understand why this is the case.

c) p-Adic length scale hypothesis allows quantitative grasp to the structure of the self hierarchy and one can build general picture about how various p-adic length scales emerged during the evolution. In particular, one can identify various p-adic length scales associated with the brain.

d) One level of the self hierarchy corresponds to the topological field quanta of ELF em fields associated with EEG. ELF (extremely low frequency) em fields are known to have dramatic effects on living matter and brain and the origin of these effects is poorly understood. A simple argument based on Uncertainty Principle leads to the conclusion that ELF photons in 10 Hz frequency range correspond to topological field quanta of size of entire Earth. This leads to a rather dramatic conclusion that our biological body is only a dip of an iceberg and we are much more than our neurons. The most important levels in our personal self hierarchy contains levels are of size of Earth! Support for this picture come from the quantitative success of the scenario: one can immediately understand various important neuro time scales in terms of the cyclotron frequencies of various charged particles in Earth's magnetic field.

e) Each bio-structure is accompanied by a topologically quantized magnetic field defining corresponding magnetic body and these magnetic bodies form a hierarchy. Magnetic bodies could serve as intentional agents, as templates for the formation of various biological control circuits crucial for homeostasis and biological information processing, define the basic structure making possible metabolism with universal metabolic energy currencies, and could even define what might be called Nature's own bio-laboratory.

f) The magnetic flux structures associated with body could be of crucial importance for understanding human consciousness. For instance, eyes generate magnetic fields. Also brain, in particular pineal gland (the 'third eye' of mystics and the seat of soul for Descartes), contains

magnetic materials. Corresponding magnetic transition frequencies correspond to time scales relevant for the self narrative in human time scales. Perhaps these higher levels of magnetic self hierarchy could relate with NDE experiences and represent structures surviving in physical death.

## 1 Introduction

The understanding of the biological systems from the first principles seems to be an almost insurmountable task. These systems are both structurally and functionally extremely complicated and the existing basic physics doesn't offer very many obvious clues as how one might understand the generation of the spatial and temporal structures from the first principles. In fact, it is not at all obvious whether the first principles are even known. The standard reductionistic and materialistic world view combined with the notion of linear time is extremely restrictive framework and might simply not allow life and consciousness. TGD and TGD inspired theory of consciousness has indeed led to a general conceptual framework, which differs radically from that of the standard physics. The highly nontrivial implication is that TGD inspired theory of consciousness provides, not only general insights, but very detailed ideas as regards to the structure and functioning of the living systems. In this chapter the emphasis is more on structure whereas the next chapters entitled "Quantum Control and Coordination in Bio-Systems: part I/II" [I4, I5] concentrate on the functional aspects.

### 1.1 The notions of self and self hierarchies

The breakthrough idea in TGD inspired theory of consciousness was the notion of self defined as a subsystem able to remain unentangled during the unitary quantum "time evolutions"  $U$  associated with quantum jumps  $\Psi_i \rightarrow U\Psi_i \rightarrow \Psi_f$ . The notion of self leads to the concept of self hierarchy and the interpretation of quantum self-organization as evolution of selves. p-Adic unitarity implies automatically evolution as a gradual increase of the p-adic prime of the universe. The infinite size of the universe forces to introduce the notion of infinite primes and corresponding p-adic topologies. Infinite primes have decomposition into finite primes labelling space-time sheets possessing p-adic topology. The notion of infinite prime allows to understand continuous evolution of physical systems as increase of the finite p-adic prime associated with them as also discontinuous processes in which entirely new p-adic space-time sheets emerge. The gradual increase of the cell size during evolution and emergence of multicellular structures provide examples of the two aspects of the evolution. The increase of the finite prime corresponds to gradual refinement of the corresponding p-adic topology in the sense that the notion of nearness as it is realized at the level of conscious experience becomes more and more refined. Also the maximum information content of conscious experiences increases with p-adic prime. Thus a measure for the complexity of a conscious system is in question.

### 1.2 Selves self-organize

A system possessing self (possibly having sub-selves) performs quantum jumps and dissipates. This leads to quantum self organization leading to asymptotic patterns selected by dissipation, which thus acts as a Darwinian selector of both memes and genes. Actually, there is no deep difference between genes and memes (understood here rather metaphorically) since selves are always conscious systems and consciousness is present already at elementary particle level. In light of this the notion of the self hierarchy should be of crucial importance for the understanding of living systems and the purpose of this chapter is to demonstrate this and also to propose a general view about how biological self hierarchy is realized.

### 1.3 Mind like space-time sheets as massless extremals

Space-time sheets, in particular mind like space-time sheets having finite temporal duration and providing representations of the material world, are geometrical correlates of selves and biological self hierarchy reduces geometrically and topologically to a hierarchy of space-time sheets. Crucially involved is the notion of topological field quantization, which implies that also photons have as their geometrical correlates so called topological field quanta. Electromagnetic (em) fields and their topological field quanta are expected to be especially important in bio-systems. One possible interpretation for the topological field quanta of em field is as classical/quantal coherence regions of classical/quantum em field. ELF (extremely low frequency) em fields are known to have dramatic effects on living matter and brain and the origin of these effects is poorly understood. A simple argument based on Uncertainty Principle leads to the conclusion that ELF photons in 10 Hz frequency range correspond to topological field quanta of size of entire Earth! This leads to a rather dramatic conclusion that our biological body is only a dip of an iceberg and we are much more than our neurons. The most important levels in our personal self hierarchy contains levels are of size of Earth!

The so called massless extremals (MEs) are excellent candidates for the topological field quanta of radiation fields. They allow at their light like boundaries representations of super-conformal and super-canonical algebras with gigantic state degeneracies broken only by gravitation. These states are genuinely quantum gravitational states in the space of 3-surfaces ('world of worlds') and thus in a well-defined sense correspond to a higher level of abstraction. Beyond general coordinate invariance these states define quantum holograms and are excellent candidates for coding biological information. The properties of MEs make them also ideal for holographic quantum teleportation. Also the quantum model of qualia relies on the quantum phase transitions for super-canonical representations [K3, M5].

### 1.4 Hierarchy of super-conducting magnetic flux tube and electret structures

All magnetic flux structures associated with body could be of crucial importance for understanding human consciousness. For instance, eyes generate magnetic fields. Also brain, in particular pineal gland (the 'third eye' of mystics and the seat of soul for Descartes), contains magnetic materials. Corresponding magnetic transition frequencies correspond to time scales relevant for the self narrative in human time scales. Perhaps these higher levels of magnetic self hierarchy could relate with NDE experiences and represent structures surviving in physical death. It took some time to realize that magnetic flux tubes have the flux quanta of electric field as dual solutions of the field equations. Bio-system is indeed populated by various electret structures, mention only micro-tubuli and cell membrane as examples.

### 1.5 Living matter as symbiosis of MEs, super-conducting magnetic flux tube structures, electrets and ordinary matter

This picture leads to a view about living matter as a symbiosis of the fractal hierarchies of MEs and super-conducting magnetic flux tube structures and electrets with ordinary bio-matter at atomic space-time sheets. Bio-control is based on many-sheeted ionic flow equilibrium and magnetic quantum phase transitions allowing very effective control of biochemistry. The interactions between MEs and super-conducting ions are standard interactions between em fields and super-conductors (magnetic induction, induction of Josephson currents, magnetic phase transitions).

In the following the most recent (and still developing) TGD inspired view about biological self hierarchy is described and the possible consequences are considered at various length scales. For

the reader willing to learn about the general ideas relating to self and self hierarchy, the references [H1, H3] of [10] are recommended.

## 1.6 TGD based view about dark matter

TGD suggests an explanation of dark matter as a macroscopically quantum coherent phase residing at larger space-time sheets [J6].

1. TGD suggests that  $\hbar$  is dynamical and possesses a spectrum expressible in terms of generalized Beraha numbers  $B_r = 4\cos^2(\pi/r)$ , where  $r > 3$  is a rational number [C6, J6]. Just above  $r = 3$  arbitrarily large values of  $\hbar$  and thus also macroscopic quantum phases are possible. The criterion for transition to large  $\hbar$  phase is the failure of perturbative expansion so that Mother Nature takes care of the problems of theoretician. A good guess is that the criticality condition reads as  $Q_1 Q_2 \alpha \simeq 1$  where  $Q_i$  are gauge charges and  $\alpha$  gauge coupling strength. This leads to universal properties of the large  $\hbar$  phase. For instance,  $\hbar$  is scaled in the transition to dark phase by a harmonic or subharmonic of parameter  $1/v_0 \simeq 2^{11}$  which is essentially the ratio of  $CP_2$  length scale and Planck length [D6, J6]. The criticality condition can be applied also to dark matter itself and entire hierarchy of dark matters is predicted corresponding to the spectrum of values of  $\hbar$ .
2. The particles of dark matter can also carry phase carry complex conformal weights but the net conformal weights for blocks of this kind of dark matter would be real. This implies macroscopic quantum coherence.
3. An infinite hierarchy of dark matters is predicted [F6]. The basic hierarchy corresponds to the values of  $\hbar$  coming as  $\lambda^m \hbar(1, m)$ ,  $\lambda = v_0/n$ ,  $v_0 \simeq 2^{11}$ .  $\hbar(1, m)$  corresponds to the values of  $\hbar$  labelled by Beraha numbers  $B_m$ . Second hierarchy corresponds to particles labelled by selected integers characterizing the p-adic length scales of particles with which the particle interacts. Direct interactions occur only between the particles characterized by integers having common p-adic prime factors characterizing the p-adic length scales of bosons exchanged in the interaction. The algebraic extensions of p-adic numbers define an additional hierarchy. Also the notion of darkness must be refined by attributes partial and relative.
4. From the point of view of nuclear physics application of this hypothesis is to QCD. The prediction is that the electromagnetic Compton sizes of dark quarks are scaled from  $L(107)$  to about  $2^{11}L(107) = L(129) = 2L(127)$ , which is larger than the p-adic electromagnetic size of electron! The classical scattering cross sections are not changed but changes the geometric sizes of dark quarks, hadrons, and nuclei. The original hypothesis that ordinary valence quarks are dark whereas sea quarks correspond to ordinary value of  $\hbar$  is taken as a starting point. In accordance with the earlier model, nucleons in atomic nuclei are assumed to be accompanied by color bonds connecting exotic quark and anti-quark characterized p-adic length scale  $L(127)$  with ordinary value of  $\hbar$  and having thus scaled down mass of order MeV. The strong binding would be due the color bonds having exotic quark and anti-quark at their ends.
5. Quantum classical correspondence suggests that classical long ranged electro-weak gauge fields serve as classical space-time correlates for dark electro-weak gauge bosons, which are massless below the appropriate weak length scale  $L_w$ . This hypothesis could explain the special properties of bio-matter, in particular the chiral selection as resulting from the coupling to dark  $Z^0$  quanta. Long range weak forces present in TGD counterpart of Higgs=0 phase should allow to understand the differences between biochemistry and the chemistry of dead matter.

6. For ordinary condensed matter quarks and leptons  $Z^0$  charge are screened in electro-weak length scale whereas in dark matter  $k = 89$  electro-weak space-time sheet have suffered a phase transition to a p-adic topology with a larger value of  $k$ . Gaussian Mersennes, in particular those associated with  $k = 113, 151, 157, 163, 167$  are excellent candidates in this respect. The particles of this exotic phase of matter would have complex conformal weights closely related to the zeros of Riemann Zeta. The simplest possibility is that they correspond to a single non-trivial zero of Zeta and there is infinite hierarchy of particles of this kind.

In dark matter phase weak gauge fluxes could be feeded to say  $k = k_Z = 169$  space-time sheet corresponding to neutrino Compton length and having size of cell. For this scenario to make sense it is essential that p-adic thermodynamics predicts for dark quarks and leptons essentially the same masses as for their ordinary counterparts [F3].

## 2 Many-sheeted space-time concept and living systems

### 2.1 Topological field quantization

Topological field quantization is a concept whose central importance in TGD has become only gradually clear. In the following some aspects of the topological field quantization are discussed. Super-conducting magnetic flux tubes and massless extremals (MEs) are especially important topological field quanta as far as quantum control is considered. MEs allow at their light like boundaries representations of super-conformal and super-canonical algebras providing quantum hologram type representation of biological information with enormous state degeneracies. Since these representations have interpretation as genuinely quantum gravitational state functionals in the 'world of worlds', they should correspond to higher level consciousness than the super-conducting BE condensates at magnetic flux tubes.

#### 2.1.1 Topological field quantization as geometric counterpart of 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 prerequisite 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" 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 [G2, G3]. Also bio-systems might have invented negative energy space-time sheets: in fact, so called "massless extremals" (MEs) provide an ideal manner to generate coherent motions as recoil effects caused by the creation of negative energy massless extremals [14, 15]. An interesting possibility is that quantum entanglement has the formation of the join along boundaries bonds as its geometric correlate.

The crucial question is of course 'How to make this idea quantitative?'. An attractive possibility is that topological field quanta identified as material or mind like space-time sheets could be regarded as counterparts of oscillator operators of free fields in quantum field theory. This would mean that one could make order of magnitude estimates for the probabilities for the presence of various numbers of both material and mind like space-time sheets using quantum field theoretical intuition. The coefficient of a particular state in the expansion of the creation operators of the outgoing interacting quantum fields in terms of the creation and annihilation operators of free quantum fields could provide an estimate for the probability that a particular configuration containing topological field quanta with positive and negative energies results in quantum jump between quantum histories. Since mind like space-time sheets are correlates for virtual particles, this would also mean a deep connection between quantum field theory and cognition.

Topological field quanta, in particular flux tubes of magnetic fields, could serve as templates for the formation of the bio-structures. Thus topologically quantized classical electromagnetic fields could be equally important for the functioning of the living systems as the structures formed by the visible bio-matter and the visible part of bio-system might represent only a tip of an ice berg.

### 2.1.2 Topological field quantization and classical de-coherence

The fact that topological field quanta correspond to coherence regions of classical field suggests that there must be a deep connection between classical de-coherence and space-time topology. This connection indeed exists. An innocent question of Claude Rifat concerning macroscopic classical coherence led me to realize that the nebulous phenomenon of de-coherence can be regarded as a direct evidence for the many-sheetedness of the space-time! In principle, the counting the number of noncoherent components of various fields gives an experimental method to deduce the number of space-time sheets present. The nature of de-coherence gives also information about the sizes of the space-time sheets and their durations! Thus everyday physics provides direct demonstration for the notion of the many-sheeted space-time: for some reason I had not realized this earlier. The detailed argument goes as follows.

#### 1. *Everything is classically coherent at basic level*

Topological field quanta can be said to be coherence regions of classical fields, say em field. Typically frequency determines the size of the coherence region by Uncertainty Principle and topological field quanta of ELF em fields are huge: 10 Hz corresponds to the circumference of Earth. One can also say that everything is coherent at the level of the microscopic description. In TGD framework the loss of coherence is only a phenomenological manner to describe certain experimental facts in Maxwell's theory.

#### 2. *'Loss of coherence' provides direct evidence for topological field quantization!*

In standard physics one has topologically trivial space-time containing classical fields: fields propagating to a given region just superpose. The predicted interference effects of two interfering classical fields are *not* always observed: this is called loss of coherence. As if superposed components would live in their own space-times so that interference is not possible so that energy and momentum densities are sums over the energy densities associated with these space-times. *This indeed the case in TGD! When two classical field sum noncoherently this means that they live on different space-time sheets and correspond to different topological field quanta* Classical coherence is also more or less equivalent with quantum coherence. The belief that physics does not allow macroscopic quantum coherence is illusion created by wrong space-time concept.

#### 4. *Phenomenological description of many-sheetedness as a loss of coherence*

In Maxwell theory one describes the observed lack of interference effects due to many-sheetedness phenomenologically. The very definition of de-coherence is extremely problematic: one is forced to assume that measured quantities correspond to an ensemble or temporal averages and that the phases for the superposed fields vary randomly. This need not be the case actually. Only when one builds effective description by replacing the entire many-sheeted space-time with ordinary space-time, one is forced to introduce linear superposition of various fields associated with various space-time sheet plus the nebulous notion of non-coherent superposition. At the level of many-sheeted space-time everything

*5. Classical de-coherence is the counterpart for the loss of quantum coherence*

By 'Ontogeny Recapitulates Phylogeny Principle' (analogous to the corresponding biological principle), the loss of classical coherence is classical counterpart for the loss of quantum coherence occurring in quantum jumps. What this concretely means is that the initial quantum state, which is in general Fock state associated with single topological field quantum containing fermions and bosons, develops in time to a quantum superposition of states in which each fermion and boson resides at its own topological field quantum. This occurs already at the level of single quantum history. The occurrence of quantum jumps makes it possible to observe this since the sequence of quantum jumps increases the value of the psychological time of observer: sooner or later the final 'de-cohered' state consisting of topological field quanta representing elementary particles is observed. It should be emphasized that quantum jump selecting one space-time surface from the superposition of space-time surfaces representing final state many particle configurations is a genuine element of this process: quantum jump cannot be reduced to classical physics.

## 2.2 Bio-system as a topological condensate with several important space-time sheets

Topological condensate has hierarchical structure consisting of 3-surfaces with various sizes condensed on each other. In case of a bio-system several space-time sheet are expected to be important and to form a hierarchical information processing structure. Organic molecules belong to the lowest level of the hierarchy and correspond to 3-surfaces with outer boundary so that the association of the geometric form to molecules becomes much more than a convenient phenomenological modelling tool and leads to a new view concerning the understanding, say, the action of the organic catalysts. The topological condensation of the polymers to larger surfaces in turn gives rise to the formation of the cells, the topological condensation of the cells gives rise to the formation of the higher organs. In general, the vacuum quantum numbers tend to increase with the size of the structure.

p-Adic length scale hypothesis provides a precise quantitative formulation of the length scale hierarchy and predicts correctly several important biological length scales. In particular, the thicknesses for both the cell membrane consisting of two lipid layers and for the lipid layer appear in this hierarchy.

## 2.3 Topological field quantization and dark matter hierarchy

The realization that the unavoidable hierarchy of long ranged classical color and electro-weak gauge fields at various space-time sheets is a space-time correlate for an infinite dark matter hierarchy and a hierarchy of color and electro-weak physics characterized by a p-adic hierarchy of weak and confinement length scales [A1, F6, F8, F9, J6] means that ordinary elementary particles are only a tip of an iceberg. For instance, the scope of the term "supra current" in TGD context becomes much wider than originally believed to be.

One might illustrate TGD Universe as being analogous to a Mandelbrot fractal. Just as each zooming in of Mandelbrot fractal reveals new worlds, each zooming out of TGD Universe reveals

new universes for which the elementary particles of scaled down physics are lighter than at previous level and remain easily invisible for the previous level because the energies involved are so tiny. From the point of view of life and consciousness these subtle higher levels however represent the most essential aspects and we experience them directly.

Topological field quanta correspond to space-time correlates of particles at various levels of hierarchy. Wormhole contacts ( $\#$  contacts) discussed in [F6] and join along boundaries bonds ( $\#_B$  bonds) connecting boundaries of holes at different space-time sheets mediate interactions between space-time sheets.  $\#$  contacts can be modelled as  $CP_2$  type extremals with an Euclidian signature of induce metric glued to the two space-time sheets with Minkowskian signature of induced metric. Wormhole contacts are thus accompanied by two light-like causal horizons having identification a partons. Thus  $\#$  contacts represent an instance of an exotic dark matter residing simultaneously at two space-time sheets: this form of matter should be present in all length scales and could play decisive role in living matter [J5]. If the time orientations of two space-time sheets are opposite, these particles can have vanishing inertial energies. The splitting of  $\#$  contacts gives rise to dark particles at the two space-time sheets involved.

The finding that the dark matter component of even astrophysical systems could be macroscopically quantum coherent and determine the properties of the visible matter to a high degree [J6] forces to seriously consider the possibility that living matter is much more than what is caught by eye. In particular, the notion of field body as a key concept in the attempts to understand of living systems finds additional support. The grand vision is that it is the presence of macroscopically quantum coherent dark matter hierarchy which makes "dead" matter living. The first attempt to deduce implications of this vision can be found in [J6] and a more detailed view is discussed in [F9].

## 2.4 Topological field quantization and vacuum quantum numbers

Topological field quantization provides a TGD based first principle explanation for the emergence of the spatial structures. The size of the bio-structure depends on the vacuum quantum numbers [D7] and is dictated by the stability criteria implied by the minimization principle allowing to assign unique space-time surface to a given 3-surface, which is in general union of space-like 3-surfaces with time-like separations since the classical determinism in standard sense fails.

The hypothesis that bio-systems are super conductors in some sense implies that supra currents are a basic tool of the bio-control. The density of the charge carriers dictates the stable size and form of the organ and also the nontrivial phase information carried by the order parameter is expected to be important. There are handful of vacuum quantum numbers arising from the time and spatial behavior of the phase angles  $\phi_i$  associated with the two complex  $CP_2$  coordinates [D7]. One can express the dependence of these phase angles on space-time coordinates as a sum of Fourier expansion plus zero mode term linear in some coordinates and not allowing Fourier expansion. In linear Minkowski coordinates the vacuum quantum numbers behave like components of four-momentum. In spherical coordinates vacuum quantum numbers correspond to frequency, momentum in given direction plus integer analogous to the component of the angular momentum in the direction of momentum.

The set of vacuum quantum numbers associated with the two phase factors depends on the choice of the coordinates for  $M_+^4$  and  $CP_2$  and involves a selection of maximal number of mutually commuting observables in the Lie-algebras of Poincare group and color group. This is consistent with the fact that topological field quantization indeed is the classical counterpart of quantization. The construction of quantum TGD and understanding of the p-adic aspects of quantum TGD involves in an absolutely essential manner the choice of these quantization axes.

To fix the notation, the quantum numbers associated with the spherical coordinates will be denoted by  $(\omega_i, k_i, n_i)$ ,  $i = 1, 2$ . detailed definitions of vacuum quantum numbers reader should

consult the appendix of this book and [D7]. The first consequence is that given space-time sheet is characterized by two frequencies. A good guess is that the frequency difference associated with two space-time sheets connected by Josephson junctions corresponds directly to the voltage difference over Josephson junction:  $\Delta\omega_1 = ZeV$ .

## 2.5 Vacuum quantum numbers as carriers of biological information

The supra currents flowing in a closed loop of an organic polymer or of the brain nerve circuit depends linearly on the vacuum quantum numbers  $n_i$ ,  $i = 1, 2$  corresponding to the phase angles of the two complex  $CP_2$  coordinates. The values of  $n_i$  for closed loops provide a manner to store biological information and a model for the memory. The change of  $n_i$  in a closed loop is achieved by a phase slippage process creating a kink, that is a localized change of  $\Phi$  or  $\Psi$  by an integer multiple of  $4\pi$  or  $2\pi$  respectively, propagating in the loop. Associated with the kink is a localized supra current depending linearly on the integer  $n_1$ . Kink like supra currents provide a possible mechanism of the information processing at the bio-molecular level and at the level of the nerve cell, too. TGD based model of nerve pulse and EEG, to be described later, identifies nerve pulse as this kind of kink. The flux quanta are carriers of magnetic and  $Z^0$  magnetic fields and these fields provide a candidate for memory storage and information processing mechanism.

## 2.6 Super-canonical representations and quantum holograms

Peter Marcer [27, 29] has strongly advocated the idea that quantum holograms are crucial for the information processing in bio-systems. TGD leads to a similar vision. An almost universal manner to satisfy field equations at the boundaries of space-time sheets is to assume that boundaries are light like 3-surfaces. For massless extremals (MEs) this condition can be always satisfied [J4] and in this case also the  $M_+^4$  projections  $X^3$  of MEs are light like.  $X^3$  is completely analogous with the boundary of the future light cone and thus metrically two-dimensional. Therefore the cosmological super-conformal and super-canonical symmetries generalize. Fractality, the classical non-determinism of Kähler action, and quantum holography suggest that the construction of the configuration space geometry and quantum TGD can be in good approximation reduced to that in the sub-configuration spaces  $CH(X^3)$  consisting of 3-surfaces in spaces  $X^3 \times CP_2$  using super-conformal and super-canonical symmetries.

The boundaries of MEs are in many respects like moments of big bang and by general coordinate invariance the states restricted to the boundaries contain all relevant information about the physical state in the 'subcosmology' defined by 4-surfaces for which the  $M_+^4$  projection is ME. This is nothing but quantum hologram property. The classical lighlike vacuum currents which are non-deterministic at given point of ME correspond to classical aspects of quantum communication and actually define dynamical hologram in the classical sense. Super-canonical transformations do not commute with Poincare transformations but the non-commutativity is expected to be small and only due to gravitational interactions. Thus gigantic multiplets of super-canonical states with almost degenerate masses are predicted and are obviously ideal for representative purposes. Genuine quantum gravitational states in the space of 3-surfaces ('world of worlds') are in question and these states clearly represent higher abstraction level than ordinary physical states. Thus TGD seems to realize Marcer's vision in the sense that MEs would correspond to the highest and most abstract level of consciousness and intelligence in the self hierarchy. Genetic code would be analogous to read-only-memory burnt into the hardware and that most interesting and dominating information correspond to quantum holograms associated with MEs.

## 2.7 Many-sheeted space-time concept and living matter

The notion of many-sheeted space-time has several nontrivial implications. Many-sheeted space-time concept makes possible the transfer of particles between various space-time sheets. Since non-atomic space-time sheets are almost empty and couple weakly to atomic space-time sheets, this effect is expected to make possible effects like high  $T_c$  super-conductivity. The transfer of particles between two space-time sheets could also occur via possibly temporary join along boundaries of the (self) hierarchy. The quantum dynamical counterpart of this process are supra-currents and Josephson currents running along join along boundaries bonds serving as Josephson junctions.

1. The first implication is the possibility of many-sheeted ionic flow equilibrium for a circuitry involving both atomic (non-super-conducting) and super-conducting space-time sheets (magnetic flux tubes). In ionic flow equilibrium extremely small densities of super-conducting ions and magnetic space-time sheets can be amplified to much larger ion densities at atomic space-time sheets. The magnetic induction interaction between magnetic fields of MEs and ions in magnetic flux tubes (analogous to interaction of the weak magnetic fields of brain with SQUIDS) allows MEs to control the magnetic quantum numbers characterizing supra-currents and thus also the ion densities at the atomic space-time sheets. Ohmic currents on atomic space-time sheets require weak but coherent em fields and this provides a reason why for why bio-matter must be liquid crystal and electret. The DC circuitry discovered already by Becker [30] can be identified as the part of control circuitry associated with the atomic space-time sheets.
2. Josephson current serves effectively as a harmonic perturbation for the system formed by weakly coupled super conductors. If Josephson frequency corresponds to a difference for the energies associated with two states localized in either super conductor quantum jumps occurs leading to 'wake-up' of sub-self occur. Also magnetic interaction with ME at magnetic transition frequency can induce magnetic transitions. Parallel supra currents running in the weakly coupled super conductors could induce the resonant ion transfer. For instance, if the phases of the supra currents in the two super conductors are identical, constructive interference of Josephson currents associated with various junctions occurs. Josephson currents and resonant ion currents generated at critical Josephson frequencies might provide the royal road to the understanding of the quantum level coordination and control in the living systems [I4, I5].
3. p-Adic physics as physics of cognition suggests that real-p-adic phase transitions for space-time sheets give rise to the transformation of thoughts to actions and of sensory input to thoughts. The phase transition must conserve quantum numbers and this suggests that net quantum numbers must vanish for the space-time sheets created in these transitions: this is indeed possible. In TGD energy density is vector field rather than tensor. The time orientation of the space-time sheet need not always be the standard one. For a negative time orientation classical energy density is negative. Pairs of MEs or magnetic flux tubes (wormhole magnetic fields) of opposite time orientation and with vanishing net energy and momentum could transform between p-adic and real states.
4. Pairs of MEs make also possible "buy now, pay later" type energy production by generating negative energy space-time sheets. In the similar manner, effective generation of momentum becomes possible and the MEs with negative energy are optimal in this respect. Therefore the fundamental mechanism realizing "matter mind interaction" at the level of the space-time geometry could be in question. Bio-systems could also feed some fraction of their own gravitational flux to "nonstandard" space-time sheets and also channel part of the

gravitational flux of Earth to "nonstandard" space-time sheets. This ability might make bio-systems antigravity machines. At negative energy space-time sheets classical fields could propagate backwards in time. Together with the vision about entire space-time surface as a community of mind like space-time sheets, one ends up with the idea that communication from geometric future to past is possible (and that we are just now discovering it!).

Obviously the notion of many-sheeted space-time would have fantastic explanatory power in biology. Thus it is especially gratifying that the strange findings challenging the association of ionic channels and pumps to cell membrane [26] provide strong empirical support for the notion of many-sheeted space-time and for ionic super-conductivity at non-atomic space-time sheets. These findings will be discussed in [J3].

## 2.8 Self-referentiality and space-time topology

The notion of self-referentiality is one of the deepest and most fascinating notions of mathematics but for some reason it has not caught the full attention of physicists. I encountered the mystic variant of this notion during my 'great experience' (the idea about living system as a computer sitting at its own terminal) and a more mathematical variant of the idea for a year or two later while reading the book "Gödel, Escher, Bach" of Douglas Hofstadter. It took however more than fifteen years before I managed to identify a possible concrete realization of the notion in TGD based physics.

### 2.8.1 Does physical system provide a representation for a theory about physical system?

MEs and magnetic mirrors play a key role in TGD based model of living matter. The connection with standard chemistry has been however lacking. It seems that some deep principle is needed to build this connection. The hints about the big principle come from the following observations related to the topological field quantization implying what might be called Bohr orbitology for the classical fields.

1. TGD predicts the existence of negative energy space-time sheets, in particular MEs. The prediction is based solely on the assumption that the space-time is representable as a 4-surface.
2. One can understand gravitational binding energy only if negative energy MEs represent this energy. This suggests that binding energy of a system has a very concrete representation as a negative energy MEs.
3. Quantum entanglement has as a geometric correlate join along boundaries bonds, in particular MEs and possibly also magnetic mirrors. Only the entanglement associated with the bound states is stable against the state preparation process leading to a maximally unentangled state in each quantum jump.
4. Classical superposition for em fields could mimic quantum superposition for states. The multiples of the fundamental frequency for ME could represent the BE condensate of bosons with energy defined by the fundamental frequency  $f = c/L$ .
5. The phase increments of the  $CP_2$  coordinates around closed loops could represent phase increments of spinor fields and super-conducting order parameters around them as suggested in [D7].

6. Join along boundaries bonds can represent even half-odd integer spin topologically. The join along boundaries bonds connecting 3-surface to a larger 3-surface get entangled in  $2\pi$  rotation but in  $4\pi$  rotation no entanglement results : this is due to the fact that the bonds provide a representation for the homeotopy group of 3-dimensional rotation group. A good manner to visualize the situation is to think of a cube inside a larger cube with threads connecting the corresponding vertices of the cubes. An interesting question is whether also spin and statistics connection could be represented classically somehow.

These observations suggests a far-reaching generalization. Perhaps many-sheeted space-time allows the system to represent in its own structure the theory about itself. All theoretical concepts usually thought to have rather ethereal existence would have a concrete topological representation. These representations would exist already at the elementary particle level. Not only bio-molecules, but even hadrons, would be accompanied by a topological representation about their theory analogous to a written language. p-Adic-to-real transition would actualize this theory. Thus not only cognition but also symbolic representations of thoughts would be present in all length scales.

This idea of self-referentiality is actually an essential part of the basic philosophy of TGD. TGD inspired theory of consciousness implies that the Cartesian division to a world and theory about it is an illusion. Quantum histories, which are TGD counterparts for the solutions of field equations *are* the reality, there is no need to postulate any 'real' reality behind them since conscious experience is associated between quantum jumps between quantum histories rather than the 'real' reality. 'Ontogeny recapitulates phylogeny' principle states that quantum histories have geometric and topological correlates at space-time level. This is just what the idea about topological representation of a theory about the system as a part of the system itself means. System could consist of a hierarchy of levels such that  $N + 1$ :th level represents  $N$ :th level. Or perhaps more precisely, what results in the interaction of  $N$ :th level systems.

In atomic and molecular physics the basic implications would be following.

1. Atoms and bio-molecules would carry a representation about their own theory based on MEs. Since MEs carry light like four-momentum, they should appear as pairs of parallel MEs with opposite momenta and with frequency corresponding to one half of the binding energy:  $f = E_B/2$ . The frequencies associated with ME come as multiples of its fundamental frequency  $f = c/L$ ,  $L$  the length of ME. This dictates to a high degree the lengths of the MEs associated with a given binding energy. The most natural length corresponds to the wavelength defined by one half of the binding energy. In the spirit of Bohr orbitology justified by the absolute minimization of Kähler action, one can also require that ME pair has a classical energy equal to the binding energy: this requirement correlates the field strength and the thickness of the negative energy MEs.
2. Atomic binding energies would correspond to MEs with wavelengths in UV region. The binding energies of typical covalent bonds would give rise to MEs with lengths in wavelength region which corresponds to UV and visible light. The binding energies of hydrogen bonds in turn would give rise to MEs with lengths which correspond to wavelengths in the near infrared, cell size would be the typical length scale.
3. In the case of a potential well, such as the one associated with a harmonic oscillator or constant magnetic field, a natural representation would be in terms of positive energy ME allowing various harmonics. Vibrational and rotational frequencies would correspond to infrared and microwave region and magnetic energies to ELF region. The idea that these frequencies correspond to high level representations for the system is of course already now a basic element of TGD inspired theory of consciousness and conforms fully with the idea about topological self reference.

### 2.8.2 Possible biological implications of topological self reference

The notion of topological self-referentiality, if correct, means the possibility to combine enormous amount of knowledge from biochemistry to build a concrete view about em bodies of molecules and about how living matter represents itself in its own structure. One could also try to identify the chemical counterparts for the special frequencies predicted by the p-adic length scale hypothesis. One might even hope that one could at some level understand how such very high level phenomena like written language emerge from the topological self-referentiality. What is so interesting is that the hypothesis connects various length scales. For instance, the binding energies of atoms with nuclear charges  $Z \sim 10$  are in keV range and correspond to MEs with size of order nanometer. Perhaps even the structure of condensed matter is partly coded into the representation of the binding energies of atoms.

Some examples of the possible consequences in biological length scales deserve to be mentioned.

1. The many-sheeted structure associated with a molecule would provide a representation for the molecule identifiable as its electromagnetic signature introduced in the theories of homeopathy and water memory [K5]. And not only this: this structure would also serve as a 4-D dynamical hologram serving as a photograph-like template for the self-organization of matter around the molecule. This would mean effective reductionism, but obviously only effective.
2. Genetic code would be a highly developed form of this representation. It would involve the negative energy MEs associated with various atomic and molecular binding energies. Especially important negative energy MEs would be in the visible region and associated with the covalent bonds and in the near infrared associated with the hydrogen bonds connecting DNA nucleotides together. Also the MEs associated with rotational and vibrational degrees of freedom are expected to be very important and for them liquid crystal blocks of water could serve as mimickers and amplifiers. The transparency of water to visible frequencies (covalent bonds have energies 4.7 eV in UV region) means that water is an ideal medium in the visible region for communications by MEs since coherent visible light can propagate long distances with attenuation caused only by the absorption by bio-molecules.

This picture gives a justification for the suggestion of Peter Gariaev that DNA is accompanied by laser mirror pairs [29]. The negative energy ME pairs associated with various binding energies would correspond to the laser mirror pairs. This picture differs slightly from the earlier proposal for the realization of genetic code involving orthogonal pairs of MEs associated with each nucleotide giving rise to 4 different pairs of polarizations and suggests a simpler realization in which the four polarization pairs associated with a pair of parallel MEs would realize the genetic code in a given length scale.

Topological self-referentiality allows also to understand what happens in overunity energy production and these insights might be also crucial for the understanding of how life has evolved as a parallel development of macroscopic quantum bound states and the ability to metabolize. The components of the system can bind mutually or with the environment and negative energy space-time sheets represent binding energy. Bound state energy is liberated as a usable energy. The resulting bound states have entanglement irreducible under state function preparation process: this makes possible fusion of sub-selves to larger sub-selves. The bound states correspond to space-time sheets having typical sizes given by the p-adic length scale hypothesis and the process means basically space-time engineering. The typical wavelength of the radiation emitted in the process gives estimate for the electromagnetic or gravitational size of the bound state. In ELF frequency range the electromagnetic size is of order Earth size. Electrolytic processes are especially interesting from the point of view of over unity energy production.

For instance, the production of hydrogen molecules in the electrolysis of water might be accompanied by the formation of large bound states of water molecules and the liberation of the

binding energy as a usable energy. The signature for the process is simple: the energy liberated is larger than the energy deduced from the binding energies of water and hydrogen molecules. Rather interestingly, the hydrogen bond energy deduced from the evaporation energy per water molecule is .485 eV and is very near to the photon energy  $E(167) = .4844$  eV corresponding to p-adic length scale  $L(167) = 256L(151)$  for  $L(151) = 10$  nm:  $k = 167$  is one of the four subsequent p-adic length scales  $k = 151, 157, 163, 167$  which correspond to Gaussian Mersennes. Perhaps cold fusion involves both the nuclear fusion by Trojan horse mechanism and the formation of large scale bound states. Biology provides an important area of applications and the model of bio-photons developed in [K5] leads to a concrete model for the generation of pairs of positive and negative energy MEs at DNA level. Bio-molecules and cells are indeed bound states of macroscopic size.

The first form of life evolved under conditions in which electrolytic processes occurred: perhaps bound state formation led to the generation of bio-molecules and cells. What is nice that the development of long range order (negative energy MEs) would have been automatically accompanied by the development of metabolism (positive energy MEs!). Sol-gel transition crucial for the cellular locomotion is a particular example of this process. Thus a natural path to follow in the attempts to build new energy technologies is to try to mimic what living nature has already achieved. This kind of energy production would be also wasteless and support evolution. Quantum spin glass analogy means that Kähler action has an enormous almost ground state degeneracy and only classical gravitational energy differentiates between different ground states. Thus the classical gravitational binding and also the generation of coherent gravitons by MEs might have a role to play in the quantum physics of living matter. A rough order of magnitude estimate for the gravitational binding energy for a blob of water having size  $L(k)$  is

$$E_{gr} \sim \frac{GM^2}{L(k)} = G\rho^2 L(k)^5 \sim \frac{Gm_p^2}{L(137)} \frac{L(k)}{L(137)^5} \simeq 2^{-127} 2^{5/2(k-137)} \frac{1}{L(137)} .$$

Gravitational binding energy is larger than the p-adic energy  $\pi/L(k)$  for  $L(k = 179) \simeq .169$  mm. In the range  $L(163) = 640$  nm and  $L(167) = 2.56 \mu m$  gravitational binding frequency varies between 1 Hz and 1 kHz, that is over EEG range up to the maximal frequency of nerve pulses. For  $k = 157$  and  $k = 151$  the gravitational binding frequency corresponds to a time scale of 9 hours and 100 years respectively so that the time scales relevant for life are spanned by the Gaussian Mersennes. Perhaps gravitonic MEs carrying vanishing em fields accompany the basic building blocks of the cell. Neither the connection with EEG is excluded.

### 3 Realization of the lower levels of biological self hierarchy

An 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. In the following the lowest levels of the hierarchy are discussed.

#### 3.1 General ideas about biological self hierarchy

Neurons are only one level of selves in the biological self 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 micro-tubuli 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. One can (with tongue slightly in cheek) wonder whether they have achieved in meditation the level of DNA selves and recognized its presence clearly? In [L1] a very simple model of abstraction process reproducing the

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

### 3.2 Criteria for being biologically significant self

The biologically relevant selves might be distinguished as selves able to stay awake for sufficiently many quantum jumps. Possible additional criteria are following.

1. Self corresponds geometrically to a system with a well defined inside and outside. In standard physics context this requirement looks too strong. For instance, it is questionable whether DNA satisfies this requirement in standard physics framework. In TGD framework inside-outside decomposition is satisfied if system corresponds to a separate space-time sheet. Presumably DNA and proteins satisfy this criterion.
2. The effect of anesthetics on self candidate must affect also our consciousness. In TGD framework loss of sub-selves at any level affects the experience at the higher levels so that this criterion is sensible.
3. The behavior of self candidates should show responsiveness and adaptivity. Selves should demonstrate the ability to control their own structure or the structure or behavior of the structure to which they belong. These abilities would follow from the ability of self to quantum self-organize. For instance, in case of proteins the allowed protein foldings could be regarded as fixed states of self-organization by quantum jumps.
4. The exponent of the Kähler action provides measure for the cognitive level of the subsystem measured as the number of degenerate space-time surfaces associated with given 3-surface. Thus the presence of strong Kähler electric fields is a good signature for the presence of cognition. Polar molecules (say proteins) are thus good candidates for systems containing selves.
5. Self candidates should be able to communicate. One possible means of communication is proton conduction in ordered water associated with the structure. Second means of communication are dipole oscillations: this requires that structures in question are polar. Wormhole BE condensate and coherent photons provide TGD based means of communication. Also electrons 'dropped' on larger space-time sheets provide make possible this kind of communication.
6. There exist irreducible selves containing no sub-selves. Irreducible selves are thus "elementary particles" of consciousness. This slightly "romantic" criterion is motivated more by my particle physicist background and should be only taken as an attractive candidate for a rule of game.

### 3.3 Possible interpretation for the system formed by DNA and proteins

In [H7] it was proposed that DNA and proteins could form a physical representation for so called formal systems [16] formalizing arithmetic systems to a set of symbols and rules for manipulating them. DNA sequences represent possible special cases of theorems represented by amino acid sequences and genetic code is mapping determined which are the special cases corresponding

to given theorem. The larger structure formed from proteins correspond to statements about statements. This suggests that proteins and higher level structures formed from them forming self hierarchy give meaning to the theorems represented by amino-acid sequences.

The modelling of DNA and protein interactions is based on chemical kinematics which is basically a statistical model for the time development by quantum jumps occurring at the level of individual chemical compounds.

This requires that DNA and proteins participating the chemical reaction form entangled subsystems of some self and that quantum jumps leads to states in which reaction products become are unentangled subsystems, possibly selves which stay awake for some time. This argument only requires that some larger system containing DNA and proteins is in self state. This system could be some cell organelle, nucleus for DNA replication to mRNA and ribosome for the translation of mRNA to to proteins. In this picture the magical looking processes of biochemistry (replication of DNA, translation of DNA sequences to protein molecules) could be understood as fixed points of quantum self-organization resulting from a sequence of quantum jumps. For a wake-up time of order  $10^{-10}$  seconds this would mean  $10^{30}$  quantum jumps during single wave-up period of self. Therefore the precise determinism of DNA replication and translation could be perhaps understood as processes completely analogous to the formation of convective pattern in Benard flow. Final state would only depend on the macroscopic parameters the self containing the reactants (pH, temperature, electric fields).

This picture allows a realization of self hierarchy in which the fraction of time (quantum jumps) spent in self state increases with the size of the self. Natural guess is that this time scales as the size of the system. Wake-up time of  $10^{-10}$  second in protein length scale would give time of order second in the length scale of meter which look rather sensible result. In the following a first guess for self hierarchy based on some general criteria is proposed.

### 3.4 Proteins as selves and protein folding

Proteins are good candidates for building blocks of self-hierarchy for several reasons.

1. Proteins are known to react sensitively to what happens in the surrounding world by changing their conformation.
2. Individual proteins are characterized by a huge number of enfoldings and one of the mysteries of biophysics is to understand what determines the few allowed configurations that are actually realized (self-organization by quantum jumps and spin glass analogy might help to solve protein enfolding problem as suggested in [11]).
3. Proteins are polar molecules and form electrets. This is in accordance with the fact that electric field serve as a measure for cognitive resources. Already Fröhlich suggested that electret property is crucial for life. Proteins contain both hydrophilic polar parts and hydrophobic residues. The enfolding of proteins creates "dry" pockets in which hydrophobic residues of the proteins point inward so that one can speak of inside-outside distinction. It is not however clear whether one cannot regard protein pockets as selves having sufficiently long lifetime. Protein folding seems to however require that protein cannot be irreducible self but decomposes in quantum jumps to subsystem and its complement. How long times subsystems created in this manner can spend in self state is an open question.
4. There are speculations that these pockets could form the "brain" of protein. The states of this tiny brain would corresponds to the conformations of hydrophobic residues inside pocket. The motivation is that anaesthetics seem to act on the electrons associated with the pockets and reduce their motility.

In TGD framework one could understand the ability of protein to control its conformation as resulting from the interaction between the electrons in the pockets with the wormhole BE condensate associated with the boundaries of the protein. In quantum jumps electrons could be entangled with the conformations of proteins and quantum jump would select one conformation. The loss of electron mobility by interaction with anesthetics leads to the loss of protein self or at least the ability of protein to control its motions by quantum jumps. It seems however unnecessary to assume that electron or hydrophobic pockets behaves as a self.

5. Proteins are typically surrounded by ordered water and proton conduction makes possible communication. The dipole oscillations associated with the polar bonds of proteins provide a second communication mechanism. Wormhole BE condensate and coherent photons provide additional purely TGD based communication mechanisms. Also electrons dropped to non-atomic space-time sheet could provide a new conduction mechanism.

Protein folding is one of the mysteries of biology and provides direct justification for the hypothesis that proteins has self. The duration of the self of average protein having length of order  $10^{-7}$  meters is about  $10^{-15}$  seconds: this time scale corresponds to the wavelength of visible light. The assumption that protein can be in self state resolves the mystery of protein folding [I1]. The self-organization occurring inside protein self leads unavoidably to a bottom of some deep valley in the energy landscape of the protein representing the values of Kähler function for various protein conformations. Dissipation associated with self-organization by quantum jumps selects the final pattern of self-organization determined by external parameters like pH and temperature and with very slight dependence on initial conformation.

### 3.5 Larger selves formed by proteins

The larger structures formed by proteins give rise to the next level of the self hierarchy. The basic hydrophobic-hydrophilic splitting of the protein personality implies that proteins dissolved in water form very rich structures. Typically bi-layered structures, micelles, for which hydrophobic residues point inwards, are formed. Hollow cylinders, spheres and disks are possible. Micelles self-organize further to form liquid crystal phases. The end result of self-assembly depends on the pH, ionic concentrations and temperature of as well as electric fields in the surrounding water. Rather general belief is that the dipole oscillations of proteins could be the Bose-Einstein condensate relevant for bio-consciousness. TGD framework suggest that the Bose-Einstein condensate of charged wormholes located on boundaries of tubulin dimers is one relevant BE condensate: the charge density of the wormholes is in fact equal to the normal component of electric field on boundary. The completely new element is the presence of phase of the wormhole order parameter mathematically analogous to order parameter of super-conductor. One can say that wormholes are the square root of the dipole condensate of Fröhlich.

#### 3.5.1 Micro-tubuli

Protein molecules arrange into several, typically linear structures. The cytoskeleton is formed by micro-tubuli [20, 21]. They consist of hollow cylinders formed as a lattice like structure of tubulin dimers. Tubulin dimer consists of two tubulin isomers,  $\alpha$ - and  $\beta$ -tubulin. Second tubulin isomer contains attached  $Ca^{++}$  ion and second isomer contains two electrons, the other one being in the region intermediate to the isomers. Therefore tubulins are polarized. The region, where the tubulins of individual tubulin dimer join together, contains an electron. Tubuline dimers have at least two basic conformations and give rise to two different polarization states. Quantum jumps of the electron in the hydrophobic pocket are believed to induce jumps between the two conformations.

anesthetics are known induce anaesthesia by affecting the mobility of these electrons. The relevant interaction is presumably van-der-Waals interaction since even noble gases are known to act as anesthetics [20].

An important question is whether the tubulin isomers are sub-selves of micro-tubule or not. The crucial question is whether tubulin isomers have mutual join along boundaries contacts. Join along boundaries contacts carry magnetic or electric fluxes and this would require magnetic or electric polarization of tubulins joined by the join along boundaries bond. Tubulins have only van der-Waals type interactions induced by the induced dipole-moments. This suggests that join along boundaries bonds are not present. The important conclusion is that tubulins are excellent candidates for selves and the mental life of micro-tubule can be very obviously very rich. The two conformations corresponding to two different polarization states of the tubulin would give a rough characterization for the mental state of single tubulin.

The lattice formed by polarized tubulin dimers can be regarded as a spin lattice like structure. The first phase corresponds to randomly oriented dipoles. This phase is ideal for communication since arbitrary message can be conveyed. Second case corresponds to spin glass like phase with groups of neighboring dipoles are in same orientation. This phase is ideal for computational activities since the configurations are temporally stable and memory storage becomes possible. The third case correspond to ferro-electret phase with all dipoles having same orientation.

If tubulin isomers are selves, they are rather simple selves having perhaps only two basic mental states corresponding to two different tubulin conformations. The mental state of micro-tubule self is "sum" of the tubulin selves and experienced by the micro-tubule as separate mental images. This if entanglement between tubulins is absent. In this manner the mental state of the micro-tubule could perhaps be interpreted as representing a binary sequence. Even the interpretation as a conscious computer could be considered. The mental states of the micro-tubule self would correspond to time developments of the tubulin conformations starting from the last moment of wake-up. Conformational waves propagating along micro-tubule, suggested also in [21] to correspond to fundamental mental images, would give rise to very rich repertoire of micro-tubular experiences. Thus anesthetics reducing the mobility of electrons in hydrophobic pockets should have a dramatic effect also on "our" consciousness.

### 3.5.2 Cell membranes

Cell membranes are basic example of a structure formed by two lipid layers such that the hydrophobic residues point inwards. The region between the lipid layers could perhaps be regarded as forming "cell membrane self". The hydrophobic tails of lipids point inwards. Unless the lipids contain hydrophobic pockets, there are no candidates for sufficiently long lived lower-level selves. Thus cell membranes could perhaps in good approximation be regarded "irreducible selves" having no mental images.

Cell is full of endoplasmic membranes and contains also cell organelles like nucleus surrounded by similar membranes. All these membranes are good candidates for material counterparts of selves if the proposed criteria are accepted. One possibly relevant macroscopic quantum phase is now the BE condensate of wormholes [J5].

### 3.5.3 Larger structures

1. Protein collagen is the main component of the connective tissue in living systems. According to observations of Mae-Wan Ho [22], collagen forms liquid crystalline mesophases extending through the entire body. This encourages the conjecture that collagen fibres, which could be regarded as a scaled up version of cytoskeleton formed by micro-tubuli, could form one level in the self hierarchy. Mae-Wan Ho has indeed suggested that this structure is the seat of body-consciousness [22].

2. Entire cells, having clear inside-outside separation, are good candidates for selves and the superpositions of mental images of micro-tubuli would be part of the content of conscious experience of “cell self”. The binary structure of micro-tubuli indeed makes possible very large number of different mental states even in the case that the contents of the cellular conscious experience reduces to the conformational dynamics of tubulins.
3. The two cell layers in epithelial sheets form a structure, which is much like a scaled up version of the cell membrane. Bio-systems are full of these structures: both skin, organs and the nuclei of brain are surrounded by epithelial sheets. In TGD based model for bio-consciousness “our” consciousness is assigned with the structures formed by epithelial sheets.
4. Brain contains also larger bi-layered structures, which seem to correspond to twin integers  $k$  and  $k + 2$  such that  $p \simeq 2^k$ ,  $k$  power of prime is p-adic prime. These structures could give rise to even higher levels of consciousness. One possibility is that the hierarchy sensory-emotional-cognitive corresponds to p-adic length scale hierarchy, perhaps  $k = 169, 173, 179$ . Also the level  $k = 181$  could be present and correspond to highest levels cognition. Cell layers forming ocular dominance columns correspond to  $k = 179$  whereas  $k = 181$  corresponds the combination of visual fields to stereo vision. This suggests that  $k = 181$  combines the experiences of left and half brain to single experience.

### 3.6 Identifying our sensory sub-selves in p-adic length scale hierarchy

The synchronous firing of neurons would mean the ‘waking up’ of quantum critical neuronal selves in a cascade like manner (think of fox perceived by a crowd of hens sleeping initially!). The receipt of a nerve pulse would wake up neuron. Perhaps neurons inside synchronously firing neuron groups of both hemispheres have small real entanglement slightly above the critical value for wake-up so that small perturbation is needed for wake-up. In this case neuronal self creation would not involve any quantum jump.

The nature of cognitive act depends on the type of the quantum entanglement involved as well as on the nature of wake-up process. The richness of structure associated with dark matter hierarchy implies that very many combinations are possible for cognitive cascades possessing several levels and at this stage one can only speculate. TGD based model for thoughts is based on “cognitive neutrino pairs” consisting of dark neutrinos as giving realization for Boolean algebra. The density of dark neutrinos is predicted to be very low in p-adic length scales much larger than  $L(169) \simeq 5 \mu\text{m}$  (two times cell size roughly). The defects of dark neutrino super conductor could define representations of thoughts and in the simplest model the macroscopic quantum phases formed by  $Z^0$  magnetized antineutrons at the cell membrane space-time sheet give rise to symbolic representations of thoughts.

If the levels of self hierarchy correspond to p-adic space-time sheets and dark neutrinos are present at all levels, thoughts cannot involve too many hierarchy levels. In the model of cell membranes as defects of dark neutrino super conductor, the relevant p-adic length scales correspond to  $k = 169$  and  $k = 151$ . If dark neutrino super conductor can however form defects also at levels  $k = 167, 163, 157$ , then hierarchies with four levels are possible (sentences, words, syllables, phonemes?).

Direct support for the idea that the components of our conscious experience correspond to sub-selves comes from the phenomenon of after mental images. For instance, by looking at bright light source and closing eyes, one can experience periodically emerging after images changing their color. Phenomenon is actually much more general: all our mental images tend to occur periodically. A natural explanation is in terms of a periodic wake-up of the sub-selves representing these mental images. Even we are periodically occurring mental images of some high level self if the hierarchy of selves exists: there would be no deep difference between thinker and thought!

One could wonder how many cognitive sub-selves (mental images) we typically have.  $7 \pm 2$  rule of psychology states that we can typically classify things into this number of different categories unless we use auxiliary tools. For instance, the number of digits in phone number is typically 7 for this reason. During intense concentration the number of categories is smaller and can reduce to only one. This would suggest that the number of cognitive sub-selves is typically  $7 \pm 2$ : of course, also other kinds of selves, such as bodily self, can exist simultaneously.

Good candidates for *our* sub-selves are structures bounded by epithelial sheets bounding various structures. Our body is full of these structures: skin, various organs and various brain nuclei, especially hypothalamus, hippocampus and reticular formation [20] are examples of these structures. The seats of the primary sensory experiences should contain primary sensory organs. Hippocampus is crucial for laying down of the long term memories and this suggests that hippocampus can quantum entangle with higher level selves having long range memories as subjective memories. Limbic brain and hypothalamus are often regarded as the seat of emotions and the simplest hypothesis is that limbic brain is the seat of emotional consciousness which involves the comparison of the geometric memories with subjective memories. The damage of the reticular formation, which is the oldest and the most primitive part of the brain, implies unconscious state (at least using the generally accepted criteria for consciousness). Since reticular formation is not active during dreams, also the other parts of brain must have the ability to perform quantum jumps so that the sometimes heard claim that reticular formation is the seat of consciousness is incorrect. Various sensory homunculi in brain are good candidates for sub-selves performing higher level processing of the sensory information (pattern recognition, novelty detection,...).

An interesting question is what subconscious activity as opposed to unconscious activity might mean: one might think that this kind of activity is conscious activity of some self at the same level of self hierarchy as 'our self'. Perhaps Zombi within us type phenomena such as blind sight correspond to activities of this kind of parallel self perhaps identifiable as body with sensory organs acting as primary sensory experiencers. Could drives correspond to the desires of limbic brain or higher level selves? Could association cortex or even society correspond to the desires of 'superego'? Could the splitting of the personality correspond to the presence of a too large number of parallel 'our-selves' and having conflicting desires and plans? Or is poor communication between 'our-selves' the problem. It has indeed been found that the hemispheres of the split brain subjects are separately conscious [20]. The 'collective unconscious' of Jung, on the contrary, might correspond to larger self, say, the whole society or even bio-system.

### 3.7 Hardware for body consciousness

The great challenge is to identify the hardware for the self hierarchy. The ideas of Mae-Wan Ho and her colleagues [22, 23, 24, 25] seem to be on right track in this respect. Mae-Wan Ho has suggested that collagen network of body gives rise to body-consciousness understood to be something different from brain consciousness under usual conditions. This hypothesis indeed seems natural also from TGD point of view.

#### 3.7.1 Liquid crystals

Liquid crystals (for excellent introduction see [17] containing online text book about liquid crystals) can be regarded as mesophases: phases which are intermediate between solid crystal phase and liquid phase. Large class of crystals indeed appears in narrow temperature range between crystallization and melting.

The molecules able to form liquid crystals must be nonsymmetric under rotations. Typically rod like or disc like molecules are in question. The detailed structure of the molecule does not matter: typically only length-to-thickness ratio is what characterizes liquid crystals. Liquid crystal

molecules contain also rigid polarizable part. Permanent dipole moment does not seem to be essential for liquid crystallinity.

Liquid crystals allow two basic phases. In nematic phases there is long range orientational order but translational order is lost. In smectic phases translational order is present in single direction and liquid crystal behaves like liquid orthogonal directions and has layer-like structure. Each layer behaves like two dimensional liquid. Molecules in each layer have definite average direction which can vary from layer to layer. If liquid molecules are chiral, the orientation of the molecules in layers can rotate helically.

The liquid crystals formed by collagen forms are lyotropic liquid crystals. Lyotropic liquid crystals are formed by amphiphilic molecules, surfactants, in polar solvent, say water. Amphiphilic molecules have hydrophilic and hydrophobic parts. Above critical concentration surfactant molecules form micelles, which are hollow spherical, cylindrical or disk like structures such that the hydrophobic residues point in interior and hydrophilic residues form hydrogen bonds with surrounding water. The liquid crystals in question can be electrets. In smectic phase, the direction of spontaneously generated electric field is parallel to the layer formed by micelles. Micelles themselves can have spontaneous polarization. Cell membrane is biologically important example of a polarized spherical micelle formed by lipids of cell membrane in which hydrophobic lipid tails point inwards.

Micelles, rather than molecules are building blocks of nematic and smectic phases which are formed when concentration is further increased. The formation of micelles and nematic and smectic phases occurs via self-assembly and could be regarded in TGD framework as quantum self-organization process. The result of self-assembly is sensitive to pH and ionic concentrations of water, to temperature and hydration of water and to external electric fields.

Both micro-tubuli and collagen can be regarded as examples of liquid crystals. There are many kinds of collagens. All share a general repeating sequence of the tri-peptide (X-Y-glycine), where X and Y are usually proline or hydroxyproline. They also have in common a molecular structure in which three polypeptide chains are wound around one another in a triple helix [23]. In case of collagen liquid crystal micelles are long cylindrical structures, fibrils and these in turn organized to fibers with thickness of 1-20 micrometers [23]. Cells can be regarded as micelles and therefore the layered structures formed by cells could also be regarded as liquid crystals. Epithelial sheets could perhaps be regarded as higher level micelle.

### 3.7.2 Living organisms as liquid crystals?

The book "The Rainbow and the Worm" of Mae-Wan Ho [22] represents empirical support for the concept of body consciousness. The lecture talk of Mae-Wan Ho [23] gives brief summary and references to the work by her and her colleagues. There are very simple observations supporting the notion of body consciousness.

1. Oscillations in olfactory bulb and in brain are in phase with the movement of lungs. Also the coordinated movement of four limbs in locomotion is accompanied by patters of activity in motor centres of brain which are in phase with locomotion. It is very difficult to understand how this could be possible if brain would be only a central unit organizing these movements. Lags of order one second would be expected. Rather, it seems that brain and body work as a coherent unit.
2. Hydra and sea anemone, which have no nervous system, contract very rapidly when one of tentacles is touched. This suggests that consciousness is not a property of only nervous system but present already at the cell and body level.

Mae-Wan Ho [22, 23] suggests the identification of the hardware of body consciousness as collagenous liquid crystalline mesophase [25] associated with the connective tissue present everywhere

in the body. Collagen is the most common protein of body and gives rise to a mechano-electrical network making possible for the parts of body to act as a coherent whole.

1. Collagen is a good conductor of electricity. The conduction mechanism is proton jump conduction in the ordered water associated with the collagen. Proton jump conduction is much faster than nerve conduction. The conductivity increases by addition of water when the amount of absorbed water is 10-30 per cent of total weight. The maximum increase occurs at body temperature.
2. Collagen forms mechanical network having connection with intracellular matrices through proteins located on cell membranes. Collagenous network, being liquid crystal, is characterized by the local orientation of the fibrous structures. For instance, in skin the alignment is due to stresses and strains during growth. Similar oriented fibrous structures are present in bones and cartilages. The hydrogen bonded water associated with the collagenous fibres makes this network also a electrical network having connections with the intracellular structures. These properties make collagen network an electro-mechanical network making possible intercommunication and responsiveness.
3. Proteins in liquid crystals have coherent motions constrained strongly by the fibrillar structure. These mechanical motions involve vibrational deformations of protein bonds accompanied by polarization waves coupling to proton conduction. Very weak, mechanical, electrical and thermal signals are amplified and propagate as modulation of proton currents or coherent polarization waves. Metabolic pumping of energy is probably involved.
4. Acupuncture system is known to have rather interesting manifestations. For instance, the stimulation of an acupoint in little toe leads to a similar activity in visual cortex as flash of light [31]. This cannot be explained in terms of standard neuroscience. Stimulation of acupuncture points can produced local anesthesia. Thus acupuncture points and meridians might be closely related to body-consciousness.
5. Becker discovered the so-called body DC electric fields [30, 32] are of central importance for consciousness. Becker found that general anesthetics attenuate the DC field completely. Sleep state can be induced by manipulating these fields using external currents. Becker also observed that during a perceptive event local changes in body the DC field can be measured half as second before the arrival of the sensory signals in the brain. There is also evidence that anesthetics act by replacing and releasing bound water from proteins and membrane interfaces. It is known that patients under general anaesthesia can regain brain consciousness with accompanying experience of pain. On the other hand, local anesthesia by acupuncture has been applied to patients who are fully awake. Acupuncture points are known to exhibit low electrical resistances as compared to the surrounding skin and could be juncture points of this network. Mae-Wan Ho suggests that collagen network, body DC fields and acupuncture system are closely related. Conduction channels could be associated with the fibrous structures formed by collagen, most probably the bound water in collagen fibres would serve as electric conductor.
6. One of the basic mysteries of living systems is their ability to move coherently. Some miraculous mechanism making it possible to transform energy to coherent energy must be in use. Otherwise the energy of metabolism would go to an disordered molecular motion and no macroscopic motion would be possible. Mae-Wan Ho also introduces the concept of coherent energy [23], which is the counterpart of “qi” in ancient Chinese medicine. For instance, coherent energy could correspond to collective motion in which momenta of particles are in same direction. Bio-systems seem to have ability to store fraction of incoming energy flux as coherent energy. This is not in contradiction with the second law of thermodynamics if the

necessary dissipation occurs outside the bio-system or in some part of special part it. What is difficult to understand in the framework of standard physics is how bio-systems could so cleverly circumvent second law of thermodynamics.

### 3.7.3 TGD based view about living systems as liquid crystals

Protein molecules able to form micelles and crystals seem to be ideal candidate for realizing self hierarchy physically.

1. Liquid crystals are in a well defined sense critical phenomenon. This is in concordance with the idea that bio-systems are quantum critical systems.
2. The independence of the properties of the liquid crystal on the detailed shape of molecule is in accordance with idea that liquid crystal phase must be assigned to some non-atomic space-time sheet at which molecule is represented by the distribution of the wormhole contacts on the boundary of the molecule. Lyotropic liquid crystals are simple in the sense that micelles are basic building blocks with very simple geometry. Note that collagen proteins, micelles formed by them and liquid crystals formed in turn by them form naturally a hierarchy, perhaps identifiable as self hierarchy.
3. Liquid crystal assembly are sensitive to external electric fields, pH and ionic strengths. Also this supports the picture based on interaction between charged wormholes a proper description for the interaction between basic units of liquid crystal. For pure water pH determines the density of the water molecules on the boundary of 3-surface containing water molecules ( $pH = -\log(H_+)$ ,  $pH + POH = 14$ ). This is in accordance with the interaction between proteins occurs indeed via the classical em fields associated with wormholes on the boundaries of proteins. Note that as proteins contain peptide bonds which are polar. These polar bonds could involve wormhole contacts making possible amplification of the electric field in the direction of bond. There must be a compensating electric field on the larger space-time sheet.
4. Lyotropic liquid crystals seem to be ideal as far as consciousness is considered.
  - i) The hierarchy formed by proteins, micelles formed by them, and liquid crystals formed in turn by the micelles, could be interpreted as par of the physical realization of self hierarchy. At the lowest level are hydrophobic pockets of proteins and at the highest level collagen structures and organs formed by the cell layers.
  - ii) If one believes on the hypothesis that Kähler action provides an entropy type measure for cognitive resources, then the presence of electric fields and spontaneous polarization can be regarded as advantageous from the point of view of cognitive consciousness.

#### 1. First vision about liquid crystals and consciousness

The proposals of Mae-Wan Ho are restricted to the framework of the classical physics and, even if of crucial importance, might not be enough to allow understanding of body as a macroscopic quantum system. TGD suggest a more radical views about the role of collagen network, DC fields and acupuncture system in making possible body consciousness. The first vision developed for few years ago (my now corresponds to year 2001) is following.

1. In TGD one can understand the coherence of bio-system in terms of the classical coherence resulting from connectedness of appropriate 3-surfaces made possible by join along boundaries contacts (“massless extremals”) in turn implying quantum coherence. Classical connectedness is quantum correlate for quantum coherence making possible subsystems to quantum

entangle. Note that the concept of 3-surface is something totally new from point of view of standard physics were the modelling of the macroscopic structures is based on completely ad hoc assumption about their existence.

2. Liquid crystals look in short length scales like ordinary crystals behaving like single macroscopic unit. This behavior is something totally different of that of ordinary dissipating systems. A possible interpretation is that these units are irreducible selves and, being in a state of whole-body consciousness, do not dissipate in the usual manner. Thus body would consist of parts spending considerable fraction of time in a state of whole-body consciousness. If these regions belong to same level of self-hierarchy, they do not know about each other. "Brain self" knows nothing about "heart self".
3. The observations of Becker [30] about the role of the electric fields in consciousness fit nicely with the TGD based hypothesis that the negative of Kähler function measures gives entropy type measure for the cognitive resources of the 3-surface. Exponent of Kahler action gives essentially the number of absolute minima of Kähler action going through given 3-surface. The generation of Kähler electric fields is a basic manner to increase cognitive resources. In light of this one can understand why cell membranes carry huge electric fields and why body DC fields, perhaps associated with the epithelial sheets consisting of two cell layers, are fundamental for our consciousness.
4. p-Adic fractality and many-sheeted space-time concept lead to the idea that epithelial sheets consisting of two cell layers could give rise to a scaled up version of nervous system. The basic phenomena would be periodic collective oscillations and propagating solitons in the Josephson junctions formed by the cell layers of the epithelial sheets. The electro-chemical shadows of these phenomena could be different from those in case of ordinary nerve pulse and EEG. Liquid crystals [17] are typically electrets consisting of layered structures having electric fields in the transversal direction of the symmetry axis. DC fields could correspond to longitudinal electric fields associated with collagenous fibres and in direction of the fibres.
5. TGD suggests new physics mechanism realizing the notion of coherent energy purely classically. An interesting possibility is that the generation of "massless extremals" with net momentum basically generates the volitional macroscopic coherent motion in living systems. The properties of the collagen network might make it possible to "buy now and pay later" and also provide guarantee for the payment. Payment would mean that the negative energy massless extremal is absorbed by living system itself or surrounding world. Most naturally this absorption occurs when the motion of part of organism ceases. At this moment organism must be able pay back the energy gain. Thus metabolism would be needed to stop the motion rather than to initiate it! The only sensible interpretation is that stopping occurs automatically and is forced by the classical field equations.

An interesting question is whether non-volitional phenomena like heart beat involve emission of the negative energy massless extremals. The emission could indeed be purely classical process. Of course, heartbeat could be non-volitional only from the point of view point of "brain self". There could be "heart self" making decision about each heart beat!

## *2. Second vision about liquid crystals and consciousness*

The first reason why for liquid crystals involves rather general arguments. The notion of many-sheeted ionic flow equilibrium allows much more precise argument catching what seems to be quintessential for bio-control. Liquid crystals allow weak but coherent electric fields making possible ohmic currents at atomic space-time sheets which together with the magnetic super current circuitry could form many-sheeted quantum control circuitry which in ionic flow equilibrium amplifies very small densities of ions at super-conducting magnetic flux tubes to much higher densities of

ions at the atomic space-time sheets. MEs could induce various quantum transitions of ions (perhaps also molecules like enzymes) at magnetic flux tubes in quantum coherent manner and even amplify them to quantum phase transitions. This would make possible very effective biochemical control. Body consciousness could be assigned with the magnetic flux tube circuitry and magnetic quantum phase transitions whereas higher level consciousness would correspond to quantum transitions of super-canonical representations assignable to the boundaries of MEs. The difference would be that magnetic states reduce to states defined in 3-surface whereas super-canonical states are genuine quantum gravitational states defined in the space of 3-surfaces: thus body consciousness and 'our' consciousness would correspond to totally different abstraction levels (quantum field theory and quantum TGD as a matter of fact!).

## 4 p-Adic length scale hypothesis and evolution

The hypothesis that evolution corresponds to p-adic evolution is testable. The reason is that p-adic length scale hypothesis selects very few physically interesting primes in the range of biologically interesting length scales and makes the notion of p-adic evolution very predictive. The hierarchy of the p-adic primes should also correspond to the hierarchical structure of consciousness. The emergence of space-time sheets having size given by p-adic length scale  $L(k)$  should have been a dramatic breakthrough in evolution since new level of space-time sheet hierarchy emerged. In the following this hypothesis will be tested.

### 4.1 How to apply p-adic length scale hypothesis?

The p-adic length scale  $L(k)$  can be expressed in terms of the p-adic length scale  $L(151)$ , which corresponds to cell membrane length scale about  $L(151) \simeq 10^{-8}$  meters as

$$L(k) = 2^{(k-151)/2} L(151) .$$

The problem is to find whether there is some precise geometric criterion fixing the p-adic prime of the structure and what this criterion is. It must be emphasized that the upper bound for the size of a structure with given  $k$  might be dynamically determined. At least, join along boundaries condensates formed from basic objects with size of order  $L(k)$  seem to be possible. In [F9] this kind of criteria were discussed and the conclusion was that join along boundaries condensate might have size which is hundred times larger than the size of the basic building block (say atom).

Even if the criterion determining the p-adic prime of basic structure is purely geometric, one has still the problem of deciding what the precise form of the criterion is. In case of most layered structures there seem to be no special problems (note however the problem with epithelial sheets!).

1. The lower limit for the thickness of the structure should corresponds to  $L(k)$ . This criterion indeed works nicely for all layered structures. In case of spherical and cylindrical structures the criterion is not so obvious. Should one interpret p-adic length scale as the minimum radius or diameter? It seems that the identification of the p-adic length scale as a lower limit for the radius of the structure is the correct one.
2. One should have also criterion giving lower bound for  $k$  in case that the structure is irreducible in the sense that it is not join along boundaries condensate of nearly identical basic units. A possible criterion is that if the irreducible structure contains cube of side  $L(k)$  then the p-adic prime must be at least  $k$ . This would mean that  $L(k)$  is the p-adic length scale of a spherical structure up to diameter  $d = \sqrt{3}L(k)$ ,

The problem becomes especially acute in case of cell and epithelial sheets consisting of two cell layers. The twin pair (167, 169) is especially natural looking in this respect and would suggest that

the p-adic length scale of cell is  $L(167)$ .  $L(169)$  would in turn be the p-adic length scale associated with the epithelial sheets formed from two cell layers abundant in living system (skin and cavities surrounding organs, sensory organs, nuclei of brain).

This looks nice. It is however known that the sizes of cells vary in wide limits. The cells of bacteria have size about one micrometer, the lower bound for neuron size is 5 micrometers, red blood cells have size of 8 micrometers. Some sources mention the size of 20 microns as the size of a typical cell! Egg has macroscopic size. Also neurons can have gigantic sizes. Thus it looks very questionable to assign  $k = 167$  with these cell sizes. and would be in conflict with the spirit of p-adic evolution hypothesis. The solution of the dilemma is simple. Cell differentiation means also p-adic evolution of the cell so that the p-adic prime of cell can grow during the development. Of course, the p-adic prime characterizing mature cell grows also in the course of evolution. Thus the p-adic prime of cell would give a measure for its level of evolution. Egg is certainly much more evolved system than bacterium.

The criterion  $d < \sqrt{3}L(k)$  for the size of cells corresponding to  $L(k)$ , implies that cells with diameters in the range (2.2, 9) micrometers should correspond to  $k = 167$ . Accepting this criteria bacteria would have  $k = 163$  and smallest neurons with diameters in the range 5 – 9 micrometers and red blood cells would have  $k = 167$ . Cells with size of 20 microns (typically neurons) correspond to  $L(169)$ . One can however quite well consider the possibility that the length scales characterizing bacteria, blood cells and neurons correspond to  $k = 167, 169$  and 173.

It seems that there are epithelial sheets consisting of two cell layers which are considerably more thicker than 5 microns suggested by the simplest guess. Rather it seems that 5 micron serve only as a lower bound for the thickness of the epithelial sheets and it is this prediction which is testable. The natural explanation is based on evolution leading to the increase of the mature cells but leaving the topology unchanged. 'Ontogeny recapitulates phylogeny' principle suggests that the evolution is repeated during the development of individual organism. Epithelial sheet is a join along boundaries condensate of more or less identical cells. Join along boundaries bonds are gap junctions now. At some stage of the growth join along boundaries condensate must have had critical thickness of order  $L(169)$ . At this stage a phase transition leading to generation of new  $k = 169$  space-time sheet occurred and led to the separation of the structure as separate geometric space-time sheet. After than cell growth continued and the p-adic prime of cells could grow in a phase transition manner to  $k = 169$  at some later stage. Of course, also larger p-adic primes are possible. Note that the p-adic prime of cells and of the epithelial sheet can be also same.

To make things even more complicated, biologists tend to determine the size of cell by dividing the area spanned by cells by their number so that the size of the cell is actually determined as the area occupied by the cell! Therefore one must be very cautious with the numbers claimed to give "cell size".

k	127	131	137	139	149
$L_p/10^{-10}m$	.025	.1	.8	1.6	50
k	151	157	163	167	169
$L_p/10^{-8}m$	1	8	64	256	512
k	173	179	181	191	193
$L_p/10^{-4}m$	.2	1.6	3.2	100	200
k	197	199	211	223	227
$L_p/m$	.08	.16	10	640	2560

Table 1. p-Adic length scales  $L_p = 2^{k-151}L_{151}$ ,  $p \simeq 2^k$ ,  $k$  prime, possibly relevant to biophysics. The last 3 scales are included in order to show that twin pairs are very frequent in the biologically interesting range of length scales. The length scale  $L(151)$  is take to be thickness of cell scale,

which is  $10^{-8}$  meters in good approximation.

## 4.2 Are also Gaussian primes and Eisenstein primes important?

Besides ordinary primes also Gaussian and Eisenstein primes exists and it seems that one define the notion of G-adic and E-adic number fields. This makes these primes very interesting from the point of view of bio-systems.

### 4.2.1 Gaussian primes

Gaussian primes consist of complex integers  $e_i \in \{\pm 1, \pm i\}$ , ordinary primes  $p \bmod 4 = 3$  multiplied by the units  $e_i$  to give four different primes, and complex Gaussian primes  $r \pm is$  multiplied by the units  $e_i$  to give 8 primes with the same modulus squared equal to prime  $p \bmod 4 = 1$ . Every prime  $p \bmod 4 = 1$  gives rise to 8 non-degenerate Gaussian primes. Pythagorean phases correspond to the phases of the squares of complex Gaussian integers  $m + in$  expressible as products of even powers of Gaussian primes  $G_p = r + is$ :

$$G_p = r + is \quad , \quad G\bar{G} = r^2 + s^2 = p \quad , \quad p \text{ prime \& } p \bmod 4 = 1 \quad . \quad (1)$$

The general expression of a Pythagorean phase expressible as a product of even number of Gaussian primes is

$$U = \frac{r^2 - s^2 + i2rs}{r^2 + s^2} \quad . \quad (2)$$

By multiplying this expression by a Gaussian prime  $i$ , one obtains second type of Pythagorean phase

$$U = \frac{2rs + i(r^2 - s^2)}{r^2 + s^2} \quad . \quad (3)$$

### 4.2.2 Eisenstein primes

Whereas Gaussian primes rely on modulo 4 arithmetics for primes, Eisenstein primes rely on modulo 3 arithmetics. Let  $w = \exp(i\phi)$ ,  $\phi = \pm 2\pi/3$ , denote a nontrivial third root of unity. The number  $1-w$  and its associates obtained by multiplying this number by  $\pm 1$  and  $\pm i$ ; the rational primes  $p \bmod 3 = 2$  and its associates; and the factors  $r + sw$  of primes  $p \bmod 3 = 1$  together with their associates, are Eisenstein primes. One can write Eisenstein prime in the form

$$\begin{aligned} E_p(r, s) &= r - \frac{s}{2} + is\left(r - \frac{s}{2}\right)\sqrt{3} \quad , \\ r^2 + s^2 - rs &= p \quad . \end{aligned} \quad (4)$$

What might be called Eisenstein triangles correspond to the products of powers of the squares of Eisenstein primes and have integer-valued long side. The sides of the orthogonal triangle associated with a square of Eisenstein prime  $E_p(r, s)$  have lengths

$$\left(r^2 - rs - \frac{s^2}{2} \quad , \quad s(r - s)\frac{\sqrt{3}}{2} \quad , \quad p = r^2 + s^2 - rs\right) \quad .$$

Eisenstein primes clearly span the ring of the complex numbers having the general form  $z = (r + i\sqrt{3}s)/2$ ,  $r$  and  $s$  integers. To my very restricted best knowledge, the other algebraic extensions of integers do not allow the notion of prime number.

### 4.2.3 G-adic and E-adic number fields

It seems possible to generalize the notion of p-adicity so that could speak about G-adic and E-adic number fields. The properties of the Gaussian and Eisenstein primes indeed strongly suggest a generalization for the notion of p-adic numbers to include what might be called G-adic or E-adic numbers.

1. Consider for definiteness Gaussian primes. The basic point is that the decomposition into a product of prime factors is unique. For a given Gaussian prime one could consider the representation of the algebraic extension involved (complex integers in case of Gaussian primes) as a ring formed by the formal power series

$$G = \sum_n z_n G_p^n . \quad (5)$$

Here  $z_n$  is Gaussian integer with norm smaller than  $|G_p|$ , which equals to  $p$  for  $p \bmod 4 = 3$  and  $\sqrt{p}$  for  $p \bmod 4 = 1$ .

2. If any Gaussian integer  $z$  has a unique expansion in powers of  $G_p$  such that coefficients have norm squared smaller than  $p$ , modulo  $G$  arithmetics makes sense and one can construct the inverse of  $G$  and number field results. For  $p \bmod 4 = 1$  the extension of the p-adic numbers by introducing  $\sqrt{-1}$  as a unit is not possible since  $\sqrt{-1}$  exists as a p-adic number: the proposed structure might perhaps provide the counterpart of the p-adic complex numbers in case  $p \bmod 4 = 1$ .

Thus the question is whether one could regard Gaussian p-adic numbers as a natural complexification of p-adics for  $p \bmod 4 = 1$ , perhaps some kind of square root of  $R_p$ , and if they indeed form a number field, do they reduce to some known algebraic extension of  $R_p$ ?

3. In case of Eisenstein numbers one can identify the coefficients  $z_n$  in the formal power series  $E = \sum z_n E_p^n$  as Eisenstein numbers having modulus square smaller than  $p$  associated with  $E_p$  and similar argument works also in this case.
4. What is interesting from the physics point of view is that for  $p \bmod 4 = 1$  the points  $G_p^n$  and  $E_p^n$  are on the logarithmic spiral  $z_n = p^{n/2} \exp(in\phi_0/2)$ , where  $\phi$  is the Pythagorean (Eisenstein) phase associated with  $G_p^2$  ( $E_p^2$ ). The logarithmic spiral can be written also as  $\rho = \exp(n \log(p)\phi/\phi_0)$ . This reminds strongly of the logarithmic spirals, which are fractal structures frequently encountered in self-organizing systems: perhaps G- and E-adics might provide the mathematics for the modelling of these structures.
5. p-Adic length scale hypothesis should hold true also for Gaussian primes, in particular, Gaussian Mersennes of form  $(1 \pm i)^k - 1$  should be especially interesting from TGD point of view.
  - i) The integers  $k$  associated with the lowest Gaussian Mersennes are following: 2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113.  $k = 113$  corresponds to the p-adic length scale associated with the atomic nucleus and muon. Thus all known charged leptons, rather than only  $e$  and  $\tau$ , as well as nuclear physics length scale, correspond to Mersenne primes in the generalized sense.
  - ii) The primes  $k = 151, 157, 163, 167$  define perhaps the most fundamental biological length scales:  $k = 151$  corresponds to the thickness of the cell membrane of about ten nanometers and  $k = 167$  to cell size about  $2.56 \mu m$ . This strongly suggests that cellular organisms have evolved to their present form through four basic stages.

iii)  $k = 239, 241, 283, 353, 367, 379, 457$  associated with the next Gaussian Mersennes define astronomical length scales.  $k = 239$  and  $k = 241$  correspond to the p-adic time scales .55 ms and 1.1 ms: basic time scales associated with nerve pulse transmission are in question.

$k = 283$  corresponds to the time scale of 38.6 *min*. An interesting question is whether this period could define a fundamental biological rhythm. The length scale  $L(353)$  corresponds to about  $2.6 \times 10^6$  light years, roughly the size scale of galaxies. The length scale  $L(367) \simeq \times 3.3 \times 10^8$  light years is of same order of magnitude as the size scale of the large voids containing galaxies on their boundaries (note the analogy with cells).  $T(379) \simeq 2.1 \times 10^{10}$  years corresponds to the lower bound for the order of the age of the Universe.  $T(457) \sim 10^{22}$  years defines a completely super-astronomical time and length scale.

6. Eisenstein integers form a hexagonal lattice equivalent with the root lattice of the color group  $SU(3)$ . Micro-tubular surface defines a hexagonal lattice on the surface of a cylinder which suggests an interpretation in terms of E-adicity. Also the patterns of neural activity form often hexagonal lattices.

#### 4.2.4 Do Gaussian Mersennes define 'miracle frequencies' in living matter?

Ordinary and Gaussian Mersenne primes are of special importance in elementary particle length scales. All charged leptons, atomic nuclei, hadrons and intermediate gauge bosons correspond to ordinary or Gaussian Mersennes. The number theoretical, and there are reasons to assume that also biological, miracle is that there are four subsequent Gaussian Mersennes in the biologically most interesting length scale range. The values of  $k$  for these length scales  $L_p$ ,  $p \simeq 2^k$ ,  $k$  prime, are  $k = 151, 157, 163, 167$  and correspond to the p-adic length scales 10 nm, 80 nm, 640 nm, and 2560 nm. The next p-adic length scale is also very special and corresponds to  $k = 13^2 = 169$  which is not prime but a power of prime and very rare as such. It is quite possible that neutrinos could metastably topologically condense at these length scales so that one would have four metastable neutrino physics besides the stable one corresponding to  $k = 169$  (this on basis of the data about neutrino mass squared differences [F3]).

The photon energies corresponding to these length scales are  $E(151) = 124.0$  eV (UV),  $E(157) = 15.5$  eV (UV),  $E(163) = 1.9375$  eV (red light) and  $E(167) = .4844$  eV (near infrared). The energy corresponding to  $k = 169$  is  $E(169) = .2422$  eV. One must notice that there is few per cent uncertainty related to an overall scaling of length scales and energies. These energies indeed seem to correspond to biologically important photon energies.

1.  $E(163) = 1.9375$  eV corresponds to wavelength of 640 nm which is with .6 per cent accuracy equal to the wave length 644 nm of the photon absorbed in photosynthesis associated with chlorophyll b). For chlorophyll a) the wavelength is 680 nm and deviation is 6 per cent. This suggests that photosynthesis leads to a generation of positive energy ME representing the stored energy and having length of near to  $L(167)$ .
2. From the yield of 48 kJ/mole of energy in ADP-to-ATP transformation, .4976 eV corresponds to the energy liberated when ATP decays to phosphor atom and ADP and is few per cent higher than  $E(167) = .4844$  eV. In the spirit of the topological self-referentiality, one might play with the thought that also the stored energy, rather than only binding energy, is represented topologically. If so, this energy might be simply stored as positive energy ME carrying this energy disappearing when ATP gives up its energy. It is unclear whether the vibration energy quantum .52 eV of water hydrogen bond could relate to  $E(167)$ .

In [J3] a model for ATP as a universal 'energy currency' is developed. The model is based on the hypothesis that  $E(167)$  MEs, rather than theoretically and empirically questionable high energy phosphate bonds, serve as the energy currency. This leads also to a model for the

coherent locomotion relying on the assumption that the hydrogen ion current accompanying the phosphorylation of ADP molecules to ATP molecules is generated by the leakage of the protonic supra currents from the flux tubes of Earth's magnetic field to the atomic space-time sheets. The macroscopic quantum coherence of the protonic supra currents allows to understand the coherency of the locomotion, which is miracle in the framework of the standard biochemistry.

3.  $k = 169$  corresponds to energy  $E(169) = .2422$  eV and belongs to the region of hydrogen bond energies, which depend on which kind of molecules hydrogen bond connects with each other. The range of weak hydrogen bond energies is  $.13 - .3$  eV and in the near infrared. Also strong hydrogen bonds with energies extending up to 1.6 eV are possible but the hydrogen bonds associated with the biological molecules such as those connecting the DNA nucleotides are weak. The maximum binding energy for water hydrogen bond equals to  $E(169)$  with one per cent accuracy. Notice however that hydrogen bond energy depends on its environment: typically the energy of the first bond in DNA is largest which gives rise to what might be called zipper effect. Negative energy MEs with this frequency should be very important and allow better understanding of the collective properties of water. Sol-gel transition involves the generation of hydrogen bonds and thus  $k = 169$  MEs might be involved with this transition. Hence it would be interesting to look for the effects of coherent light with this frequency on water and to the sol-gel phase transition and its reversal. Also irradiation of DNA by photons with energy  $E(167)$  might yield interesting effects. It deserves to be noticed that  $E(169)$  which correspond rather nearly to the hydrogen bond energy is liberated together with the corresponding momentum when only the second member of  $k = 167$  ME pair liberates its energy.
4. What about the miracle frequencies in ultraviolet? A not very plausible possibility is that these frequencies are associated with atomic transitions. They could also correspond to energies associated with structures with corresponding lengths. For  $k = 151$  MEs parallel to lipids of cell membrane are a possible candidate and it is known that the charging of the mitochondrial energy batteries occurs at its membrane.  $k = 163$  and  $k = 167$  seem to be related to metabolism and one can wonder whether the same could hold true for all the miracle length scales.
  - i) Perhaps the simplest possibility is that MEs with length of  $L(167)$  are in question but em field corresponds to  $n = 2^8 = 256$  harmonic serving as a topological correlate for a Bose-Einstein condensate of 256 photons with energy  $E(167)$ . During the discharging of the mitochondrial energy battery the value of  $n$  would gradually decrease. During the charging process, which perhaps involves p-adic-to-real phase transition representing the transformation of intention to action, the reversal of this process would occur. It is also possible that the notion of momentum battery makes sense. During discharging coherent momentum would be given to the bio-molecules involved. This could make possible coherent locomotion at the cellular level.
  - ii) If one assumes that also 124.0 eV and 15.5 eV correspond to minimum length MEs representing energy packets, one ends up to an alternative idea about how metabolism might work. 124 eV bunches of energy with length equal the cell membrane thickness could be first divided to 8 bunches of 15.5 eV at the membrane of the mitochondria, then these bunches could be divided to .19 eV bunches and finally .48 eV bunches would result. This would be like wares coming to a market store in big packets containing smaller packets containing... Now however every sub-packet of the energy packet have larger size that the packet by uncertainty principle. The problem here is that rather complex topological processes are needed to liberate the energy in this case.

To sum up, the study of the effect of the 'miracle frequencies' in living matter might be very revealing concerning the understanding of the bio-control and demonstrate unexpected effects.

### 4.3 p-Adic length scale hypothesis and molecular evolution

As far as DNA determines the structure of living systems, the evolution of living systems reduces to molecular evolution at the level of DNA. The p-adic primes relevant to molecular evolution span essentially the same range of the length scales as the p-adic primes related to the body since, at least in human, total length of DNA in single chromosome is of order centimeter.

#### 4.3.1 The pair $k = 137, 139$ : atoms and simple molecules

The scales associated with  $k = 137, 139$  form a twin pair related by a factor two. These length scales are given by  $.75 \times 10^{-10}$  meters and  $1.5 \times 10^{-10}$  meters if  $L(151)$  is taken to be  $10^{-8}$  meters.

It is interesting to look what the p-adic length scales of typical simple bio-molecules are when their size is defined as their diameter. Using Angström as unit the diameters are  $d(Mg) = 1.44$ ,  $d(Na) = 1.96$ ,  $d(Ca) = 2.0$ ,  $r(Ca) = 2.74$ ,  $r(H_2O) = 2.74$ . The criterion  $d > \sqrt{3}L(k)$  gives an upper bound for the p-adic length scale for the object of diameter  $d$ . Applied to  $k = 139$  this gives  $d > 2.7$  Angstrom for objects having  $k = 139$ . Only Ca and  $H_2O$  satisfy this criterion and thus they represent  $k = 139$  level of molecular evolution.

One can say that light atoms belong to the lowest level of evolution defined to start from  $k = 137$  objects. Calcium represents second level of atomic evolution. Interesting possibility proposed already earlier is that outer electrons of Calcium drop on non-atomic space-time sheet  $k = 139$  and this indeed makes Ca object involved object consisting of two space-time sheets.  $H_2O$  represents the second level of evolution of molecules. It is rather remarkable that Ca and  $H_2O$  molecules are indeed in central role in control and coordination protein conformations. For instance, gel-sol phase transition, which seems to be basic process at intracellular level, involves  $Ca^{++}$  ions in essential manner.

Tubulins, which are the basic building blocks of micro-tubule, have diameter of 4 nm, which is below the critical diameter of  $d = \sqrt{3} \times L(149) \simeq 8.75$  nm. Also the size of tubulin dimer about 8 nm seems to be slightly below the critical size.

The building blocks of DNA strand and double strand have radii of order 1 Angstrom and single strand corresponds to  $k = 137$ , whereas molecule pair in double strand corresponds to  $k = 139$  respectively. For  $L(151) = 10^{-8}$  meters, DNA molecule in double helix corresponds to a length of  $3.4 A \simeq 1.13 \times 2 \times L(139)$  of the double helix. This is quite near to  $4 \times L(137)$ . This suggests that one could perhaps fix the over all normalization of p-adic length scale by requiring that DNA triplet corresponds precisely to  $4 \times L(137)$ . This gives

$$L(151) = 108.8 \times 10^{-8} \text{ meters} .$$

That single DNA would correspond so precisely to a multiple of p-adic length scale would not probably be an accident.

Since DNA and protein molecules are obviously at quite high level of evolution it seems that the length of the molecule is what determines the value of the corresponding p-adic prime. Thus the evolution maps to the evolution of the p-adic length for DNA molecules! Thus the molecular length of  $L(149) = 5$  nanometers should have been the first breakthrough in the molecular evolution (lipid layer of the cell membrane by the assembly of micelles of the liquid crystal!), which was followed rapidly by additional breakthroughs. It is obvious that the evolution reduces in well defined sense to the evolution of DNA sequences. This aspect of evolution will be discussed separately later.

### 4.3.2 p-Adic evolution of DNA

p-Adic evolution should involve two aspects.

1. The increase of the p-adic length scale characterizing the basic DNA modules. This suggest the classification of the basic building blocks of the genome by the p-adic length scale associated with the corresponding DNA sequences.
2. The fractal evolution involving emergence of longer p-adic length scales characterizing the size of the space-time sheets to which basic DNA sequences had # contacts. Thus the lengths of introns and exons are not expected to correlate with the p-adic scale of the space-time sheet to which they possibly have # contacts. Rather, same gene can have # contacts to arbitrarily large space-time sheets.

Consider first the critical lengths of the basic program modules. The lengths  $L(149), L(151), L(157), \dots$  of gene or DNA sequence might mean the emergence of something genuinely new in the evolution. This length scale hierarchy expressed in terms of  $L(137)$  comes in powers of 2 as  $N_{137} = 1, 2, 64, 128, 2^{10}, 2^{13}, 2^{15}, \dots$

Single nucleotide pair corresponds to in double helix to distance of .34 nanometers which is larger than the length scale of  $L(139)$ . The structure of the double helix is such that there is a periodicity of 3.4 nanometers: this means that basic period corresponds to 10 nucleotides. This implies that 5 DNA triplets correspond to a length of 5.05 nanometers, which equals to p-adic length scale  $L(149)$  if  $L(151)$  is defined to be  $L(151) = 10.2$  nm.  $L(149)$  corresponds to the thickness of the lipid layer of cell membrane and  $L(151)$  corresponds to 10 DNA triplets, to the thickness of the cell membrane and the basic period of DNA sequence when DNA triplet is regarded as a basic unit. Perhaps this periodicity is not accident but has deeper meaning possibly related to the periodicity of phase variable associated with DNA. The lengths of DNA sequences corresponding to p-adic length scale  $L(k)$ ,  $p \simeq k$ ,  $k$  power of prime are  $N(DNA) = 2^{k-149} \times 5$  DNA triplets.

This means that the critical numbers of DNA triplets possible leading to the emergence of qualitatively new properties of organism are given by

$$\begin{aligned} N(DNA) &= 2^{(k-149)/2} \times 5, \\ k &\in \{149, 151, 157, 163, 167, 169, 174, 179, 181, 191, 193, \dots\} \end{aligned} \quad (6)$$

The few lowest critical values of DNA triplets in gene are

$$\begin{aligned} N(DNA) &= n \times 5, \\ n &= 1, 2, 2^4 = 16, 2^7 = 128, 2^9 = 512, 2^{10} = 1024, 2^{12}, 2^{15}, 2^{16}, \dots \end{aligned}$$

The steps of this hierarchy resembles bring in mind the evolution for the length of the basic memory unit of computer memory! One must however notice that 5 DNA triplets seems to serve as a basic unit.

The emergence of new p-adic length scales could have meant emergence of new levels of modularization in the genetic program and it is interesting to look these numbers from this point of view.

1. One could think that short sequences of precursors of DNA, mRNA and tRNA molecules were generated spontaneously by self-assembly. This implied automatically the generation of amino-acids by the more primitive counterparts of transcription and translation processes. The lengths of DNA molecules began gradually grow and at the critical lengths of DNA corresponding to p-adic length scales dramatic new effects emerged. Also new space-time sheets emerged in the genome and the first guess is that this occurred for the critical sizes of the organism given by p-adic length scales.

2. Formation of lipid layers might have been the revolution occurring at this stage and since lipids should have had size of order  $L(149)$ . This revolution should have occurred when the length of the genome became longer than 5 DNA triplets and meant formation of lipid layers by self organization process known to occur in all liquid crystals: these layers were perhaps formed in the surface of water such that hydrophobic ends of proteins would have pointed out of water. Self organization presumably led simultaneously to the formation of double membranes having thickness  $L(151)$  such that the hydrophobic ends of proteins pointed in the interior of the double membrane. Second revolution became possible when the number of DNA triplets became larger than 10 triplets so that proteins connecting cell interior of the double membrane to its exterior became possible and the control of ion concentrations became in principle possible. Transfer RNA (tRNA) has length of at most 27 triplets. Third revolution should have occurred  $L(157)$ , which corresponds to 80 triplets.
3. Smallest viruses possessing single strand of DNA have lengths between 15-100 nanometers and this suggest that genome correspond to p-adic length scales  $L(149)$ ,  $L(151)$  and  $L(157)$ . These length scales could characterize largest space-time sheets also present in genome. The building blocks of the envelope of viruses are genetically coded separately and self-assemble spontaneously so that only building blocks need to be coded. Therefore p-adic prime associated with the genome of virus could be smaller than that determined by the size of the virus. Viruses with two DNA strands have sizes between 250 – 1000 nanometers. This suggest that the emergence of  $k = 163$  length scale in the genome of virus was accompanied by the emergence of double stranded DNA.  $k = 163$  is perhaps the largest p-adic length scale associated with virus genome.
4. Bacteria have typically sizes of 1 – 10 micrometers. This suggests that  $k = 163, 167, 169$  are the possible space-time sheets associated with the bacterial genome. The emergence of  $k = 169$  could have meant the emergence of multicellulars and generation of epithelial sheet like structures consisting of two cell layers as well as emergence of introns and DNA cognition.

Consider now the typical lengths for the structures of the eukaryotic genome.

1. The presence of introns means that the length of a gene coding given protein plus introns is much longer than the DNA coding only the protein. The higher the evolutionary level of the species, the larger the fraction of the introns. For human genome the fraction of the exons is roughly 1 per cent. The typical length of hnRNA in nucleus is 6.000-8.000 np (nucleotide pairs) which corresponds to 18 micrometers and length scale  $L(163)$  and  $L(167)$ . Even genes with length 20.000 np are possible and correspond to  $L(169)$ . The lengths of mRNA vary between 500-3.000 nucleotides corresponding to interval  $1.7 \times 10^{-7}$ - $10^{-6}$  meters and length scales  $L(157)$  and  $L(163)$ . RNA sequences coding typical protein consisting of roughly 300 amino acids are about  $3 \times 10^{-7}$  meters and correspond to  $L(159)$ .
2. Most of the highly repetitive DNA has rather short length between 5 – 300 nucleotides. Introns having typically lengths between 10 – 1000 nucleotide pairs. The length of ribosomal DNA is not longer than  $10^3$  nucleotides. These examples suggests that the basic program modules correspond to p-adic length scales between  $L(139)$  and  $L(157)$  and that introns and genes are built as fractal versions of the basic program modules possibly present in all plants and animals. The basic programs are chemically identical. They could however have wormhole contacts to increasingly larger space-time sheets so that organism possesses fractal like structural hierarchy. Alternatively, the contacts are on the space-time sheets with same  $p$  in all animals but the sizes of the join along boundaries condensates formed by fundamental expression domains depend on organism. The frequent occurrence of Hox genes in the genetic code of body parts of various sizes in the entire animal kingdom is consistent with both options.

### 4.3.3 Cell membrane and cytoskeleton

$k = 149, 151$  is the twin pair related to the lipid layers of cell membrane and cell membrane itself. Micro-tubuli having radius of 25 nanometers correspond to  $k = 151$  structure. Also chromosomes have radius of order 25 nanometers.

The length scale associated with  $k = 157$  is 80 nanometers. Cell cytoskeleton contains as its basic structural element the cylindrical structures formed by the triplets of micro-tubuli on a cylindrical surface having doublet of micro-tubuli at center. The size of this structure corresponds to  $L(157)$ . For viruses the diameter of the membrane envelope is between 80 – 120 nanometers. Cell organelles contain smaller membrane bounded structures (christae, thylakoids,...), which could correspond to the p-adic length scale  $L(157)$ .

It must be emphasized that DNA evolution occurs also in different direction and corresponds to the emergence of new space-time sheets to many-sheeted DNA. The number of these space-time sheets might serve as more important measure for the evolutionary level of organ than the length of the gene and distinguish between humans and dinosauri.

## 4.4 Evolution of the cellular structures

Cells can be classified into prokaryotic cells having no cell organelles enclosed by membranes and eukaryotic cells containing this kind of cell organelles, which in turn contain further sub-cell organelles surrounded by membranes. The second distinction is division into plant and animal cells. Nanno-bacteria are still further potential but not yet established life form. Besides cell like life there are viruses enclosed by envelope like structure. Viruses are not however able to metabolize.

### 4.4.1 $k = 163$ and bacteria (prokaryotes)

The length scale associated with  $k = 163$  is .64 micrometers. Bacteria have typically cell size of 1 micrometer and would thus have radius of order  $L(163)$ . Also substructures of collagen fibres in connective tissue have radius about .5 – 10 micrometers and might correspond to  $L(163)$  and possibly larger p-adic length scales. Of course, evolution of these structures means that their p-adic prime has possibly increased. Also cell organelles like mitochondria, chloroplasts and nucleus could correspond to  $k = 163$  length scale. The diameter of mitochondria is indeed of order 1 micrometer.

### 4.4.2 Evolution of the eukaryotic cellular structures

It is tempting to regard the evolution of cellular structures as gradual increase of p-adic prime and to classify primitive cellular life forms by their p-adic prime. The key observation is that various cell organelles are surrounded by membrane and cell organelles contains smaller organelles surrounded by membrane. There is thus 3-fold hierarchy of membrane like structures present. For instance, nucleus, mitochondria and chloroplast basic cell organelles inside plant cell and mitochondria and chloroplast contain smaller structures like cristae and thylakoids. This Russian dolls structure suggests strongly interpretation in terms of space-time sheets labelled by p-adic primes. Evolution of cell has proceeded in steps. When new space-time sheet emerged some population of structures of the previous level remained confined inside the new space-time sheet. Some structures left out and remained possibly living fossils.

1. The first step would correspond to the generation of  $k = 157$  structures enclosed by cell membrane (say cristae and thylakoids) with size not smaller than  $L(157) = 80$  nanometers. The general model predicts that bacteria are preceded by a more primitive form of life corresponding to  $k = 157$ . Besides viruses and nanobacteria [33] correspond to this form of

life: in fact, the sizes of nannobacteria are reported to be in the range .2 – .6 micrometers and thus correspond to p-adic length scale  $k = 157$ .

2. At the next step emerged the  $k = 163$  structures (nucleus, mitochondria and chloroplasts) enclosed by cell membrane and containing structures.  $L(163) = .64$  micrometers corresponds to the lower limit for the size of prokaryotes (bacteria) so that bacteria are living fossils from this period of evolution. The fact that bacteria lack membrane bound compartments is consistent with the assumption that they correspond to  $k = 163$ . The absence of internal membrane bound structures however suggests that they have evolved from  $k = 157$  form of life by a gradual growth of cell size.
3. The next step was the emergence of  $k = 167$  structures, eukaryotes, closed by a further cell membrane. These structures are the predecessors of animal and plant cells. No larger structures surrounded by cell membrane emerged anymore.
4. The emergence of  $k = 169$  space-time sheets must have meant a dramatic breakthrough in the evolution since double cell layers emerged as new structures condensed at  $k = 169$  space-time sheet. The emergence of  $k = 169$  space-time sheet makes possible the generation of epithelial sheets as autonomous selves and must have led to a proliferation of structures. The explanation for the difference between plants and animals is that this evolutionary step did not occur in case of plants. The reason is trivial: plant cells are surrounded by a wall hindering the formation of join along boundaries contacts between plant cells.

It must be emphasized that these structures, once created continue to evolve and typically sizes can be considerably larger than the p-adic length scale of the simplest structure. Indeed typical cell size seems to vary between 10 – 100 micrometers. The basic topological structure however reflects the evolution of these structures.

## 4.5 p-Adic length scale hypothesis and neural evolution

It is tempting to try to identify the components of sensory experience in terms of the p-adic length scales involved. Both the identification for the quantum correlates of the sensory qualia and emotions and the model for cognition [K3, L1] relies on the hierarchy of p-adic space-time sheets representing selves and forming a master-slave hierarchy of weakly coupled super-conductors. Sensory experiences are parameterized by various magnetic transition frequencies serving as resonance frequencies for which Josephson currents induce 'wake-up' of the sub-selves representing sensory mental images. A partial characterization for a component of conscious experience is in terms of p-adic length scales involved with the group of sub-selves, which are 'awake' during a particular conscious experience.

The general rule helping to understand the general evolution of neural consciousness seems to be that the more emotional the experience is, the lower is the corresponding magnetic transition frequency. This is understandable if emotions are byproducts of sensory experiences resulting from the automatic comparison of subjective (real) memories and geometric memories (expectations, simulations). Thus the typical timescale of the experience measures how emotional the experience is: emotions are indeed long-lasting whereas the characteristic time scale of sensory experiencing is below .1 seconds.

### 4.5.1 p-Adic length scale hierarchy and components of conscious experience

The p-adic primes relevant above bacterium length scale are twin pair  $k = 167, 169 = 13^2$ ,  $k = 173$ , twin pair  $k = 179, 181$ , twin pair 191, 193, and twin pair  $k = 197, 199$ . Note that with single exception all length scales in this range relevant to the functioning of human brain have twin

partner! The density of primes and twin primes (note however that  $k = 169 = 13^2$  is power of prime rather than prime) is exceptionally large in this region. This implies that the number of p-adic hierarchy levels per length unit is exceptionally large. Already this observation sheds some understanding to the question why human brain is so miraculously structured system.

After  $k = 199$  there is a huge gap in the distribution of twin primes: next pair (227, 229) corresponds corresponds to length scale of 3 kilometers!

1. In TGD framework cognition is based on cognitive neutrino pairs associated with  $k = 151$  defects of  $k = 169$  neutrino super-conductor. Cognition making possible to assign names to experiences and thinking as internal speech involves the pair formed by the cellular space-time sheet ( $k = 169$ ) and cell membrane space-time sheet ( $k = 151$ ). Despite the short length scale involved, linguistic thought, being a critical phenomenon, is a latecomer in evolution. The model for many-sheeted DNA suggests that genes at chromosome space-time sheet, which also has  $k = 151$ , could represent our conscious beliefs [L2] and represent one form of Boolean mind realized in terms of cognitive neutrinos. The dramatic difference between eukaryotes and prokaryotes can be explained as the emergence of  $k = 169$  space-time sheet and exon-intron degree of freedom making possible Boolean cognition and genetic representation of beliefs. Thus introns seen as 'junk DNA' by hard-nosed materialists is absolutely crucial for consciousness in TGD framework!
2. Primary sensory experiencing corresponds to  $k = 169$  at which Earth's magnetic field resides. Sensory modalities which are simple in the sense that they involve very few sub-modalities (vision, taste, tactile sense) can be parameterized in terms of magnetic transition frequencies of ions in Earth's magnetic field.
3.  $k = 173$  space-time sheet is identified as a carrier of Earth's  $Z^0$  magnetic field with strength roughly  $g_Z B_Z \sim eB/16$ . The emergence of this space-time sheet meant the emergence of olfaction with a rich repertoire of sub-modalities having as quantum-correlates the  $Z^0$  magnetic transition frequencies of various particles (atoms, ions and even molecules). Geometric cognition based on the formation of geometric representations for the objects of perceptive field by generating mind like space-time sheets is related with the emergence of  $k = 173$  and longer p-adic length scales. The long time scale (low magnetic transition frequency) associated with olfaction explains why olfaction is so emotional experience.
4.  $k = 179$  and  $k = 181$  form twin pairs and correspond to sizes of ocular dominance columns and double layered sheets formed by them.  $k = 179$  would correspond to higher level geometric cognition implying decomposition of the perceptive field into objects.
5.  $k = 181$  could integrate left and right cognition to stereo cognition. Stereovision is excellent example of this integration. Usually the right and left visual fields combine to single field and it is impossible to experience them as separate ones. Visual self is in a state of whole body consciousness. This requires entanglement of the left and right visual field. For instance, if person has been drinking too much, the situation changes. Visual field splits into two separate fields. The interpretation is that visual self contains two sub-selves and is not anymore in a state of whole-body consciousness.

Summation hypothesis for conscious experiences explains at least partially the existence of sensory homunculi in brain. Various sensory homunculi would provide maps sensory experience of self at given level to experience of self at the next hierarchy level. This kind of mapping would be necessary since given self forms average about the experiences of its sub-sub-selves. For instance, all experiences from the points of skin would average to single experience without this map at 2 levels above the primary sensory experience.

The stages at which the sizes of subunits of brain have reached critical size given by some p-adic length scale must have been meant dramatic boosts in the rate of the evolution.

#### 4.5.2 Twin pair (167, 169) and bi-layered epithelial sheets

Already bacteria form colonies but one can regard this as join along boundaries condensates having no internal structures. The size  $L(167) = 2.22$  micrometers must have meant a decisive critical size in the evolution of cell. When this size of achieved, the formation of bi-layered epithelial sheets as double sheeted structures condensed on newly emerged  $k = 169$  space-time sheet became possible and evolution of genuine multi-cellulars became possible. Cells continued still their own evolution and size of order 9 micrometers must have been landmark in the evolution of cell. It would be interesting to know whether there is some neurophysiological identification for this step.

In order to avoid confusion it must be emphasized that the sizes of many cells are much larger than  $L(167)$ , egg is extreme example of this. This can be understood as a result of evolution of cells which in their primitive form had size given by  $L(167)$  leading to a larger p-adic prime characterizing the cell. In case of neurons the complexity of neuron indeed correlates with its size. Thus the proper interpretation of  $L(167)$  is as minimal possible size of cell. Also other p-adic length scales should be interpreted in the same spirit.

#### 4.5.3 $k = 173$ , Cambrian explosion and field axis orientation columns of cortex

The proposed model for the hierarchy of consciousness predicts that the size  $L(173)$  for basic unit of primitive brain could have been a threshold for the emergence of emotions (of course, also other interpretations are possible). The lower bound for neuron radius is  $L(167)$  and and sphere with radius  $L(173) \simeq 2 \times 10^{-5}$  meters contains roughly  $N = 512$  neurons. Actually the number is smaller since neurons are not tightly packed.

The Orch OR model of Penrose and Hameroff [34] predicts that Cambrian explosion occurred, when critical neuron number about 300 (nematode worms! TGD in turn suggests that it was the emergence of  $k = 173$  neuronal space-time sheets that led to Cambrian explosion. According to TGD, the emergence of micro-tubuli meant the emergence of vision making possible formation of cell societies. Of course, it is possible that primitive eye had the critical number of  $N = 256$  neurons. Cambrian explosion meant the emergence of arthropods and several phyla which do not exist anymore [18].

The obvious place for the identification of this kind of structures is cortex. The relatively small thickness of the cortex (about 1 *mm*) implies that curvature effects do not mask the local cylindrical symmetry. Cortex is indeed known to possess columnar organization. There are in fact several columnar structures. The first columnar structure [19] in the visual cortex corresponds to the so called field axis orientation columns consisting of locally stripe like regions of cells, which preferentially react to the orientation of a bar of light in the visual field. The width of the stripes with fixed orientation is about 20 – 50  $\mu m$  [19]. The condensation level in question might correspond to  $k = 173$  since the lower bound for thickness is  $L(173) \simeq 20 \mu m$ .

#### 4.5.4 Twin pair (179, 181) and ocular dominance columns of visual cortex

$k = 179, 181$  forms also a twin pair of length scales. The emergence of brain substructures with size larger than  $L(179) \simeq .16$  millimeters must have also meant an explosive stage in evolution. The emergence of  $k = 181$  level must have boosted the this explosion further. Note that  $k = 179$  cube contains  $8^3$  structures of size  $k = 173$ . Thus it can be regarded as a three-dimensional chess-board or 8-move simulation for ordinary chess. Perhaps it is not accident that chess-board has  $8 \times 8$  squares! It would be interesting to find at what is the level of evolution at which single structural unit reached the size  $L(179)$ . The first possibility is that the emergence of  $k = 179$  space-time

sheets meant the emergence of insects. Insects are basically sensory experiences having more sense than we do but not too much brain. Perhaps the emergence  $k = 181$  space-time sheets was related to the emergence of vertebrates and stereo-cognition. This evolution step meant that brain size began to grow rapidly.

Also this twin pair of p-adic length scales seems to be realized in brain. Besides orientation columns visual cortex contains also so called ocular dominance columns. Also other parts of cortex contain similar columnar structures. The thickness for ocular dominance columns seems to correspond to  $k = 179$  whereas the thickness for a pairs formed by them corresponds to  $k = 181$ . Ocular dominance columns consist of cells reacting appreciably to the stimulus from the second eye only and form columnar structures [19] with complicated cross section and become visible via a continued stimulation of one eye only. The typical width of the stripe in the region is about .2 – .5 mm.

The levels  $k = 179$  and  $k = 181$  forming a pair with  $L(179) \simeq .16$  mm might be the relevant p-adic levels now. The ocular dominance columns associated with right and left eye alternate and the regions formed by right-left pairs of ocular dominance columns is natural candidate for the double layered structure at level 179 and corresponds to  $k = 181$ . Also the hypothesis that  $k = 181$  space-time sheet is the level at which right and left cognition integrate to stereo cognition is suggestive.

#### 4.5.5 Larger structures

*Hypercolumns as Rubik cube type structures?*

Visual cortex contains also larger structures, "hypercolumns" [19], which form basic units for the processing of visual information (and sensory information in general). These structures have roughly the size of order 1 mm, the thickness of cortex, and contain few thousand neurons. This length scale does not correspond to directly to any p-adic length scale. A possible interpretation is as a Rubik cube type structures formed from  $3^3 = 27$   $k = 181$  cubes. Structures consisting of 3 basic units are rather abundant in brain (for instance, structures consisting of 3 cell layers).

*What is the interpretation of the pair (191, 193)?*

Next structures correspond to the twin pair  $k = 191, 193$ .  $L(191)$  corresponds to cube with size of 1 cm and  $k = 193$  to a cube of 2 cm. Pituitary gland seems to be a structure allowing interpretation as pair of structures with size about 1 cm. It however seems that human cortex does not contain these kind of structures as moduli: the reason is simple: the thickness of cortex (grey matter) is only 1 millimeter.

*Pair (197, 199) and brain lobes*

$k = 197$  and 199 form again a twin pair of length scales related by a scaling factor of two. Structures would have size of order  $L(197) = 8$  cm and  $L(199) = 16$  cm. Could one identify brain lobes as a binary structure related to this pair of p-adic length scales? After this twin prime there is a huge gap in the spectrum of twin primes which suggests that the length scale range covering biological important length scales is indeed exceptional.

## 5 Higher level in biological self hierarchy

TGD not only predicts infinite hierarchy of selves but also strongly suggests that "me" as an intentional agent should be identified as my field body, or perhaps better to say, my magnetic body having an astrophysical size. Magnetic body would also serve as an intentional agent and controlling biological body by time mirror mechanism. An entire hierarchy of magnetic bodies is predicted since the flux quanta of each body part define corresponding magnetic body. Also the

magnetic body of Earth should define a conscious unit, kind of Magnetic Mother Gaia perhaps responsible for some third person aspects of our consciousness. The role of the magnetic body would be like that of a manual of an electronic instrument, that is it would provide a higher level representation for the body and its environment. Magnetic body would also serve as template for the formation of bio-structures. Magnetic body would share the mental images produced by brain as symbolic representations of the sensory input. The basic theoretical arguments supporting the notion of magnetic body derive from p-adic physics as physics of intention and cognition. Also time mirror mechanism of long term memories and Uncertainty Principle applied to EEG provide support for the notion. Some experimental findings supporting the notion of field body are Libet's findings, the role of Schumann resonance frequency for consciousness about time delays of consciousness, and the effects em radiation on brain and living matter at cyclotron frequencies.

## 5.1 Support for the notion magnetic body

### 5.1.1 Theoretical support

#### 1. EEG and Uncertainty Principle

There are good reasons to expect that EEG is accompanied by radiation, which in TGD framework has topological light rays as space-time correlates. Typical EEG frequencies correspond to wavelengths  $\lambda = c/f$  which for which natural length scale unit is Earth size. Thus Uncertainty Principle suggests that structures of at least this size are involved with the self hierarchy associated with the brain.

#### 2. p-Adic physics as physics of cognition and intentionality

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

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

p-Adic topology differs radically from real topology in the sense that p-adically infinitesimal is infinite in real sense.

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

This means that intentionality and cognition are literally cosmic phenomena and evolution of cognition and intentionality proceeds from long p-adic length scales to short ones in real sense (but from short to long scales in p-adic sense). The carving of a statue by starting from a rough sketch

and adding details gradually is a good metaphor for what is involved. Development of any motor skill, say piano playing, is an excellent example of what happens.

Intentions are transformed to action in a phase transition changing p-adic space-time sheet to a real one. This process is most probable when real and p-adic space-time sheets have maximal number of common rational points. Hence one expects that intentions can be transformed to large space-time sheets and topological field quanta are best candidates for these space-time sheets. Pairs of positive and negative energy topological light rays and negative energy topological light rays generated in the dropping of particles to larger space-time sheets, provide an example realizations of intentions. Also wormhole magnetic fields consisting of pair of space-time sheets carrying magnetic fields of equal intensity and having opposite time orientations could be generated intentionally.

### 3. *Time mirror mechanism of long term memories*

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

1. In the case of active memory recall the desire to remember is communicated to the geometric past by sharing and fusion of mental images made possible by entanglement. In the case of episodal memories also the memory recall would result in this manner. For non-episodal memories the memory would be communicated from the geometric past using classical communications.
2. In the case of episodal memories active precisely targeted memory recall might be difficult since the entanglement with a correct mental image seems to require good luck. In principle it is possible to select the distance  $T$  to the geometric past where the memory comes from by selecting the fundamental frequency of ME.
3. The most natural manner to realize the time mirror mechanism is to regard magnetic body as the system communicating with the brain of the geometric past serving as mirror. The fundamental frequency  $f = c/L$  of associated with a topological light ray of length  $L$  would naturally code for the time span of the long term memory as  $T = L/c$  in the sense that only these memories would be communicated resonantly. Thus the distance from brain along magnetic flux tubes would code the time span of the memory. Long term memories with a span of order lifetime however require that the size of the magnetic body involved is measured in light decades.

### 5.1.2 **Experimental support for the notion of magnetic body**

The work of Blackman and other pioneers of bio-electromagnetism concerning the effects of ELF (extremely low frequency) em fields on brain [35, 36] discussed in [M3], provides dramatic support for this idea and also a concrete view about how brain manages to act as macroscopic quantum system. The currents generating EEG certainly create weak electromagnetic radiation fields which in TGD framework correspond to topological field quanta of size of Earth having natural coupling to the magnetic flux tubes.

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 [39] 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 micro-seizures and epilepsies [40]. 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.

The explanation of the effects related to water memory [37, 38] suggests that similar magnetic effects appear at much wider frequency range than ELF frequencies which would mean that the super-conducting magnetic flux tube circuitries form a fractal hierarchy. The findings challenging the notions of ionic pumps and channels [26] provide additional strong support for the notion of many-sheeted space-time and hierarchy of super-conducting of magnetic flux tubes. The evidence for the fractal hierarchy of magnetic flux tubes is discussed in [J1, J2].

These observations support the view that our "physical" body is only a dip of an iceberg and formed by the topological condensation of the bio-matter around electromagnetic topological field quanta serving as templates for the bio-structures.

## 5.2 Some functions of magnetic body

The magnetic bodies associated with various body parts, including cellular and even molecular magnetic bodies, could have several functions besides defining a hierarchy of intentional agents (for this aspect see [K1]).

### 5.2.1 Topologically quantized classical fields as templates for the formation of bio-structures?

Magnetic bodies could serve as templates of bio-structures. For instance, blood circulation and central nervous system could have magnetic circuitries as templates. The web like structure formed by topological field quanta representing classical fields, in particular em fields, is reminiscent of structures formed by micro-tubuli and collagens forming the connective tissue of living systems. It has been already earlier suggested that magnetic flux tubes and other topological field quanta serve as templates for various bio-structures 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 (mental image!) 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. There is direct evidence for the hypothesis that ions in a magnetic field  $B_{end} = 2B_E/5 = .2$  Gauss, where  $B_E = .5$  Gauss is the nominal value of the Earth's magnetic field, 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. It must be emphasized that  $B_{end}$  is not equal to  $B_E$  as I erratically believed for a long time. The model for dark matter as macroscopic quantum phases with Planck constant equal to an integer multiple of the ordinary Planck constant [C7] leads to the working hypothesis that  $B_{end}$  corresponds to the dark counterpart of  $B_E$  [M3].

For  $B_{end} = 2/5B_E = .2$  Gauss interpreted as a dark magnetic field with  $\hbar = 5\hbar_0$  carrying 2 units of flux (the unit is  $h_5 = 5h_0$ ) and corresponding also to the p-adic length scale  $L(169)$ , the radius is  $25 \mu\text{m}$ , the size of a large neuron. This possibly relates to the fact that the effects of ELF em fields are observed for vertebrates (for details see [M3]).

The coupling of the neuronal layers of cortex and perhaps all cells with the flux tubes of Earth's magnetic field could make possible entanglement between brain and Mother Gaia. If magnetic flux tubes of the dark counterpart of  $B_E$  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 micro-tubuli, cells navigating along collagen fibres and birds navigating along Earth's magnetic field lines would all be guided by higher level selves.

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 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 ( $5 \times 10^8$  m), the height of the wave cavity of Earth (80 km) to Earth radius ( $7 \times 10^6$  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 the cell membrane ( $10^{-8}$  m) to the radius of neuron ( $2.5 \times 10^{-6}$ ) have roughly the same value of order  $10^{-2}$ . Could this mean that cell membrane, cortex, electromagnetic cavity of Earth and solar corona might have similar role in the self hierarchy? The general ideas about self-organization indeed support this view: boundary regions are subject to the most intense external energy feed and thus self-organize most effectively.

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.

### 5.2.2 Dark magnetic fields and living matter

A considerable sharpening of the above discussed speculative picture came with the development of TGD inspired vision about dark matter as macroscopic quantum phases with quantized value of Planck constant having arbitrarily large values coming as integer multiples of the ordinary Planck constant [C7].

As often occurs, also the spotting of errors leads to important new insights. 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 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  $p = 2^{127-1}$ ,  $k = 0, 1, 2, \dots$  [M3]. Also integer valued sub-harmonics and integer valued sub-harmonics of  $\lambda$  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  $\lambda$  [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 using only iterated square root operation 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  $r = 18 \mu\text{m}$ , 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  $B_n = 4\cos^2(\pi/n)$  equal to Golden Mean [O3].

An natural working hypothesis is that  $B_{end}$  defines the dark counterpart of the ordinary magnetosphere and that the relationship  $B_{end} = 2B_E/5$  holds as a time average in the entire magnetosphere. The flux quanta of  $B_{end}$  would carry dark matter and would be responsible for the quantum control of the living matter.

### 5.2.3 Magnetic flux tubes and metabolism

Magnetic flux tubes could define super-conducting circuitry making possible a many-sheeted control of homeostasis: this aspect is discussed in [K6]. The hierarchy of magnetic flux tubes could also define many-sheeted lasers, and the dropping of particles to the larger space-time sheets would define a hierarchy of metabolic energy currencies as zero point kinetic energies liberated in the process. Process would also generate radiation at the harmonics of cyclotron frequencies at the larger space-time sheet. These frequencies could define a considerable part of EEG. Also fractally scaled up versions of EEG having similar band structure are predicted. The findings of Peter Gariaev [28] are consistent with this prediction [K4]. The dropping of particles to larger space-time sheets for population inverted lasers would be also ideal for the realization of bio-control by time mirror mechanism and make possible remote metabolism and remote motor control.

### 5.2.4 Magnetic flux tubes as Nature's own bio-laboratory

Magnetic flux tubes could be ideal structures for the isolation and purification of various biomolecules, and make also possible precise targeting of the reactants to reaction volumes defined by the nodes of the magnetic flux tube circuitry. Purification is made possible by the weight of the molecule if quantum-classical correspondence holds true in the sense that a magnetic flux tube carrying super-conducting bosons of mass  $m$  deforms so that it runs along a classical orbit of the particle with radius proportional to  $m$ . This would make sense for a many-sheeted magnetic field for which the fluxes associated with the magnetic flux tubes along which particles move return along much larger space-time sheets and define the average magnetic field in which the particles move. This kind of Nature's own bio-laboratory might explain the miraculous selection of biomolecules essential for the pre-biotic evolution. In accordance with the p-adic vision about the evolution of cognition, the evolution would have been proceeded from and guided by the magnetic flux tube structures of the Earth's magnetic field to the bio-chemical level [N4].

## 5.3 The magnetic fields associated with body parts and higher levels of consciousness

The basic vision is that magnetic flux tubes containing ionic super-conductors, MEs carrying exotic representations of p-adic Super Virasoro algebra, and biological organisms live in a fractal symbiosis. MEs can induce cyclotron transitions amplified to quantum phase transitions inside magnetic flux tubes provided they have length above the wavelength defined by the cyclotron frequency. The exotic p-adic Super Virasoro representations with MEs have wavelength determined

by the fundamental frequency which is of same order as the cyclotron frequency. The interaction of MEs and magnetic flux tubes by SQUID mechanism requires that magnetic flux of ME generates a current inside a circuit formed by magnetic flux tubes. Magnetic flux tubes to have arbitrary size scales below the size scale of ME.

Some body parts are carriers of static magnetic fields. The value of the static magnetic field associated with eye is slightly below  $10^{-11}$  Tesla whereas the strength of Earth's magnetic field is about  $.5 \times 10^{-4}$  Tesla. Also pineal gland ('third eye' also in a rather literal sense, see [K3]) contains magnetic material. Unfortunately I do not know the value of the corresponding dipole strength: for a dipole having size of order micrometer the maximal dipole strength would be very roughly  $10^{-9}$  times corresponding dipole strength for Earth's magnetic field which would mean field of order  $10^{-13}$  T. Also head and entire body could act as static magnetic dipoles.

For purely sensory consciousness .1 seconds is the characteristic time scale and EEG is closely related with this form of consciousness. In case of  $B_e$  the magnetic cyclotron frequencies are in the range obtained by scaling the range of cyclotron frequencies in Earth's magnetic field by a factor about  $2 \times 10^{-7}$ . This means that the periods of the ionic cyclotron frequencies are roughly in the range 12 hours-1.6 years for ionic cyclotron frequencies corresponding to the range of frequencies 90 – 0.1 Hz in Earth's magnetic field. These time scales are typical for the contents of higher level self consciousness involving self narrative. Notice however that these fields are perhaps not sufficiently weak for a self narrative in the time scale of several years.

The minimal thickness of the flux tubes for ULF selves associated with  $B_e$  would be roughly of the order of few millimeters, as one finds by scaling the radius for the flux tube of Earth's magnetic field which is about 5 microns.

Also bodily magnetic fields  $B_b$  could be involved. By scaling one obtains for the head's magnetic field an estimate  $(mm/headsize)^2 B_e \sim 10^{-4} B_e$ , which gives fT which is slightly above the thermal noise produced by body. The flux tube would have minimal thickness about 10 cm, the size scale of the head. The cyclotron frequency range would be scaled by a further factor of  $10^4$  factor meaning that the time scale range would be between 10 years and  $10^4$  years!

### 5.3.1 Could the flux tubes of bodily magnetic fields correlate with more abstract levels of self consciousness?

The previous observations combined with the general speculative vision about Indra's web of consciousness stimulate several questions and ideas relating to the role of various magnetic fields associated with body.

1. Could it be that the ULF selves associated with the ionic super-conductors residing at the flux tubes of the bodily magnetic fields  $B_e$  and  $B_b$  (notice also the static magnetic fields of pineal gland and of other organs) belong to the self hierarchy and represent higher level selves contributing to our non-sensory consciousness under ordinary circumstances? This translates to the question whether the flux tubes of the corresponding topological quantized magnetic fields are closed in a relatively small volume as in case of an ideal dipole field or whether part of flux tubes have astrophysical lengths.
2. The above arguments do not pose restrictions on the strengths of the magnetic fields. In case of Earth's magnetic field the magnetic flux tubes have sizes of order of the wavelength associated with a typical cyclotron frequency. Could it be that the interacting MEs and magnetic flux tubes have sizes comparable to the wavelength defined by cyclotron frequency? If this is the case for  $B_e$  and  $B_b$ , the sizes of flux tubes would be astronomical with light day serving as lower bound. One could see the flux tubes of  $B_e$  and  $B_b$  as kind of umbilical cords connecting human bodies with magnetic structures of astronomical size and perhaps also with other organisms. Could one assign the more abstract levels of human consciousness

and long term memories with the ULF selves associated with both the flux tubes of  $B_e$  and  $B_b$  and with MEs? In this view biological organisms would be like sensory-motor organs of this magnetic super organism.

3. Could one possibly test this hypothesis in case of  $B_e$  by studying the interaction of ULF em fields with frequencies above the time scale defined by day? Is the daily rhythm somehow relevant at the level of these em fields? For instance, could the natural 24 hour period certainly associated with ULF em fields of eye define the analog of alpha peak in EEG? Could the strength of the magnetic fields of eye be seen as a result of adaptation to the daily rhythm or is it dictated by the size of eye and flux quantization (there is roughly unit flux over an area of order millimeter squared)?

### 5.3.2 Objection

The bodily magnetic field change with time if the location orientation of the magnetic dipoles are fixed with body. Already the rotation of Earth induces periodic rotation of the magnetic flux tubes  $B_e$  and  $B_b$ . The volitional motion during wake-up period induces further effects.

There are several manners to circumvent this objection.

1. The most convincing manner to avoid the objection is that the flux tubes relevant for ULF consciousness have size at least of order of the wavelength defined by the cyclotron frequency and thus of the same order of magnitude as the size of the corresponding MEs. In this scale the rotating motion for the end of the magnetic flux tube of  $B_e$  or  $B_b$  would have absolutely no significance and magnetic flux tubes would be somewhat like magnetic umbilic cords (like the tunnel involved with the NDE experiences connecting patient to the deceased relatives!).
2. If the magnetic flux tubes in question have sizes comparable or smaller than Earth size, the situation changes. Only in the very special case that the flux tubes rotate around Earth in the direction of equator,  $B_e$  and  $B_b$  could remain stationary and it makes sense to speak about stationary states.
3. One could also consider the possibility that magnetic flux quanta are layer like structures around Earth rather than rotating tubular structures, and have rotational symmetry with respect to the rotations around Earth axis so that it is body which is rotating with respect to these structures rather than these structures rotating with body. In this case it would make sense to assign cyclotron frequencies to the super-conducting ions in question since local magnetic states are certainly possible. In super-conductors of type I near critical temperature complicated layer like flux structures are indeed possible and in [J1, J2, J3] it has been suggested that epithelial sheets formed by cell membrane inside cells correspond to this kind of flux structures.

The obvious question is how the rotation of Earth affects localized stationary states of the super-conducting ions inside co-rotating magnetic flux tubes with sizes smaller than Earth size. Does the description of the system in terms of cyclotron states make sense anymore? Quantum mechanically the ion in a stationary magnetic magnetic field is in radial degrees of freedom like a harmonic oscillator.

1. A simple analog system would be a harmonic oscillator rotating with an Earth and having an oscillation period which is longer than 12 hours. By separating center of mass degrees of freedom one finds that the particle in the rotating oscillator well feels besides the ordinary harmonic force a harmonic force  $m\omega^2\bar{r}_{cm}$  which means that the complete solution to the equations of motion is superposition of the harmonic oscillator motion plus a periodic oscillatory term with the frequency of the external force. The average motion is therefore just the rotating harmonic oscillator motion.

2. In quantum case one has harmonic oscillator coupled to an external harmonic force having a frequency much larger than the oscillator frequency. Time dependent perturbation theory allows transitions only between the states whose energy difference  $n\omega_0$  equals to the forcing frequency and transitions thus possible only if one has  $\omega = n\omega_0$ . Thus no quantum jumps would occur in the generic case.
3. The guess motivated by these considerations is that the magnetic state in a rotating magnetic field is in a good approximation obtained by applying time dependent rotation to the ordinary magnetic state and that in the time scale defined by the cyclotron frequency the average effects to the state cancel also now. Thus effective adiabaticity holds true.

### 5.3.3 Further questions related to vision

One can make several interesting questions related to vision and the magnetic fields of eye.

1. What is the role of the rapid eye movements during REM sleep, in particular during dreams? Could it be that the communication of long term memories from ULF level is involved with dreams and that the rhythmic eye movements are essential for establishing this communication?
2. The motor control associated with eyes is decoupled from the motor control of the remaining body. Therefore persons who are totally paralyzed can still move their eyes and can even communicate in this manner. Could the special role of the eye-motorics relate to the remaining ability to stay in contact with ULF selves associated with eyes?
3. What is the interpretation of the rays of light characterizing the visual perception of intense light. Perhaps there is some natural explanation for this but since I do not know about it, I can entertain myself with the idea that these rays could directly correspond to MEs representing rays of light and connecting me with the objects of the external world. The correspondence between sensory experience and reality would be amazingly simple, if this is true.

### 5.3.4 NDE experiences and magnetic consciousness

NDE experiences [41, 42] involve vision in an essential manner. This suggests that the dominating component of NDE consciousness could correspond to ULF selves associated with  $B_e$  and or  $B_b$  and give rise to the typical bird's eye of view about own body involved with the OBE and NDE experiences. The cyclotron frequency time scale associated with  $B_b$  would indeed fit with the life review experienced in NDE experiences. Body would be seen by ULF selves in bird's eye of view through the magnetic flux tubes of  $B_e$  and  $B_b$ . There would be a strange reciprocity resembling to the reciprocity encountered in the techniques of radio communications where the antennae sending messages can also serve as receiving antennae. NDE experiences involve also meeting of the dead relatives. Magnetic flux tubes can connect patient also to other organisms. and it would not be too surprising if magnetic flux tubes starting from the body could serve as an umbilic cord connecting the patient with living relatives or magnetic structures representing deceased relatives.

NDE experiences involve also the experience of travelling through a tunnel. The tunnel is experienced also during epilepsy and migraine, during meditation and relaxed state of mind, and with certain drugs like LSD, phencyclidine and mescaline.

I have also personal 'tunnel experiences' every-daily: when I close my eyes in a half-meditative state achieved by writing at computer terminal, I can see a dim flow consisting of points. Typically this flow enters to or emerges from a tunnel. It can be rotating spiral like flow or simple sink or source. Source or sink can be also linear structure. The experience is not stable and tends to

fade away all the time, and after few minutes I am not anymore able to achieve it. During my great experiences this flow was much more complicated and completely visible and formed a stable background of the ordinary visual experience and of hallucinatory visual images.

There is however no experience of entering into the tunnel in this case so that the tunnel need not be the same as encountered in NDEs. I have pondered quite a many times about the possible interpretation of this background flow. The basic observation was that it resembles liquid flow to a very high extent. Liquid flows are usually incompressible in an excellent approximation and this means that the velocity field is divergence free. This is the basic property of also magnetic fields and means that magnetic flux through a circuit moving along magnetic flux lines is conserved. This has stimulated the obvious guess that the background flow indeed represents magnetic field. The question which I have not made is whether this magnetic field resides inside my brain or outside it. In light of the above considerations the most natural answer to the question is that the magnetic field visualized by the flow is precisely where it seems to be. The flow would represent nothing but the magnetic field associated with my own eyes or more probably head, or rather how the self associated with the flux tubes of this magnetic field experiences the world.

The thickness of the flux tubes of  $B_b$  would be roughly the size of the head and this fits with idea that the tunnel experience represents directly the magnetic flow without any scaling factors involved. The fractality of TGD Universe suggests that these magnetic fields contain flux tubes of stronger magnetic fields inside them, so that the tunnel experience would represent the flux tubes of these magnetic fields experienced as sub-selves by the ULF self contributing to my visual consciousness in this altered state of consciousness. Of course, it might well be that also during the ordinary consciousness the experiencer is this magnetic ULF self and that sensory input dominates the content of the conscious experience and creates the illusion about body as self. In the absence of a sensory input the contents of consciousness of a clinically dead person is determined by these magnetic field and bird's eye of view about body results.

What remains after the physical death could therefore be determined by the magnetic fields involved with body. Magnetic flux conservation allows configurations of the closed magnetic flux loops containing ionic super-conductors as the counterpart of soul continuing existence after death. Wormhole magnetic fields and p-adic variants of these magnetic fields would also make it possible to store information about the magnetic fields originally associated with body. The overall view suggesting itself that our bodies are like sensors and motor organs of a gigantic electromagnetic organisms of astrophysical size and represent its sub-selves (mental images). This interpretation conforms with the fact that in EMDR method rhythmic eye movements induce experiences involving the meeting of deceased relatives [43].

The experimental study of what happens to the magnetic fields associated with eyes, head and other body parts after the physical death would obviously provide interesting information in this respect, perhaps one can someday even develop refined methods of communication with the deceased.

### 5.3.5 What about magnetic fields of heart?

The magnetic fields associated with eyes are not the only bodily magnetic fields with peak intensities higher than the non-static magnetic fields generated by brain. Heart generates a periodically oscillating magnetic field  $B_h$  of order  $.5 \times 10^{-10}$  Tesla which is almost ten times higher than the static magnetic field generated by eyes. I do not know whether  $B_h$  contains a static component and if so, what is its strength. In any case, the absence of the static component means that the possibly super-conducting ions inside flux tubes of heart's magnetic field are in a periodically oscillating dipole field (most probably with respect to the geometric time!).

Also here my 'great experience', which has turned out to be an extremely valuable repertoire of altered states of consciousness, provides an illustrative example. During the second great experience which lasted only one night, I experienced what might be called 'heart consciousness'.

In the beginning of the experience my whole consciousness was filled by the rhythmic '..aqua-aqua-aqua..'. It took some time to recognize that this rhythm was the rhythm of my own heart. Involved was also the mystical experience about the fundamental importance of water for life (said jokingly, heart is an organ specialized to deal with liquid!) and the precognition of the notion of infinite primes. Could it be that the MEs associated with heart dominated the contents of my consciousness during this experience.

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