Biosystems as macroscopic quantum systems

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Abstract

In this article the still developing TGD based view about biosystems as macrosystems is summarized. The notion of manysheeted spacetime together with the notion of topological field quantization allows to understand biosystems as macroscopic quantum systems. Non-atomic spacetime sheets can have extremely low temperatures and are thus excellent candidates for the seats of various macroscopic quantum phases. Especially important macroscopic quantum phases are various ionic superconductors at the flux tubes of Earth's magnetic field having thickness of order cell size. The so called massless extremals (MEs) are TGD counterparts of light rays. MEs are ideal for both classical and quantum communication purposes, MEs give rise to quantum holograms, the lightlike vacuum currents accompanying MEs generate coherent photons; MEs act also as templates for Bose-Einstein condensates of photons and for coloured configuration space photons predicted by TGD. Also Z^0 MEs are possible and might be a crucial element of bioconrol (the synchronous firing of neurons might be induced by Z^0 ME acting as a pacemaker).

Life can be understood as a symbiosis of the hierarchy of MEs, superconducting magnetic flux tube structures and of the ordinary biomatter. MEs are at the highest level of the control hierarchy and control superconductors by inducing super currents and magnetic quantum phase transitions and by acting as Josephson junctions. The superconducting flux tube structures in turn control ordinary biomatter via ionic flow equilibrium. Magnetic quantum phase transitions allow place coding by a varying cyclotron frequency (flux tube thickness) and the models for sensory representations, long term memory, frequency imprinting and electromagnetic aspects of DNA rely on the hierarchy of magnetic laser mirrors consisting of MEs parallel to magnetic flux tubes. Spacetime sheets containing liquid crystal water provide representations for rotational, conformational and vibrational aspects of biomolecules and amplify the em fields associated magnetic mirrors providing similar representations for biomolecules. Magnetic mirrors mediate a resonant interaction between molecules having similar transition frequencies. This makes possible electromagnetic recognition mechanism which could be crucial in DNA replication, transcription of RNA into proteins and for the functioning of the immune system.

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1 Introduction

The hypothesis that biosystems are macroscopic quantum systems is a key assumption in Topological Geometrodynamics (TGD) inspired theory of consciousness. TGD approach however differs from many competing approaches (such as Penrose-Hameroff approach assuming that microtubular level is somehow special) in that an entire fractal hierarchy of macroscopic quantum systems made possible by the notion of manysheeted spacetime is predicted. The key idea is that the non-atomic spacetime sheets can have extremely low temperatures unlike the atomic spacetime sheet and thus allow various macroscopic quantum phases.

Consciousness is assumed to involve also physics of the TGD counterparts of the classical em fields at much longer length scales than body length scale. Topological field quantization means that field-particle duality is realized also classically and topological field quanta represent Bohr orbits of classical fields identifiable also as coherence regions of field. The magnetic flux tube structures representing topological field quanta of magnetic fields and 'massless extremals' (MEs) representing topological field quanta of classical radiation fields are central to the whole approach. Superconducting magnetic flux tube structures define what might be called 'magnetic body' whose size is naturally measured using Earth size as unit. MEs define also quantum holograms and correspond to the highest level in the symbiosis of MEs, magnetic flux tube structures and ordinary matter at atomic spacetime sheets.

The interaction of MEs with magnetic flux tube structures (MEs can act as Josephson junctions and induce supra currents and magnetic quantum phase transitions) and manysheeted ionic flow equilibrium are fundamental quantum control mechanisms. What is remarkable that there is direct experimental evidence for this picture: actually the anomalous effects of ELF em fields on biomatter at multiples of cyclotron frequencies of Earth's magnetic field [Cherry, Blackman (1994)] and the findings challenging the notions of ionic channels and pumps [Pollack] were crucial input in the construction of the view about the symbiosis of MEs, magnetic flux tube structures and ordinary matter. Learning about various homeopathic effects [Benveniste$_1$ *et al*, Smith] meant a further detailing of this view.

This picture is absolutely essential for the recent model of sensory representations (see the chapter "Quantum model for sensory representations" of [cbook] and the chapter "Spectroscopy of consciousness" of [cbook2]) in which magnetic flux tube structures outside brain serve as sensory canvas to which MEs project sensory input by place-frequency coding by generating magnetic quantum phase transitions at magnetic flux tubes at distance coded by cyclotron frequency scale (local thickness of magnetic flux tube). MEs are also essential in the model of mesoscopic EEG pattern serving as correlates for 'features'. Z^0 MEs oscillating at kHz frequency are in a central role in the model of neuronal syncronization and in the model how intentions represented by p-adic spacetime sheets are transformed to actions.

2 General principles and ideas

In this section the general principles and ideas behind TGD based view about biosystems as macroscopic quantum systems are summarized.

2.1 Quantum criticality

Hierarchies involve masters and slaves. Master-slave hierarchy, defined in the spirit of Haken's theory of self-organization, is indeed a natural dynamical correlate of the self hierarchy. Quantum control is possible only if the system is initial value sensitive, that is critical. TGD universe is indeed quantum critical: this also predicts the existence of macroscopic quantum phases in all length scales. Quantum criticality fixes the value of the Kähler coupling strength α_K as a parameter analogous to critical temperature and makes TGD a unique theory (as a matter fact, entire hierarchy of values of α_K corresponding to p-adic length scale hierarchy appears).

1. $1/f$ *noise and criticality*

$1/f$ noise, which seems to be a universal phenomenon popping up in all kinds of contexts, provides direct evidence for quantum criticality. The standard explanation as self-organized criticality [Kerlesz and Kiss] is subject to a severe criticism since criticality by the definition is something unstable. Situation changes if the fundamental constant of Nature is analogous to critical temperature: there exists simply no perturbations external to the entire universe changing the value of a fundamental constant (see the chapter "Quantum Control and Coordination in Biosystems" of [cbook]). There is a beautiful connection with information theoretic aspects: quantum critical universe is in a well defined sense the most intelligent and interesting universe that can exist in TGD framework (see the chapter "Information theoretic aspects of TGD inspired theory of consciousness" of [cbook]).

2. Spin glass analogy

Spin glass analogy could be regarded as one aspect of quantum criticality and states the TGD universe can be regarded as quantum spin glass. Quantum spin glass is phenomenologically characterized by its fractal energy landscape containing valleys inside valleys ... valleys giving rise to extremely complex system. Quantum self-organization can be described as motion in this kind of energy landscape. Biosystem as a self-organizing quantum critical spin glass together with the notion of manysheeted spacetime provides rather restrictive general guide line for attempts to construct a general theory of bio-control and -coordination.

2.2 p-Adic length scale hypothesis

p-Adic length scale hypothesis states that the p-adic length scales $L_p = l\sqrt{p}$, $l \simeq 10^4$ Planck lengths, correspond to typical sizes for spacetime sheets and that primes $p \simeq 2^k$, k prime or power of prime, are physically preferred. Mersenne primes $M_n = 2^n - 1$ are especially important in elementary particle physics context. More generally, also the n-ary p-adic length scales $L_p(n) = p^{n/2}l$ are preferred length scales physically and give rise to fractality (see table 1 at the end of the article). Also p-adic time scales $T_p(n) = L_p(n)/c$ are of fundamental importance.

p-Adic length scale hypothesis provides a quantitative realization for the hypothesis about the hierarchy of spacetime sheets and is in key role in TGD inspired theory of consciousness. In particular, biologically important length scales correspond to p-adic length scales. p-Adic length scale hypothesis generalizes to the case of Gaussian primes (primes for the ring of complex integers) and it turns out that the length scale range between cell membrane thickness and cell size contains as many as four Gaussian Mersenne primes (see the chapter "Biological Realization of Self Hierarchy of [cbook]). Important resonance frequencies in EEG in turn correspond to p-adic time scales (see the chapter "Spectroscopy of Consciousness" of [cbook2]) (see table 2).

It is not too difficult to understand that p-adic spacetime sheets should have typical sizes given by the p-adic length scale hypothesis. p-Adic length scale hypothesis however says more than this: also *real* spacetime regions have typical size scales given by p-adic length scales and are in some sense characterized by p-adic primes p. If p-adic spacetime regions indeed give rise to cognitive representations, one can understand how this could result. For instance, the CP_2 type extremal representing elementary particle is a real spacetime region which topologically condenses on k-adic spacetime sheet of size of order $L_k = \sqrt{k}l$. This spacetime sheet in turn condenses or is glued along boundaries on spacetime sheet of size L_p, $p \simeq 2^k$ defining typical elementary particle length scale. This spacetime sheet can transform from real to p-adic form and vice versa in quantum jumps. p-Adic to real phase transitions have interpretation as kind of volitional acts transforming p-adic intention to a real action and intention and cognition are unavoidably present already in elementary particle length scales.

For a summary of TGD, p-adic aspects of TGD and TGD inspired theory of consciousness see the online books "Topological Geometro-Dynamics" [TGD], "TGD and p-Adic Numbers" [padTGD] and "TGD inspired theory of consciousness with applications to biosystems [cbook].

2.3 p-Adic evolution

The increase of the finite prime corresponds to a 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. The identification of p-adic physics as physics of cognitive representations adds considerable concreteness to this heuristic vision. A more precise formulation requires however the introduction of a rather exotic looking concept of infinite prime.

The infinite size of the Universe means that the corresponding p-adic length scale and thus also p-adic prime P characterizing entire Universe must be infinite. This (there are also other reasons) forces to introduce the notion of infinite primes and corresponding p-adic topologies (see the chapter "Infinite primes and consciousness" of [cbook])). Infinite primes are not so weird objects as one might think first. They are actually in one-one correspondence with certain kind of polynomial primes studied for centuries by number theoreticians and this correspondence allows to assign Fock space states of quantum theory spacetime surfaces which are purely geometric objects (see the chapter "TGD and Number theory" of [TGD]).

Given infinite prime P have in a well defined sense decomposition into finite primes

labelling spacetime sheets labelled by finite primes p: the most plausible interpretation is that these spacetime sheets have topology fluctuating between real and p-adic topology. The infinite-dimensional configuration space of 3-surfaces is assumed to decompose into regions D_P characterized by infinite p-adic primes P. In particular, this occurs in zero mode degrees of freedom characterizing spacetime surface classically. In each quantum jump localization in zero modes occurs and means a localization into a definite sector D_P of the configuration space. Since the number of the infinite primes larger than P is larger than those smaller than P, P tends to increase in a statistical sense.

This statistical growth of the infinite prime P characterizing Universe allows to understand evolution as two kinds of processes.

a) The first process is effectively continuous and corresponds to a gradual increase of the finite p-adic prime associated with the existing physical system and inducing the increase of infinite prime.

b) The second process is discontinuous and involves the emergence of entirely new p-adic spacetime sheets so that new finite prime appears in the decomposition of infinite prime and increases its size.

The gradual increase of the cell size during evolution (case a)) *resp.* the sudden emergence of multicellular structures (case b)) provide examples of these two aspects of the evolution.

2.4 Self-hierarchy, quantum self-organization, and dissipation as a Darwinian selector

The breakthrough idea in TGD inspired theory of consciousness was the notion of self defined as a system able to remain unentangled during the unitary quantum "time evolutions" U (U process of Penrose) associated with quantum jumps $\Psi_i \to U\Psi_i \to ....\Psi_f$. The notion of self leads to the notion of self hierarchy and the interpretation of quantum self-organization as evolution of selves. Spacetime surface decomposes into regions belonging to real and p-adic number fields. The unentangled subsystems resulting in quantum jump have spacetime sheets as geometric correlates.

1. Self hierarchy and sharing of mental images

Given unentangled subsystem defines a hierarchy tree with levels labelled by p-adic primes. Each p-adic prime defines p-adic length scale characterizing the typical size of the real spacetime sheets at the corresponding level of the hierarchy. The induced metric associated with the wormhole contacts connecting topologically condensed spacetime sheet to the larger spacetime sheet has Euclidian signature whereas the induced metric of the spacetime sheets has Minkowskian signature. Wormhole throats are therefore surrounded by causal horizons with a degenerate induced metric. This forces a generalization of the subsystem concept based on the notion of the p-adic length scale cutoff. Given spacetime sheet 'sees' the topologically condensed spacetime sheets as effectively point like objects, and self hierarchy corresponds to a hierarchy of state spaces with length scale cutoff.

The highly nontrivial implication is that the subsystems of separate unentangled systems can entangle if they correspond to the same value of the p-adic prime. This implies that the p-adic hierarchy trees associated with selves can have horizontal connections. More concretely, separate selves can share fused mental images resulting in the quantum entanglement of their subselves. The sharing of the mental images makes possible genuine

quantum communications at all levels of the self hierarchy. This mechanism underlies widely different processes such as molecular recognition, remote mental interactions, and the generation of social structures.

2. Darwinian selection

A system possessing self (and possibly having subselves) 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. Protein folding to a definite final configuration depending only very weakly on the initial state is a good example of a self-organization process.

3. Justification for the use of cybernetic concepts

One of the important consequences of the quantum self-organization is that it provides justification for the use of cybernetic notions in the description of biosystems. Many neuroscientists (and even physicists!) who claim that it is possible to understand brain in terms of classical notions fail to realize that the notions used are very far from classical. For instance, Hodkin-Huxley equations for nerve pulse involve in absolutely essential manner dissipation. It is the very presence of self which makes dissipation possible! Actually any description involving kinetic equations and irreversibility instead of classical field equations implicitely assumes that system is part of self! In particular, the notions of feedback, neural circuits, excitation, inhibition, signalling,... are all notions, which are not possible in the context of classical physics. The basic signature of consciousness is that it makes the world look like classical in the eyes of neuroscientist!

2.5 Manysheeted spacetime and topological field quantization

One of the fundamental implications of the manysheeted spacetime concept is the prediction that atomic spacetime sheets larger than atomic spacetime sheets contain very low densities of various ions. This makes possible very low temperatures provided the rate for the exchange of energy between spacetime sheets is low enough. Hence the non-atomic spacetime sheets are excellent candidates for seats of superconductors and other macroscopic quantum phases.

1. Topological field quantization as Bohr orbitology for classical fields

Topological field quantization assigns to various quantum concepts rather precise geometrical correlates. Absolute minimization of the Kähler action implies that the spacetime surface $X^4(X^3)$ associated with a given 3-surface X^3 satisfies generalized Bohr rules so that something generalizing Bohr model of atom to the level of classical fields results as an exact part of the quantum theory. The fact that the induced gauge fields are only locally equivalent with ordinary gauge fields implies that the imbeddings of say electromagnetic field are not globally possible but imbedded field decomposes into topological quanta (spacetime surfaces with boundaries). Also virtual and real particles of quantum field theories have classical correlates. In particular, virtual particles corresponds to cognitive spacetime sheets representing geometric correlates for selves. Furthermore, topological field quanta are characterized by vacuum quantum numbers very much analogous to ordinary quantum numbers and topological field quantum defines a unique selection of

quantization axes for spin and color quantum numbers. Topological field quanta have a natural interpretation as coherence regions for classical fields so that the nebulous notion of quantum coherence in Maxwell's electrodynamics is replaced with a mathematically precise concept.

2. Topological field quanta and EEG

The p-adic hierarchy of the spacetime sheets indeed provides a geometrical and topological realization for the self hierarchy. The real power of the notion of topological field quantization came apparent, when it became clear that the topological field quanta associated with ELF em fields with frequencies in EEG frequency range must be correlates of our subselves (mental images): they have however sizes measured using Earth size as a unit. This encourages a radical reconsideration of the basic assumptions of neuroscience. What makes this radical rethinking unavoidable is that one can indeed understand the important frequencies of the EEG and one ends up with a quantitative model for cognition and sensory experience. In particular, a general quantum model of coordination and control emerges.

3. MEs and magnetic flux tube structures

The first important class of topological field quanta are magnetic flux tubes which are identified as carries of superconducting ionic BE condensates. They form a fractal hierarchy. Massless extremals (MEs) are second extremely important class of topological field quanta and are for the clasical radiation fields what Bohr orbits are for the atom. There is a close connection with the geometric optics. MEs are ideal for communication purposes both at classical and quantum level. The lightlike boundaries of MEs are carriers of superconformal and supercanonical representations having gigantic almost-degeneracies broken only by the non-commutativity of Poincare transformations and supercanonical transformations.

The boundaries of MEs are quantum holograms in the sense of quantum gravity. The lightlike vacuum currents associated with MEs in turn define dynamical classical holograms and there are good reasons to expect that MEs make possible quantum teleportation of electromagnetic states. Supercanonical states are genuinely quantum gravitational states defined in the space of 3-surfaces whereas magnetic states (actually all states predicted by quantum field theories) can be effectively reduced to states associated with single 3-surface. This means that MEs are definitely above the superconducting magnetic flux tubes in the hierarchy of consciousness and should control what happens at magnetic flux tubes.

It seems that MEs and magnetic flux tube structures appear in parallel pairs defining what might be identified as TGD counterpart for the laser mirrors introduced in [Gariaev *et al*] and are fundamental biological structures in all length scales.

4. Join along boundaries bonds and wormhole contacts

The formation of join the along boundaries bonds between the spacetime sheets possibly representing different levels of the self hierarchy could be one of the basic mechanism of control and coordination. The interpretation as a prequisite of bio-feedback, understood in very general sense, is very suggestive. The presence of the join along boundaries bonds makes possible transfer of various particles between spacetime sheets in question (for instance, atomic and superconducting spacetime sheets). Join along boundaries bonds make also possible communication both in classical and quantum sense and MEs are excellent candidates for join along boundaries bonds.

Wormhole contacts of size of order CP_2 size connect spacetime sheets to each other and play important role in mediating classical gauge fluxes between various spacetime sheets (also join along boundaries bonds can function in this role). Wormhole contacts are perhaps not so important from the point of view of biocontrol as I though originally. There is however a possible exception: wormhole Bose-Einstein condensates near the boundaries of three-surfaces could control the shape of the boundary of three-surface and thus that of 3-surface. For instance, protein conformations could be controlled by this kind of mechanism. A model for this kind of control has been discussed in the chapter "A model for Quantum Control and Coordination" of [cbook]. Note that electronic surface super conductors could replace wormhole BE condensate in this model (electrons are very mobile as required).

5. Spacetime sheets form weakly coupled pairs of superconductors

Spacetime sheets connected by join along boundaries bonds form a system very similar to two (weakly) coupled super conductors connected by Josephson junctions. This suggests that that Josephson currents between the spacetime sheets are crucial for the coordination. The Josephson currents would act effectively as an interaction Hamiltonian representing harmonic perturbation coupling to each other single particle state basis localized in either super conductor and having overlap only in the Josephson junctions. If the frequency of the Josephson current acting as a harmonic perturbation of super conductors, equals to the energy difference for single particle states of either super conductor, the standard rules of quantum mechanics predict the possibility of quantum jumps between these states.

When the frequency of the Josephson current is not equal to energy difference, quantum jumps do not occur at the limit of an infinitely long interaction time. This suggests that harmonic perturbations provide a general mechanism of quantum coordination and control: by tuning the frequency of the Josephson current quantum master can 'wake-up' the quantum slave. Strong Josephson currents can induce failure of flow equilibrium and lead to non-equibrium process such as generation of nerve pulse. The constructive interference for parallel Josephson currents makes possible biological clocks, alarm clocks and comparison circuits (see the chapter "Quantum control and coordination" of [cbook]).

A unique signature of weakly coupled superconductors is the presence of ionic currents with anomalously low dissipation. As already mentioned, the findings challenging the notions of ionic pumps and channels could be understood as evidence for Josephson junctions between cell interior and exterior.

2.6 Self-referentiality and spacetime topology

The notion of self-referentiality is one of the deepest and most fascinating notions of mathematics but for some reason it has not catched 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.

2.6.1 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.

a) TGD predicts the existence of negative energy spacetime sheets, in particular MEs. The prediction is based solely on the assumption that the spacetime is representable as a 4-surface.

b) 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.

c) 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.

d) Classical superposition for em fields could mimick 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 $f = c/L$.

e) The phase increments of the complex CP_2 coordinates around closed loops could represent phase increments of spinor fields and superconducting order parameters around them as suggested in the chapter "Macroscopic Quantum Phases and Geometry of CP_2" of [TGD].

f) 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 2π rotation but in 4π 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 correesponding 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 manysheeted spacetime 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 biomolecules, 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 spacetime

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.

One can go even further and ask whether even quantum jumps and their sequences (selves) could have representation at the spacetime level. The inherent nondeterminism of the p-adic field equations indeed suggests that p-adic spacetime regions could represent quantum jump sequences and thus the contents of consciousness of self. The classical nondeterminism of Kähler action in real context in turn could relate to the symbolic, linguistic representations of thoughts transforming cognition to sensory experience. In this picture the fundamental self referentiality of cognitive consciousness (it is possible to become conscious about being conscious of something) could be understood since configuration space spinor fields contain in turn information about spacetime representations for the contents of consciousness of self and the self reference loop thus closes: sequences of quantum jumps between quantum histories are represented as properties of single quantum history.

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

a) Atoms and biomolecules would carry a representation about their own theory based on MEs. Since MEs carry lightlike four-momentum, strict momentum conservation would require that they 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 momenta involved are however rather small could be absorbed by biomatter in which case one would have $f = E_B$. The frequencies associated with ME come as multiplies 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.

b) 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.

c) 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.

2.6.2 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. Do also other molecules than DNA represent biological information?

a) The manysheeted 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. 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.

b) 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 biomolecules.

This picture gives a justification for the suggestion of Peter Gariaev that DNA is accompanied by laser mirror pairs [Gariaev *et al*]. 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.

2. Overunity energy production and metabolism

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 spacetime 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 subselves to larger subselves. The bound states correspond to spacetime sheets having typical sizes given by the p-adic length scale hypothesis and the process means basically spacetime 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 overunity 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.

Biology provides an important area of applications. Biomolecules and cells are 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 biomolecules 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 would be a particular example of this process. Thus a natural path to follow in the attempts to build new energy technologies is to try to mimick what living nature has already achieved. This kind of energy production would be also wasteless and support evolution.

3. What about the role of gravitational interaction?

Gravitation has been suggested to have a key role in living matter and also TGD suggests this but the direct and decisive connection to experiment is still lacking.

a) Quantum gravitational states are state functionals in the world or worlds (3-surfaces). The so called supercanonical degrees of freedom correspond to the degrees of freedom distinguishing TGD from string models and quantum states in these degrees of freedom represent genuine quantum gravitational degrees of freedom. The model for color qualia relies on this kind of states (colored photons).

b) TGD predicts that classical fields generate classical gravitational fields which give additional contribution to the gravitational interaction mediated by graviton (CP_2 type extremal) exchange. The gravitational constant involved with this 'electrogravity' is by a factor 10^8 larger than the ordinary gravitational constant so that electrogravity and its Z^0 variant might be of fundamental importance in living matter.

c) 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 gravitatons by MEs might have a role to play in the quantum physics of living matter.

2.7 Quantum control and coordination in manysheeted spacetime

The third part of [cbook], in particular the chapter "A Model for Quantum Control and Coordination" contains detailed material about the topics involved. Also the second part

of [cbook2] is devoted to the related topics. It must be emphasized that this part of theory is still more like a bundle of speculative ideas than a coherent theory.

1. Life as a symbiosis of MEs, magnetic flux tube structures and ordinary biomatter

Life as a symbiosis of the fractal hierarchies of MEs and magnetic superconductors with biomatter provides a possible dynamical model of the coordination and control. MEs would represent the highest hierarchy level controlling magnetic superconductors which in turn control and coordinate the behaviour of the non-superconducting matter at atom spacetime sheets by ionic flow equilibrium. All atoms are Z^0 ions and also Z^0 superconductivity is possible: thus the control of also neutral atomic and molecular densities by Z^0 MEs is possible.

The unique signature of a genuine control activity would be the presence of p-adic to real phase transition for some spacetime sheet, for instance p-adic ME representing intention transformed to real ME representing action at some level of the self hierarchy. The control operations presumably involve momentary loss of flow equilibrium: the simplest control mechanism is 'let it go for a moment'. What this means that the ionic flow equilibrium for ohmic currents at atomic spacetime sheets and supra currents at non-atomic spacetime sheets fails for a moment. Nerve pulse transmission could be basic example of this kind of effect.

The great challenge is to identify the basic interaction mechanisms making possible quantum control and coordination and to understand the roles of the participants of this symbiosis. MEs are certainly responsible for the highest control level of control, ionic supra currents for the direct control of what happens at atomic spacetime sheets and the ordinary biomatter at atomic spacetime sheets is expected to provide energy in the symbiosis with MEs and magnetic flux tubes, in particular amplify the em fields associated with MEs.

2. How MEs control and coordinate?

MEs can perform control and coordination in numerous manners.

a) Join along boundaries contacts can and must allow also the flow of direct supra currents or Ohmic currents above critical velocity. SQUID type circuit is a good analog for the situation. A very natural interaction mechanism between MEs and superconducting circuits is magnetic induction ($\Phi = LI$ modulo flux quantum), which induces supracurrent guaranteing the quantization of magnetic flux in the circuit. MEs can induce control action leading to a new ionic flow equilibrium.

b) The em fields associated with MEs can induce magnetic quantum transitions possibly amplified to quantum phase transitions. Of course, also other than magnetic quantum transitions might be amplified by the quantum coherence of the BE condensate. These transitions could very effectively modulate the chemical properties of, say enzymes. These quantum phase transitions are crucial in the model of sensory representations based on the notion of magnetic sensory canvas: these representations could occur in several length scales.

c) The superconducting electrons at spacetime sheets associated with the molecular spacetime sheets could be in electronic flow equilibrium with atomic spacetime sheets and control the conformation of the molecule very effectively. MEs in turn could control the supra currents by magnetic interaction and thus the conformations of molecules. Thus the superconducting magnetic flux tubes are taylor-made for biochemical control.

d) MEs can act as Josephson junctions inducing possibly time dependent potential

difference over junction and thus Josephson current oscillating with frequency equal to the potential energy difference. MEs can act as pacemakers. The syncronization of neural firing with precision of order millisecond could be cause by Z^0 MEs which couple strongly with structures having size of few microns.

e) As already explained, MEs generate coherent photons and these patterns of coherent light interact with ordinary biomatter and superconducting magnetic flux tubes and could serve as control commands.

f) There is also a feedback loop from the magnetic superconductors to MEs since quantum phase transitions induce emission of photons which can Bose-Einstein condense to MEs carrying collinear BE condensates of photons (and also gravitons). For instance, endogeneous NMR spectroscopy and its generalizations could be possible in this manner if magnetic flux tubes have varying thickness! This endogenous NMR might be basically responsible for chemical senses at some levels of the self hierarchy.

3. Magnetic mirrors formed by MEs and magnetic flux tubes

The MEs parallel to magnetic flux tubes give rise to TGD counterparts of laser mirrors and the fractal hierarchy of these structures are in key role in TGD inspired theory of consciousness. Both our long term memory and water memory can be seen as a particular realization of same mechanism based on these magnetic mirrors. These magnetic mirrors are also in crucial role in the model of sensory representations (see the chapter "Spectroscopy of Consciousness" of [cbook2]). Also the laser mirrors assigned with DNA [Gariaev *et al*] can be identified as magnetic mirrors.

The scale of magnetic transition frequencies depends on the thickness of the magnetic flux tube (by magnetic flux quantization). This makes it possible to code the position along the magnetic flux tube by the scale of the magnetic transition frequencies. This frequency coding is in key role in the TGD based model for sensory representations based on the notion of magnetic sensory canvas outside the body. Various mental images (primary qualia like colors and more complex features) entangle with MEs projecting from subunit of brain to its magnetic sensory canvas. The direction of ME and its fundamental frequency (length) code for the position of the object of perceptive field.

4. Liquid crystal water blobs represent and amplify

The basic characteristic of living system is the ability to form representations for objects and events of external world. Water is the basic element of life so that one expects that evolution of life means also the development of the representations of chemical world provided by water. The attempt to understand the effects related to frequency imprinting [Smith] led to a considerable progress in the understanding how this might be achieved.

The basic idea is that the spacetime sheets containing water in liquid crystal form can provide representations for both the rotational and vibrational spectra of molecules. Charged LC water spacetime sheets are characterized also by cyclotron frequencies below those associated with atomic ions and could be closely related to the biological rhytms above second time scale. These water blobs can in turn amplify em fields of MEs at these transition frequencies. This makes possible resonant interactions between molecules having similar portions of frequency spectrum. This kind of resonant interaction might explain the ability of biomolecules to recognize each other (immune system, translation of RNA to proteins).

3 Massless extremals

Massless extremals (MEs) have were originally introduced as structures associated with microtubules (see the chapter "Quantum Antenna Hypothesis" of [cbook]) but have gradually taken dominating role in TGD based model of living matter. Therefore they deserve a separate section. The reader can however skip this somewhat technical section at first reading.

3.1 What MEs are?

Massless extremals (MEs) are an extremely general solution set of field equations associated with absolute minimization of Kähler action [TGD] and representing various clasical gauge – and gravitational fields as induced gauge fields (see the chapter "Quantum antenna hypothesis" of [cbook]). Being scale invariant, MEs come in all size scales. The simplest geometry has axial symmetry in the sense that CP_2 coordinates are arbitrary functions of two variables constructed from Minkowski coordinates: lightlike coordinate $t - z$ and arbitary function of the coordinates of the plane orthogonal to the z-axis defining the direction of propagation. The polarization of the electromagnetic field depends on the point of the plane but is temporally constant. Cylindrical MEs represent waves propagating with velocity of light in single direction so that there is no dispersion: preservation of the pulse shape makes MEs ideal for classical communications. There are however much more general solutions which are analogous to orbits of lightfronts emitted from some surface. In this case the local direction of propagation is not constant anymore.

Electric and magnetic parts of various gauge fields are orthogonal to each other and to the direction of propagation. Classical gauge field is sum of a free part plus part having as its source lightlike vacuum current. The time dependence of the vacuum current at given transversal sectionof ME is arbitrary, this is only possible by its lightlikeness. This makes it possible to code all kinds of physical information to the time dependence of the vacuum current. MEs can have finite spatial size and in this case they are classical counterparts of virtual photons exchanged between charged particles and represent classical communication between material spacetime sheets. MEs carry gravitational waves and also classical Z^0 fields propagating with light velocity. Since classical Z^0 force is strong in cellular length scales (nuclear Z^0 charges are not completely screened by neutrinos), Z^0 MEs might make possible biological control in astrophysical length scales.

MEs can also carry constant electric field in but in this case the boundaries of ME contain necessarily the sources of this field. This can be achieved if MEs form double-sheeted structures and wormhole contacts serve as effectively sources of the field. TGD allows the possibility that the two sheets have opposite time orientations and therefore also opposite classical energies. More generally, the exchange of two or more MEs between material spacetime sheets can be such that no net momentum exchange occurs so that the absolute minimum of Kähler action only in a finite region of spacetime and gives rise to new degenerate absolute minimum of Kähler action since ME has vanishing action. This kind of structures are obvious candidates for cognitive and sensory structures since classical non-determinism is localized in a finite spacetime volume. World should be full of MEs with all possible sizes since they have vanishing action: addition of ME with finite time duration yields new absolute minimum of Kähler action since Kähler action does not change in this operation. This suggests that MEs should be of crucial importance in TGD

Universe.

MEs serve as receiving and sending quantum antennae (see the chapter "Quantum antenna hypothesis"). Lightlike vacuum current generates coherent light. Also coherent gravitons are generated. MEs serve also as templates for Bose-Einstein condensation of photons and gravitons with momenta parallel to the lightlike vacuum current. Linear structures, say DNA and microtubules, and also magnetic flux tubes are natural but not the only candidates for structures accompanied by MEs. Since MEs are massless, they carry maximal possible momentum. This makes exchange of ME ideal mechanism for locomotion. The possibility of negative energy MEs is especially fascinating since it suggests 'buy now, pay later' mechanism of energy production: perhaps living matter uses MEs to generate coherent motions (see the chapter "Model for Quantum Control and Coordination").

3.2 MEs and p-Adic physics

The transformation of p-adic MEs to real ones could conserve energy if pair of real MEs with opposite energies is generated. One can consider also processes in which p-adic ME associated with the real system (say charged particle) changes to real ME such that the charge particle takes the recoil energy and momentum. This would represent the most primitive transformation of intent to action.

A general vision providing quantitative grasp about p-adic–real transformations is one of the great challenges for TGD inspired theory of consciousness. The interpretation of positive/negative energy MEs as classical correlates for photon emission/absorption processes could help to build up such a view. Positive and negative energy MEs could correspond to bosonic creation and annihilation operators and manysheeted spacetime could provide a geometric correlate for the expasion of interacting fields in terms of the oscillator operators.

3.3 MEs as Josephson junctions

MEs can act as Josephson junctions between biostructures. Since the electric field of ME is orthogonal to the direction of the propagation of vacuum current, the Josephson junction with potential difference is formed most naturally when super conductors are joined by join along boundaries bonds to ME in the direction of the electric field associated with ME. MEs can in principle be arbitrary thin so that the thickness of Josephson junction can be much smaller than the dominating wavelength of ME.

ME's electric and magnetic fields can contain also constant component. In this case ME is necessary double sheeted since constant electric fields are created by the rotating wormhole throats at the boundaries of ME serving as effective charges. These MEs could give rise to the Josephson junctions with constant potential difference. An attractive hypothesis is that these ME pairs have opposite time orientations so that total energy of ME pair can vanish and can be created from vacuum without any energy cost. Clearly, these structures are cognitive in the strong sense of the word.

This coding of the transversal potential difference associated with ME pair to Josephson frequency could be fundamental information coding mechanism in living matter. ME pair can contain also oscillating electric field over Josephson junction at magnetic or some other transition frequency so that MEs are ideal for control purposes.

3.4 MEs and exotic representations of supercanonical algebra

TGD predicts two kinds of local supersymmetries. Quaternion conformal supersymmetries are associated with ordinary elementary particles whereas supercanonical representations assignable to the lightlike boundaries of MEs are something new and there is temptation to assign them with the highest levels of self hierarchy, the reason being that they correspond to genuine state functionals in the 'world of worlds'.

1. Exotic representations of p-adic super algebras

The so called exotic representations of p-adic supercanonical and Super Virasoro algebras form excellent candidate for a hierarchy of lifeforms are associated with both p-adic and real MEs (see the chapters "The Possible Role of p-Adic Numbers in Biosystems" of [cbook]). p-Adic representations have interpretation as cognitive representations but also real counterparts of these representations could be important biologically. For supercanonical representations the scaling operator L_0 is *not* assumed to contribute to the mass squared operator unlike for quaternion conformal representations which are associated with the real particles. Otherwise real massses for exotic representations would be astrophysical and real counterparts of these MEs could occur only as pairs of opposite time orientation and vanishing net energy.

In p-adic context and for $L_0 \propto p^n$, $n = 1, 2, ..$, the real counterpart of the scaling eigenvalue is extremely small, being proportional to $1/p^n$ for R_p. Obviously these states are approximately scaling invariant. Indeed, by Fermat's theorem, the integrated p-adic scalings a^{L_0}, a positive integer, act like identity operator modulo $O(1/p)$ corrections. By the inherent fractality of Super Virasoro and supercanonical algebras, one can indeed construct representations of subalgebras spanned by supercanonical and Super Virasoro algebra for which conformal weights are proportional to p^n.

2. Mersenne primes are especially interesting

Mersenne primes $M_n = 2^n - 1$ are especially interesting since for them the action of the integrated scaling 2^{L_0} on the states having $L_0 \propto n$ reduces to that of a unit operator apart from $O(1/M_n)$ corrections. In real context the scaling 2^{L_0} acts in an excellent approximation as a fractal scaling by a power of p which has physical interpretation in terms of the approximate invariance of fractal under scalings by powers of p. This makes Mersenne primes especially interesting.

Also Gaussian Mersennes are biologically highly interesting (see the chapter "Biological Realization of Self Hierarchy" and "New Physics Behind Qualia" of [cbook2]). The length scale range defined by cell membrane thickness and cell size is completely exceptional containing four Gaussian Mersennes! For Mersenne primes only exponentiated (as contrast to infinitesimal) p-adic scalings leave states almost invariant. In both cases one can speak about approximate conformal invariance since the states generated by L_n do not have zero norm unlike for the usual representations of the conformal algebra so that L_n act more like oscillator operators and generate new states.

These states are generated by a subalgebra of Super Canoical Algebra in case of MEs since the conformal weight of the vacuum state vanishes (for ordinary elementary particles conformal weight of the vacuum is negative integer). Thus very special representations of p-adic Super Virasoro algebra are in question.

3. Degeneracy of states gives rise to huge negentropy resources

The degeneracy of states (number of states with same mass very small squared) is proportional to the exponent of L_0 and is enormous for the physically interesting values

of p-adic prime p. This means that these states provide huge negentropy resources. Thus exotic Super Virasoro representations be interpreted as quantum level articulation for the statement that TGD Universe is quantum critical quantum spin glass.

4. Hierarchy of em life forms?

Exotic Super Virasoro representations clearly provide an excellent candidate for an infinite hierarchy of life forms. The lifeforms possibly defined by $L_0 \propto p^n$ representations would be labelled by three integers (k,m,n): physically interesting primes correspond to $p \simeq 2^{k^m}$, whereas k prime and m are integers, and the power n appearing in $L_0 \propto p^n$. Besides this there would be special lifeforms associated with Mersenne primes. Perhaps it is these lifeforms which make mindlike spacetime sheets living creatures and these lifeforms emerge already in elementary particle length scales and become increasingly complex when the p-adic length scale increases. Life could perhaps be regarded as a symbiosis of these lifeforms. These lifeforms would interact with each other and ordinary matter via the classical gauge fields associated with MEs. A natural hypothesis is that the quantum phase transitions of the macroscopic quantum phases for the particles of the exotic Super Virasoro representations formed in classical fields of MEs (mindlike spacetime sheets) give rise to some (but not all) qualia.

3.5 MEs and quantum holography

Sokolov and collaborators [Sokolov *et al*] have proposed a model of quantum holographic teleportation in which the *classical* photocurrents from the sender to receiver take the role of a dynamical hologram. In the following the connection with MEs is described.

1. Lightlike vacuum current defines 4-dimensional diffraction grating

MEs are carriers of classical lightlike vacuum currents (one of the basic differences between TGD and Maxwell theory). This suggests that MEs could be interpreted also as *classical* holograms, which are *dynamical* as in quantum information theory. Lightlike current would be like a dynamical (four-dimensional) diffraction grating. Lightlike vacuum currents and vacuum Einstein tensor generate also coherent states of photons and gravitons and MEs serve as templates for the topological condensation of photons and gravitons to the Bose-Einstein condensate of photons collinear with ME. The Bose-Einstein condensation of collinear photons and their generalizations to colored configuration space photons should affect the vacuum current by adding to the reference current what might be called evoked response. This condensation process could generate conscious experience and higher level qualia. Thus it would seem that MEs have a triple role as receiving and sending quantum antennae as well as classical holograms.

2. Quantum teleportation by matrix of parallel MEs?

The proposal of [Sokolov *et al*] generalizes to the case of MEs provided one can device a method of coding quantum states of photon field to the vacuum currents. The high efficiency photodetector matrix is in which each pixel gives rise to a photocurrent [Sokolov *et al*], is replaced with ME or set of parallel MEs. The neural window hypothesis (see the chapter "Quantum model for conscious experiences") states that neuronal axons are accompanied by parallel MEs carrying information between sensory organs and brain and various parts of brain. This is only a less standard manner to say that ME represents classical dynamical hologram. The possibility of local lightcone coordinates allows also MEs which define curved deformations of the simplest cylindrical MEs.

The concrete realization of holographic teleportation proposed in [Sokolov *et al*] brings strongly in mind the architecture of the visual pathways. Thus one can wonder whether brain is perfoming internal teleportation of photonic quantum states with spike patterns being directly coded to the pattern of the vacuum currents flowing along MEs. If spike patterns code the dynamical hologram, a surprisingly close relationship with Pribram's views about hologrammic brain results. Nerve pulse patterns could be seen as specifying the necessary classical aspects of the quantum teleportation (in TGD classical physics is essential part of quantum physics, rather than only an effective theory).

3. Lightlike boundary of MEs as a hologram

The lightlike vacuum current at a 3-dimensional timelike section of ME as a function function of time defines a dynamical 3-dimensional hologram. This is consistent with the fact that our visual experience is two-dimensional: the information is always about outer boundaries of the objects of the perceptive field. The values of the vacuum current at a given point are non-deterministic which means that vacuum current is ideal for coding information. Classical data also propagate without dispersion with light velocity obeying the laws of geometric optics and MEs imply channelling so that MEs are taylor-made for classical information transfer.

4. Long term memories and quantum holography

Spacetime sheets can have both positive and negative time orientations and the sign of energy depends on time orientation in TGD framework. This means that classical communication can occur both in the direction of the geometric future and past: this is essential for the classical model of the long term memories as a question commmunicated to the geometric past followed by answer. The dynamical nature of the holograms means that there is no need to combine 2- or 3-dimensional holograms associated with several moments of geometric time to single hologram. To remember is to perceive an object located in the geometric past. Of course, fractality might make possible temporally scaled down versions of the geometric past but the principle would remain the same. The TGD based model of long term memory is based on classical signalling by MEs between geometric past and geometric now and generation of timelike entanglement (possible by classical non-determinism) making possible sharing of experience by receiver and sender.

5. Quantum holograms as carriers of biological information

Quantum hologram view suggests that the supercanonical representations at the light-like boundaries of MEs characterized by gigantic almost-degeneracies are the carriers of biological information. According to the general theory of qualia (see the chapter "General theory of qualia") this information would become conscious since elementary qualia would correspond to quantum jumps for which increments of the quantum numbers correspond to the quantum numbers labelling supercanonical generators in the complement of Cartan algebra. In this view superconducting magnetic flux tubes could perhaps be seen as intermediate level in the control circuitry controlled by MEs and controlling atomic level.

6. Colored configuration space photons and visual colors

The model for visual qualia leads to the hypothesis that, besides ordinary photons, also colored configuration space photons are possible and characterized by configuration space Hamiltonians labelled by orbital spin quantum number J (in two-dimensional sense) and by color quantum numbers like quarks and gluons. The coherent states of these massless configuration space photons would be responsible for visual colors and polarization sense and the corresponding holograms might be the crux of quantum control in living matter.

Rather ironically, photons could carry color after all (this is of course loose use of language: conscious color corresponds of course increment of color quantum numbers in quantum jump).

3.6 MEs and quantum control by holograms

The lightlike vacuum current associated with electromagnetic MEs generates a hologram which interacts with ordinary biomatter. Since MEs are at the highest level in the control hierarchy, one can wonder whether these holograms could somehow act as biological control commands activated and deactivated by some mechanism (see the chapters "Quantum Model of Cognition" and "Quantum Antenna hypothesis" of [cbook]).

The passive state of ME could correspond to the p-adic variant of ME so that the transformation of ME to real form would correspond to volitional act at some level of self hierarchy. Whether or not reference beam would be required in this case is not clear. p-Adic ME could transform to real ME resonantly when its length and thus fundamental frequency corresponds to a p-adic length scale.

The passive state of ME could also correspond to Z^0 ME obtained by a suitable color rotation of ME (in TGD framework color rotations in CP_2 do not leave em and Z^0 fields invariant). The color rotation might be induced by colored configuration space photons acting as a reference beam effectively.

The phase conjugate (time reversal) of the reference beam generates the phase conjugate of a hologram. Time reversed hologram would naturally correspond to time reversed control command. This leads to ask whether biosystem manages to fight against the second law by utilizing time reversed biological programs based on the use of time reversed MEs. These time reversed MEs could be identified as negative energy MEs represented by the spacetime sheets with a negative time orientation.

3.7 MEs and magnetic flux tubes as laser mirrors

MEs parallel with magnetic flux tubes make them counterparts of the laser mirrors and DNA contains a sequence of these mirrors. Entire fractal hierarchy of these mirrors is possible. In human time scales these mirrors make possible long term memories and MEs have lenghts measured using light life as a natural length scale. Ordinary sensory experience involves also the memory aspect but in much shorter time scale. The magnetic mirrors are expected to associated not only with DNA [Gariaev *et al*], but also proteins and other biomolecules.

Even DNA could have sensory canvas and long term memory in time scale defined by MEs. The notion of manysheeted DNA implies that also DNA MEs form a fractal hierarchy closely related to the coding of morphogenesis in various length scales naturally defined by the lengths of MEs. Liquid crystal water spacetime sheets can amplify the em fields associated with MEs. In DNA length scale the sizes of the liquid crystals might be bounded by the size of the cell nucleus or perhaps some shorter length scale. It is possible that liquid crystals along DNA and proteins are dynamical and decompose into subunits and fuse again (this brings in mind the fusion of mental images by entanglement). For instance, active genes could correspond to liquid crystals having length of an entire gene. Note that the genes which are active electromagnetically need not be active chemically: thus introns and silent DNA might be fully active in electromagnetic sense.

MEs associated with various biomolecules serve imply strong resonant interaction between molecules characterized by similar frequencies. Thus molecules serve effectively as lighthouses for molecules characterized by same characteristic frequencies and this provides a general recognition mechanism.

3.8 MEs and codes

A natural expectation is that genetic code, which in TGD framework results from the simplest conceivable model for abstraction process, is used also in electromagnetic communications and holograms as control commands suggest an obvious realization for this mechanism. These realizations of genetic code need not of course induce translation of DNA to proteins: genetic code would only provide a universal coding of information. Computer metaphor suggests that there is large number of possible codings and there is some empirical support for this expectation.

a) The experiments of Gariaev's group [Gariaev *et al*, Marcer] provide support for the idea that one could assign to DNA a sequence of laser mirrors. TGD suggests that this sequence of laser mirrors corresponds to a sequence of orthogonal ME pairs in the plane orthogonal to DNA strand, one for each nucleotide. Laser mirrors would correspond simply magnetic flux tubes accompanied by parallel MEs. The two polarizations associated with an orthogonal ME pair would code for four possible nucleotides so that a representation of the memetic code would result. In the active state of gene these MEs would generate holograms. The MEs associated with the conjugate strand of DNA would in turn represent time reversed control commands. There is obvious connection with the mechanism of healing based on time reversed control commands (see the chapter "Quantum Model for Cognition" of [cbook]).

b) The experiments of Cyril Smith [Smith] related to homeopathic effects give indications for the existence of an electromagnetic coding based on 7 bits. TGD based model for genetic code is based on Boolean algebra of 2^7 statements for which $2^6 = 64$ statements correspond to mutually consistent statements. I have proposed a possible detailed form for for this code in the chapter "Quantum model for cognition" of [cbook]. A model for the homeopathic effects based on MEs and magnetic flux tube structures is discussed in the chapter "Biosystems as Superconductors" of [cbook].

c) Walter Freeman has worked with the EEG signatures of odour perception and identified what he calls mesoscopic structures [Freeman]. These structures are of size 1-2 cm and give rise to coherent patterns of EEG with duration between 80-120 ms occurring 2-7 times per second. The time variation of EEG inside these regions does not depend on position and looks chaotic. It involves frequencies in the range 20-80 Hz and can be understood if a carrier wave with alpha frequency is amplitude modulated with a wave containing besides time independent part the harmonics nf_0, $n = 1, ..., 6$ of alpha frequency (note that the modulation is fast and produces ripples in the carrier wave). The number of harmonics is 6 and this suggests that a coding of information using genetic code could be in question. The genetic codewords would represent a compression of memetic code worlds realized at neuronal level using 126 bits with single bit having duration of about one millisecond.

4 Magnetic mirrors and plasmons

Magnetic flux tubes and MEs are basic structures in TGD based model of biosystems based on the symbiosis of MEs, magnetic flux tubes and ordinary biomatter at atomic spacetime sheets. Magnetic flux tubes are topological field quanta of magnetic field whereas MEs ('massless extremals') are topological field quanta of radiation field, 'topological light rays'.

4.1 MEs are not possible in Maxwell's theory

To avoid misunderstandings, it is important to emphasize that MEs are not possible in Maxwell's theory and the classical fields assocaited with MEs differ in many crucial aspects from those possible in Maxwell's theory. Most importantly, MEs are ideal for classical communications. The signal is effectively one-dimensional wave packet with fixed local polarization, it propagates with a light velocity without change in shape, and is channelled and thus does not weaken with distance. There is no dissipation involved: in TGD framework dissipation can be seen only a phenomenological trick to model the dynamics of quantum jumps between nondissipative quantum histories using single dissipative quantum history. Of utmost importance is that MEs should not respect Faraday cage since they are spacetime sheets outside the spacetime sheet where the cage is. The whole TGD approach to sensory representations fails if this assumption does not hold.

4.2 Magnetic mirrors

Magnetic mirrors formed by the magnetic flux tube-ME pairs occur in many different contexts in TGD inspired theory of consciousness. For example, magnetic mirrors of length of order lightlife appear in the model of long term memory. Classically: when I look at sufficiently distant mirror I see the me of the geometric past. Quantum mechanically: timelike quantum entanglement made possible by the magnetic mirror makes it possible for the self of the geometric now to share the experience of the subself of the geometric past. Magnetic mirrors are crucial for the model of the sensory canvas and there seems to be no sharp difference between different types of memory which suggests that there is an entire hierarchy of memories in various p-adic time scales. Magnetic mirrors play a key role in the model of frequency imprinting and provide a general molecular recognition mechanism. Magnetic mirrors allow also a generalization of manysheeted DNA so that magnetic mirrors represent genetic information in electromagnetic form (see the chapter "Homeopathy in Manysheeted Spacetime" of [cbook2]).

In accordance with the fractality of consciousness, the wide applicability of the magnetic mirror notion suggests that various functions associated with the magnetic mirrors are different aspects of the same basic phenomenon. Magnetic mirrors would thus provide sensory canvases, long term memory mirrors and recognition mechanism at all length scales. Even manysheeted DNA would possess sensory canvas and long term memories, perhaps an entire hierarchy of them. Taking the ideas of fractality and quantum hologram to extreme, one can even consider the possibility that our long term memories are average of those associated with genes associated with various neurons!

Nothing precludes the possibility that magnetic mirrors can also serve as electromagnetic bridges between different organisms (even the notion of organism must be generalized if the idea of multibrained magnetic selves is taken seriously). For instance, communica-

tions with the deceased might be basically like looking ing magnetic mirror and seeing the image of the deceased. This could make possible effects similar to observed at DNA level (such as self assembly and translation of RNA to proteins made possible by electromagnetic recognition mechanism based on em bridges).

4.3 Plasmons

Plasmons correspond to closed toruslike magnetic flux tube structures and ions part of which flow as supra currents at the magnetic flux tubes and part as ohmic currents at non-superconducting spacetime sheets. The model for the magnetic sensory canvas leads to the identification of plasmons as candidates for fundamental magnetic life forms crucial for the self-organization of magnetic fields and also of biological matter. Plasmons appear in all length scales. The magnetic energy of plasmon is extremely small: one cell length of magnetic flux tube of Earth's magnetic fields weighs one eV, one billionth of proton mass. Thus there are no strong energetic constraints against self-organization of magnetic field by plasmon generation.

For instance, plasmons could serve as templates for DNA and neural circuits, and plasmonic self-organization might have preceded the development of the molecular life. Sun generates plasmons. Plasmons are generated also in the plasma sheet of the magnetosphere of Earth. In case of magnetosphere, plasmon should contain sensory representations about living organisms. Perhaps Earth and Sun as magnetic selves (much more intelligent than us) have discovered spacetravel! Plasmons would the spaceships but the crew would be somewhat ghostly, consisting of sensory representations. The subselves of plasmon can entangle with the magnetosphere, which can therefore share the mental images of plasmon. Plasmons clearly make possible for a magnetospheric self to extend its senses to the interstellar space and one can consider the possibility that some of UFOs are extraterrestrial plasmons managed to leak into the magnetosphere through the magnetopause acting effectively as magneto-immune system (most of them might be plasmons generated by the tectonic activity)

4.4 The role of the classical Z^0 force

One of the basic predictions differentiating between TGD and standard model is classical Z^0 field, which is very much like classical electromagnetic field but couples to neuron number and has only very small coupling to protons and electrons. All ions are completely ionized Z^0 ions so that condensed matter at cellular spacetime sheets is in Z^0 plasma state. Classical Z^0 force is strongest in the cell length scale and provides elegant explanation for the chirality selection in living matter plus explanations for long list of anomalies, one of them being the acceleration anomaly for spacecrafts found during last quarter century by NASA [Anderson].

These observations together with other applications of Z^0 force encourage to think that Z^0 MEs could have an important biological role and motor control from sensory canvas or a separate motor canvas consisting of flux quanta of Z^0 magnetic field, could be this role.

Although neutrinos seem to correspond to $k = 13^2 = 169$ spacetime sheet, the quantum model of hearing (see the chapter "Quantum model for hearing") forces to assume that neutrinos can temporally reside at $k = 151$ spacetime sheet (cell membrane length scale) and have approriately scaled-up mass (scaling factor is 512 just like between ordinary

hadron physics associated with M_{107} and its scaled-up version associated with M_{89}). This encourages a generalization: perhaps neutrinos can reside in all spacetime sheets $k = 151, 157, 163, 167$ corresponding to the biological Gaussian Mersennes.

One can test the role of classical Z^0 force in several manners.

a) The correlations of radiactive process rates with biological or even astrophysical periodicities would be a clearcut direct evidence for classical Z^0 force. The lifelong work of Russian scientist Shnoll demonstrates the fluctuations for the rates of various chemical and radioactive processes vary with periods related to astrophysical phenomena (see [Shnoll] and TGD based model in the chapter "Anomalies explainable by the manysheeted spacetime concept" of [padTGD]). According to [Yan], even radioactive decay rate of Am241 has been influenced by intent.

b) Anomalous classical information transfer in living matter with light velocity would be a direct signature of Z^0 force and could be a part of explanation for why remote mental interactions seem to penetrate Faraday cage (also em MEs could penetrate Faraday cage). Z^0 MEs could be responsible for the neuronal synchronization occurring in millisecond time scale.

c) If living matter at cellular spacetime sheets is neutrino conductor it might act as Faraday cage preventing the penetration of classical Z^0 force into region surrounded by living matter: perhaps to the spacetime sheets smaller than cellular spacetime sheets at which classical Z^0 fields indeed are very small. Z^0 MEs would be of course an exception. If living matter is neutrino superconductor the penetration of Z^0 magnetic fields into cellular spacetime sheets would not be possible except as flux quanta.

5 Important empirical inputs and constraints

The development of the ideas about quantum control has occurred in jumpwise manner with jumps being induced by some crucial empirical inputs. My own meager knowledge about biology has certainly been one important factor hindering systematic development of the ideas. This is also the reason for more or less random references to works in the fields involved.

5.1 The effects of ELF em fields on biomatter at multiples of cyclotron frequencies associated with Earth's magnetic field

Ironically, the needed empirical data providing direct evidence for the importance of the ionic superconductors has existed already at seventies [Yarrow, Cherry, Blackman (1994)]. These data convincingly demonstrate that cyclotron resonance frequencies of various ions in Earth's magnetic field are very special. Electromagnetic fields at these frequencies or modulated by these frequencies have unexpected and poorly understood effects on living matter and brain. The effects occur in certain amplitude windows for ELF em fields involved. Even more, important EEG frequencies correspond to multiples of the cyclotron frequencies of the basic ions involved with the nerve pulse generation. Most importantly, the data provide the long sought-for direct evidence for biosystems as macroscopic quantum systems (see the chapter "Biosystems as Superconductors" of [cbook]). This empirical input initiated the integration the bundle of ideas about biosystems as macroscopic quantum systems to a general model of how coordination and control are realized in living

systems.

What makes bells ring is that the cyclotron frequencies associated with various periods of the periodic table correspond to EEG bands (see the tables in the chapter "Spectroscopy of Consciousness" of [cbook]). He period corresponds to gamma and beta bands, Ne period to alpha band, Argon period to theta band and the remaining periods to delta band. The so-called scaling law quantifies the magnetic sensory canvas hypothesis. In case of brain structures the law states that the size $L(EEG)$ of the magnetic sensory canvas (and magnetic mirrors) associated with a brain structure with size L is given the dispersion relation

$$L = \lambda = vf_{EEG} = (v/c)\lambda_{EEG}$$

for EEG waves. v and f_{EEG} correspond to phase velocity and frequency of EEG wave and λ its wavelength assumed to correspond to a brain structure with size L. λ_{EEG} is the wavelength of photon with EEG frequency (and the length of ME parallel to the magnetic flux tube). In TGD framework EEG wave is interpreted as EEG ME moving along brain structure such as axon with velocity v. v represents also the velocity of a soliton sequence associated with Josephson currents for weakly coupled superconductors formed by cell interior and exterior assumed to control nerve pulse generation (see the chapter "Quantum Model of EEG and Nerve Pulse" of [cbook2]). A natural further hypothesis is that the periods of the periodic table correspond also to the sizes for a hierarchy of brain structures (such as sensory areas: see table 2). Scaling law is actually much more general and might apply down to neuronal and even DNA level as suggested by the model of water memory to be discussed below.

5.2 p-Adic length scale hypothesis and resonance frequencies of EEG

A further decisive input where the observation that the frequencies of the BE condensed photons associated with the massless extremals (MEs) correspond in EEG frequency range to important EEG resonance frequencies if one assumes that p-adic length scales define preferred lengths for MEs (see table 2 and the chapter "Spectroscopy of consciousness" of [cbook2]). For instance, 10 Hz frequency corresponds to the secondary p-adic time scale $T_2(M_{127} = .1$ s and defines the time scale associated with the memetic code. Together with the inspiration coming from the vision of Peter Marcer about biosystems as quantum holograms [Marcer], and the realization that the lightlike boundaries of MEs can be regarded as seats for so called supercanonical representations providing huge information resources, this observation led to the realization that the fractal hierarchy of MEs should represent the highest control level in biosystem.

5.3 The observations challenging the notions of ionic pumps and channels

The fourth crucially important empirical input were the empirical findings of of Ling, Sachs and Qin [Ling, Sachs and Qin] and other pioneers [Lev *et al*, Woodbury] summarized in [Pollack]. These findings challenge the notions of ionic channels and pumps central to the standard cell biology. Ling has demonstrated that the ionic concentrations of a metabolically deprived cell are not changed at all: this challenges the notion of cell membrane ionic

pumps. The work of Sachs and Qin and others based on patch-clamp technique shows that the quantal ionic currents through cell membrane remain essentially as such when the membrane is replaced by a silicon rubber membrane or by a cell membrane purified from channel proteins! this challenges the notion of cell membrane ionic channels. A further puzzling observation is much more mundane: ordinary hamburger contains roughly 80 per cent of water and is thus like a wet sponge: why it is so difficult to get the water out of it?

These puzzling observations can be understood if the homeostasis of cell and its exterior is regarded as an ionic flow equilibrium in the manysheeted spacetime. Ionic super currents from superconducting controlling spacetime sheets flow to controlled atomic spacetime sheets and back. Currents are of course ohmic at the atomic spacetime sheets. One can understand how extremely small ionic densities and super currents at cellular spacetime sheets can control ionic currents and much higher ionic densities at atomic spacetime sheets. Immense savings in metabolic energy are achieved if the ohmic currents at the atomic spacetime sheets flow through the cell membrane region containing the strong electric field along superconducting cell membrane spacetime sheet (rather than atomic spacetime sheets) as a non-dissipative supra current. This clever energy saving trick makes also the notion of ionic channels obsolete for weak ionic currents at least.

Superconducting spacetime sheets would represent a plan of the biosystem coded to ion densities and magnetic quantum numbers characterizing the super currents. Biocontrol by em fields affects these super currents and one can understand the effects of ELF em fields on biosystem in this framework. The model relies crucially on the liquid crystal property of biomatter (hamburger mystery!) making possible ohmic current circuitry at the atomic spacetime sheets as a part of the manysheeted control circuitry. There is a considerable evidence for this current circuitry, Becker is one of the pioneers in the field [Becker and Selden]: among other things the circuitry could explain how acupuncture works.

Coherent clasical electric fields at atomic spacetime sheets are required in order to have nonvanishing ohmic currents and this explains why biomatter is liquid crystal having as a consequence also the electret property. In this picture one can understand also the role of DC current circuitry discovered already by Becker [Becker and Selden]. Also the ideas of Mae Wan-Ho about control current circuitry formed by collagen network fits nicely with the vision about the manysheeted ionic flow circuitry.

5.4 Water memory, homeopathy, and acupuncture

Further guidelines for TGD based view about biocontrol and coordination were provided by the empirical evidence for water memory and various effects involved with it [Benveniste$_1$ *et al*, Benveniste$_2$ *et al*, Milgrom, Smith]. In the forthcoming chapter "Homeopathy in Manysheeted Spacetime" of [cbook2] a detailed mechanism of homeopathy and water memory based on the model of biocontrol in terms of manysheeted ionic flow equilibrium is discussed.

1. Transfer of homeopathic potency to non-atomic spacetime sheets is not enough

Manysheeted ionic flow equilibrium suggests a possible mechanism of homeopathy: the extremely low densities of homeopathic remedies are at the controlling superconducting spacetime sheets where the control is. Thus homeopathy could be seen as a high precision medicine minimizing the amount of the remedy needed (see the chapter "Biosystems as

superconductors") rather than some kind of magic treatment. This cannot be however the whole story. As already explained the study of homeopathic effects suggest an electromagnetic representation of the biomolecules based on frequencies [Smith] and it is possible achieve the healing effect by transferring mere frequencies instead of using homeopathic potency.

2. Mechanisms of frequency imprinting and entraintment

According to [Smith], the homeopathic remedies seem to be characterized by frequencies varying in the range containing at least the range $10^{-3} - 10^9$ Hz suggesting that electromagnetic fields at specific frequencies characterize the homeopathic remedy. These frequencies can be imprinted into water and also erased. Rather remarkably, the removal of Earth's magnetic field erases the imprinted frequencies. One the other hand, the studies of acupuncture support the existence of certain highly coherent endogenous frequencies [Smith] at which em radiation has strong effects. The fact that these frequencies can entrain to exogenous frequencies suggests a mechanism of homeopathy based on entraintment. Effects are observed at pairs of high and low frequencies and the ratio of these frequencies is constant over all acupuncture meridians with a standard deivation of $\pm.15$ per cent. The first branch is at GHz range: in particular the frequencies 2.664 GHz, 1.42 GHz and 384 MHz have unexpected properties. The second branch of frequencies is in ELF range, in particular Schumann frequency 7.8 Hz accompanies 384 MHz.

Consider now the explanation of the observations of Smith and others in in TGD framework using the proposed model assigning to magnetic flux tubes parallel MEs making magnetic flux tube effectively a magnetic mirror.

a) The basic idea is that water forms representations for chemicals it contains in terms of transition frequencies of the chemical which become frequencies of MEs and structures of water generating these MEs by emission and absorption processes. Also representations of representations are possible. The molecule of a homeopathic potency is characterized by characteristic frequencies associated with its transitions as well as ELF frequencies. Of course, also transitions of a complex formed by molecule of the potency and water molecule could be involved.

Water represents the transition frequencies of the potency molecule as transition frequencies of water molecules or of structures which correspond to spacetime sheets of various sizes. This conforms with the fact that frequency imprinting disappears after thorough drying and returns when water is added and that also bulk water without any potency allows frequency imprinting. In the frequency range studied by Smith rotational transition frequencies of water and of the spacetime sheets containing water in liquid crystal form provide a good candidate for a representational mechanism. ELF frequencies correspond now to the magnetic transitions of these spacetime sheets behaving like point like objects in Earth's magnetic field.

b) The simplest assumption is that the ELF branch of the frequency spectrum corresponds to the magnetic transition frequencies in Earth's magnetic field whereas the high frequency branch corresponds to the characteristic frequencies $f = c/L$ of MEs parallel to the magnetic flux tubes. This assumption conforms with the crucial role of Earth's magnetic field in the erasure of the imprinted frequencies. Also the importance of 7.8 Hz Schumann frequency for the heart chakra [Smith] can be understood. The singly ionized Ca, Ar, and K (all 7.5 Hz for $B = .5 \times 10^{-4}$ Tesla) and Cl (8.5 Hz) have cyclotron transition frequencies near to Schumann frequency. For LC water blobs the ELF frequencies are be-

low 1 Hz and the requirement that water blob has size smaller than radius of magnetic flux tube of Earth's magnetic field allows ELF frequencies down to $1/f \sim 1000$ years so that all biologically relevant length scales are covered. Quite interestingly, the frequency f_h corresponding 1000 years is 20 Hz by the scaling law suggested by Smith and corresponds to the lower bound for audible frequencies and that also language involves subneuronal mimicry by LC water blobs. A fascinating possibility is that subneuronal LC water blobs could be responsible for all biorhytms and be involved also with our long term memories.

c) Frequency entraintment for both ELF and high frequency branches can be understood if both the thickness and length of the magnetic flux tubes are subject to a homeostatic control. The assumption that the total magnetic energy of the flux tube remains constant during the frequency entraintment together with the magnetic flux quantization implies that the ratio S/L of the area S of the magnetic flux tube to its length L remains constant during entraintment. Thus the ratios f_h/f_{ELF} of the magnetic transition frequencies to characteristic frequencies of MEs would be homeostatic invariants in agreement with the empirical findings. The value of the ratio is in good approximation $f_h/f_{ELF} = 2 \times 10^{11}$.

d) The electromagnetic signature of the homeopathic potency corresponds to MEs stimulated by the electromagnetic transitions associated with the potency molecule. Since these frequencies are also transition frequencies for water molecules or spacetime sheets containg water in liquid crystal form a resonant interaction is possible and em fields of MEs can be amplified/replicated by the transitions associated with these structures.

e) According to [Smith], coherence propagates with a light velocity whereas coherent domain of size L diffuses with a velocity given by the scaling law $v \propto Lf$. In TGD the natural interpretation for the velocity of coherence propagation is as a signal velocity inside ME (possibly representing external em field). v is in turn associated with the motion of ME transversal to some linear structure along it: this effect is not possible in Maxwell's theory since particle-field duality is not realized at the classical level. The velocities are reported to be of order few meters per second and of the same order of magnitude as nerve pulse conduction velocity and phase velocities for EEG waves. This relationship is of the same form as the scaling law which relates together the phase velocity of EEG wave (velocity of EEG ME in TGD framework) and the size L of corresponding structure of brain or body. For instance, scaling law relates the size L for brain structures and corresponding magnetic sensory canvas with much larger size $L_c = c/f$ (see the chapter 'Spectroscopy of Consciousness' of [cbook2]). Scaling law would give $v/c = f_{ELF}/f_h$ and velocity of order mm/s for the motion of transversal MEs along magnetic flux tubes: this velocity is considerably smaller velocity than m/s reported in [Smith].

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References

[Anderson] J. D. Anderson *et al*(1998), Phys. Rev. Lett. Vol. 81, No 14,p. 2858.

[Becker and Selden] R. O. Becker and G. Selden (1990) *The Body Electric: Electromagnetism and the Foundation of Life*. William Morrow & Company, Inc., New York.

[Benveniste$_1$ *et al*] J. Benveniste *et al* (1988). *Human basophil degranulation triggered by very dilute antiserum against IgE*. Nature 333:816-818.

[Benveniste$_2$ *et al*] J. Benveniste *et al* (198?). *Transatlantic transfer of digitized antigen signal by telephone link.* Journal of Allergy and Clinical Immunology. 99:S175 (abs.).FFor recent work about digital biology and further references about the work of Benveniste and collaborators see http://www.digibio.com/ .

[Blackman (1994)] C. F. Blackman (1994), "Effect of Electrical and Magnetic Fields on the Nervous System" in *The Vulnerable Brain and Enviromental Risks, Vol. 3, Toxins in Air and Water* (eds. R. L. Isaacson and K. F. Jensen). Plenum Press, New York, pp. 331-355.

[Cherry] N. Cherry (2000), Conference report on effects of ELF fields on brain, http://www.tassie.net.au/emfacts/icnirp.txt .

[Freeman] W. J. Freeman (2001), *Making sense of brain waves: the most baffling frontier in neuroscience*, http://sulcus.berkeley.edu .

[Gariaev *et al*] P. Gariaev *et al* (2000), *The DNA-wave biocomputer*, International Journal of Computing Anticipatory Systems. Ed. Daniel Dubois, Published by CHAOS, Vol. 10, 2001.

[Giudice and Preparata] E. Del Giudice and G. Preparata (1994), *Coherent dynamics in water as a possible explanation of biological membrane formation*, J. of Biol. Phys. 20: 105-116.

[Hameroff-Penrose] Hameroff, S.R., and Penrose, R., (1996) Orchestrated reduction of quantum coherence in brain microtubules: A model for consciousness. In: Toward a Science of Consciousness - The First Tuscon Discussions and Debates, S.R. Hameroff, A. Kaszniak and A.C. Scott (eds.), MIT Press, Cambridge, MA. pp 507-540.

[Ho] M. W. Ho (1993), *The Rainbow and the Worm*, World Scientific, Singapore.
Ibid (1994), *Coherent Energy, Liquid Crystallinity and Acupuncture*,
http://www.consciousness.arizona.edu/quantum/Archives/Uploads/mifdex.cgi?msgindex.mif.

[Ho and Saunders] M. W. Ho and P. T. Saunders(1994), *Liquid Crystalline Mesophase in living organisms*, in *Bioelectrodynamics and Biocommunication* (M. W Ho, F. A. Popp and U. Warnke, eds), World Scientific, Singapore.

[Kerlesz and Kiss] J. Kerlesz and C. B. Kiss (1990), *Noise spetrcum in the model of self-organized criticality*, Journal of Phys. A, 23.

[LC] *Liquid crystals on line*, http://www.lcionline.net/

[Lev *et al*] A.A. Lev *et al* (1993), *Rapid switching of ion current in narrow pores: implications for biological ion channels.* Proceedings of the Royal Society of London. Series B: Biological Sciences, June, 187-92.

[Ling] G. N. Ling (1962) *A physical theory of the living state: the association-induction hypothesis; with considerations of the mechanics involved in ionic specificity.* New York: Blaisdell Pub. Co..
Îbid(1978):*Maintenance of low sodium and high potassium levels in resting muscle cells.* Journal of Physiology (Cambridge), July: 105-23.
Ibid(1992): *A revolution in the physiology of the living cell.* Malabar, FL: Krieger Pub. Co..

[Ling *et al*] G.N. Ling *et al*: *Experimental confirmation, from model studies, of a key prediction of the polarized multilayer theory of cell water.* Physiological Chemistry and Physics, 10:1, 1978: 87-8.

[Marcer] P. Marcer *et al* (2000), *Quantum Millennium, Quantum Universe, Quantum Biosphere, Quantum Man- or What Physicists can teach Biologists, and Biology, Physics*, International Journal of Computing Anticipatory Systems. Ed. Daniel Dubois, Published by CHAOS, Vol. 10, 2001.

[Milgrom] L. Milgrom (2001), *Thanks for the memory.* An article in Guardian about the work of professor M. Ennis of Queen's University Belfast supporting the observations of Dr. J. Benveniste about water memory.
http://www.guardian.co.uk/Archive/Article/0,4273,4152521,00.html .

[Neher and Sakmann] B. Sakmann and B. Neher (1983): *Single-channel recording.* Plenum Press, New York & London.

[Nordenström] B. E. W. Nordenstrm (1983): *Biologically Closed Electric Circuits.* Nordic Medical Publications, Arsenalsgatan 4, S-1ll 47 Stockholm, Sweden.

[Persinger] M. Persinger (1999), "The tectonic strain theory as an explanation for UFO phenomena",
http://www.laurentian.ca/www/neurosci/tectonicedit.htm.
Ibid (1995), "On the possibility of directly accessing every human brain by electromagnetic induction of fundamental algorithms", Percept. Mot. Skills, 80(3 Pt 1), 791-9.
Ibid (1987), *Neuropsychological Bases of God Beliefs*, Praeger Publishers.

[TGD] M. Pitkänen (1990) *Topological Geometrodynamics* Internal Report HU-TFT-IR-90-4 (Helsinki University).

[padTGD] M. Pitkänen (1995) *Topological Geometrodynamics and p-Adic Numbers.* Internal Report HU-TFT-IR-95-5 (Helsinki University).

[cbook] M. Pitkänen (1998) *TGD inspired theory of consciousness with applications to biosystems.*
http://www.physics.helsinki.fi/~matpitka/cbookI.html.

[cbook2] M. Pitkänen (2001), *Genes, Memes, Qualia, and Semitrance.* http://www.physics.helsinki.fi/∼matpitka/cbookII.html.

[Pollack] G. Pollack (200?), *Cells, Gels and the Engines of Life*, Ebner and Sons. http://www.cellsandgels.com/ .

[Popp *et al*] W. Nagl, M. Rattemayer and F.A. Popp (1981), *Evidence of Photon Emission from DNA in Living Systems*, in Naturwissenschaften, Vol. 68, No 5, 577

[Sachs and Qin] F. Sachs, F. Qin (1993), *Gated, ion-selective channels observed with patch pipettes in the absence of membranes: novel properties of a gigaseal.* Biophysical Journal, September: 1101-7.

[Shnoll] S. E. Shnoll *et al* (1998), *Realization of discrete states during fluctuations in macroscopic processes*, Uspekhi Fisicheskikh Nauk, Vol. 41, No. 10, pp. 1025-1035.

[Smith] C. Smith (2001), *Learning From Water, A Possible Quantum Computing Medium*, talk in CASYS'2001, 5th international conference on Computing Anticipating Systems held in Liege, Belgium, August 13-18. Abstract book published by Chaos.

[Sokolov *et al*] I. V. Sokolov *et al*(2001), *Quantum holographic teleportation of light fields*, arXiv:quantph/0007026v1 .

[Woodbury] D.J. Woodbury (1989): *Pure lipid vesicles can induce channel-like conductances in planar bilayers.* Journal of Membrane Biology, July 1989: 145-50.

[Yan] X. Yan *et al* (1988), *The influence of the external Qi of Qigong on the radioactive decay rate of 241Am*, Nature Journal (Chinese), Vol 11. http://home.eol.ca/∼yuan/yansci/yan241.html .

[Yarrow] D. Yarrow (1990), *Spin the tale of the dragon*, review article on biomagnetism, http://www.ratical.org/ratville/RofD2.html.

6 Tables

Table 1. The table below lists the p-Adic length scales $L_p = 2^{k-151}L_{151}$, $p \simeq 2^k$, k prime, possibly relevant to bio-physics below (ELF length scales are not listed here). 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. Rather remarkably, the four subsequent primes $k = 151, 157, 163, 167$ between cell membrane thickness and cell size correspond to Gaussian Mersennes so that this cell length scale range is number theoretically quite unique. The next length scale $k = 13^2 = 169$ in turn corresponds to the length scale at which classical Z^0 interactions enter into the game!

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 2. The table below gives the correspondence between biological and ELF length scales suggested by $v = L(k)f$ relationship assigning to the 'biological' length scale $L(k(bio))$ (not larger than body size) ELF frequency $f(k,n)$ and corresponding 'cultural' p-adic length scale, which is of order of Earth circumference for 8 Hz EEG frequency. Also the proposed assignments of the sensory areas of neocortex to these length scales are given. The lower index associated with the exponent k tells whether the scale is secondary or tertiary in case that it is not primary (one has $p \simeq 2^k$ by p-adic length scale hypothesis).

$k(bio)$	191	193	97_2	197	199	$101_2(67_3)$
$L(k(bio))/cm$	1	2	2.8	8	16	45(32)
$k(ELF)$	2_2^5	251	127_2	$2^8 = 256$	257	131_2
$f(k,n)/Hz$	40.0	28.2	10.0	5.0	3.5	.63
sensory area	I	I	II	III	IV	V
$EEG\ band$	*gamma*	*beta*	*alpha*	*theta*	*delta*	*delta*
period	He	Ne	Ar	Kr	Xe	