Biosystems as Macroscopic Quantum Systems

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Abstract Macroscopic quantum phases are an absolutely essential element of most quantum consciousness theories and topological geometrodynamics (TGD) is not an exception in this respect. TGD based theory of consciousness relies crucially on the notion of self hierarchy whose geometrical correlate is the hierarchy of spacetime sheets realized as a 4-surface in certain 8-dimensional space. The notion of manysheeted spacetime predicts new types of macroscopic quantum phases but the the lack of direct experimental evidence for the macroscopic quantum phases has been stumbling block for more detailed developments.

The crucial empirical ingredient turned out to be the observations about the effects of ELF electromagnetic fields on brain. The largest effects are obtained at odd multiples of cyclotron frequencies of various biologically important ions like Ca_{++} in Earth's magnetic field. Also amplitude modulation of RF and MW fields by these frequencies has effects. This leads to a surprising conclusion in violent conflict with standard physics view about world: magnetically confined states of ions in Earth's magnetic field having minimal size of order cell size and energy scale of order E-14 eV are in question. The notion of manysheeted spacetime indeed allows these states: various ions are 'dropped' to cellular spacetime sheets where the thermal noise is absent so that the ions can form superconducting macroscopic quantum phases. The model suggests what might be called spectroscopy of consciousness allowing to identify important EEG frequencies as correlates of various primary sensory qualia and EEG patterns as correlates of emotions.

Keywords: consciousness, qualia, macroscopic quantum system, ELF em fields, cyclotron frequencies.

1 Introduction

Topological Geometro-Dynamics (TGD) is a unified theory of fundamental interactions. TGD involves a quite far-reaching generalization of the spacetime concept and, apart from the notion of quantum jump, reduces quantum theory to infinite-dimensional geometry, which is highly unique from the mere requirement that it exists. Quantum TGD requires the introduction of several new mathematical tools and concepts, in particular p-adic numbers. p-Adic number fields R_p (one number field for each prime $p = 2, 3, 5, \ldots$) are analogous to real numbers but differ from

them in that p-adic numbers are not well-ordered. p-Adic numbers play an absolutely essential role in the formulation of quantum TGD and of TGD inspired theory of consciousness. The mapping of the real geometric structures to their p-adic counterparts is a basic feature of quantum TGD and plays also key role in TGD inspired theory of consciousness. The emergence of p-adic numbers is related to the fact that TGD universe is quantum spin glass. This has deep implications concerning the understanding of the functioning of the living systems. One could perhaps interpret p-adic topologies as possible topologies of conscious experience. The higher the value of p, the better the resolution of conscious experience is, so that p serves as kind of intelligence quotient.

p-Adic length scale hypothesis states that the p-adic length scales $L_p = l\sqrt{p}$, $l \simeq 10^4$ Planck lengths, $p \simeq 2^k$, k prime or power of prime, are physically preferred. p-Adic length scale hypothesis provides quantitative realization for the hierarchy of spacetime sheets and is in key role in TGD inspired theory of consciousness. For a summary of TGD, p-adic aspects of TGD and TGD inspired theory of consciousness see my online books "Topological Geometro-Dynamics" [13], "TGD and p-Adic Numbers" [14] and "TGD inspired theory of consciousness with applications to biosystems [15].

1.1 TGD inspired theory of consciousness very briefly

TGD inspired theory of consciousness allows to construct a general model of conscious experiences based on some very general principles.

a) The identification of quantum jump between quantum histories as a moment of consciousness defines microscopic theory of consciousness whereas the notions of self and self hierarchy allow to understand macroscopic aspects of consciousness absolutely essential for brain consciousness (Ch. "Matter, Mind, Quantum" of Pitkänen, 2000 [15]). Self is identified as a subsystem effectively behaving like its own p-adic subuniverse quantum mechanically (Ch. "Self and Binding" of Pitkänen, 2000 [15]). Physically this means that self is a subsystem able to remain p-adically un-entangled during subsequent quantum jumps: in real context this means that entanglement remains below some critical value. Simple assumptions about how the contents of consciousness of self are determined allow to understand the basic structure of conscious experience at general level. One can understand volition as closely related to the classical nondeterminism of the Kähler action; theory leads to a very general model of sensory experience and so called whole-body consciousness explaining basic characteristics of the mystic experiences is basic prediction of the theory (Ch. "Quantum model of conscious experience" of Pitkänen, 2000 [15]).

b) The understanding of the relationship between subjective and geometric time leads to the notion of psychological time involving in an an essential manner the new view about spacetime, in particular the idea about cognitive spacetime sheet as a geometric correlate of self (Ch. "Time and consciousness" of Pitkänen, 2000 [15]). The notion of psychological time forces to view the entire manysheeted spacetime

surface as a living system so that the standard notion of linear time is illusory and reflects the restricted information content of our conscious experience rather than fundamental 4-dimensional reality. The paradigm of 4-dimensional brain provides completely new understanding of the long term memory: no memory storage mechanisms are needed and one avoids the basic difficulties of neural net models. There are two kinds of memories: subjective memory (what really happened) and geometric memory (what would have happened and will happen in absence of quantum jumps). Emotions might be perhaps understood as resulting from the comparison of the geometric memories (the expectations) with the subjective memories (Ch. "Quantum model of conscious experience" of Pitkänen, 2000 [15]). It must be emphasized that anticipation (Dubois. 1999 [10]) and memory are different facets of geometric memory.

c) Subjective time development by quantum jumps implies quantum self-organization which can be regarded as a sequence of quantum jumps between quantum histories (Ch. "Quantum model of self-organization" of Pitkänen, 2000 [15]). This evolution corresponds to a sequence of macroscopic spacetime surfaces associated with the final state quantum histories. Quantum jumps imply dissipation at fundamental level. Dissipation serves as a Darwinian selector of self-organization patterns. which can represent both genes and memes. In particular, one can understand how habits. skills and behavioural patterns are gradually learned.

1.2   General model for conscious brain

The model of conscious brain relying on the following idea explains both sensory qualia and cognition.

a) TGD universe is quantum critical quantum spin glass and the plasticity of the brain is in accordance with a model of brain as point moving in an infinite-dimensional spin glass energy landscape. Inhibitory and excitatory nerve pulses induce motion in the energy landscape and justify the notion of frustration characterizing spin glass. The picture differs from ordinary neural net in that spin glass energy landscape has also time as one dimension in a well defined sense (this is due to the failure of the classical determinism in standard sense for the Kähler action defining the dynamics of the system). This allows a new view about what happens in learning (Ch. "Quantum model of conscious experience" of Pitkänen. 2000 [15]).

b) The general model of sensory experience relies on the music metaphor. Axons are like strings of musical instrument such that the sound produced by the string corresponds to sensory modality associated with the axon. Nerve pulse patterns determine the experience as chords from from the notes of various instruments in the same sense as the musician produces the music. Entire sensory pathways, possibly including also primary sensory organs, determine the sensory experience. Primary qualia are like basic notes played by different instruments or like colors of a pixel of a computer picture. This leads to a generalization of the idea about brain as an associative net. Presynaptic axons define inputs of association in various modalities

and postsynaptic axon defines the output corresponding to some modality. This allows elegant understanding of the conscious associations at neuronal level (Ch. "Quantum model of conscious experience" of Pitkänen, 2000 [15]).

c) TGD implies a radical generalization of the spacetime concept in all length and time scales. The concept of manysheeted spacetime leads to fresh proposals for how biosystems manage to be macroscopic quantum systems (Ch. "Biological realization of self-hierarchy" of Pitkänen, 2000 [15]). Examples of these mechanisms are so called wormhole superconductivity, electronic high T_c super-conductivity (Ch. "Biosystems as superconductors" of Pitkänen, 2000 [15]) and a mechanism for generating coherent light and gravitons based on so called massless extremals (MEs) (Ch. "Quantum antenna hypothesis" of Pitkänen, 2000 [15]). Besides electrons also protons and various ions can 'drop' from atomic spacetime sheet to larger spacetime sheets and this makes in principle possible entire zoo of super conductors. TGD predicts the existence of classical long range Z^0, $W^{\pm}$ and gluonic fields above cellular length scales. This makes possible also neutrino and Z^0 ionic super conductivities based on classical Z^0 force.

d) The notion of self hierarchy is central for the model and allows to understand quantum correlates of the sensory qualia.

i) Self hierarchy is very much analogous to the hierarchy of subprograms of a computer program and defines a hierarchy of increasingly abstract experiences. Self hierarchy allows to understand computational aspects of brain although connectionistic picture realized as quantum association network seems to work at various levels of the hierarchy (Ch. "Quantum model for intelligent systems" of Pitkänen, 2000 [15]).

ii) Self hierarchy has as its geometric correlate the hierarchy of spacetime sheets. So called massless extremals (MEs) (Ch. "Quantum antenna hypothesis" of Pitkänen, 2000 [15]) are excellent and unique candidates for the building blocks of the cognitive spacetime sheets since the lightlike vacuum current associated with ME has arbitrary time dependence and is ideal for coding sensory data representing passive aspects of consciousness. The free part of ME gauge field in turn has interpretation as correlate for the active aspects of ME consciousness. The fact that classical spacetimes are field theoretic counterparts of Bohr orbits, suggests that classical em field decomposes into MEs when classical decoherence occurs. MEs provide a mechanism of long term memory and the notion of MEs leads to the idea about brain as sensory and motor organ of higher level self and to a rather detailed view about the general organization of brain. Vacuum current generates coherent photons and gravitons and gives rise to hologrammic storage of information. There is quite recent empirical data supporting quantum antenna hypothesis at the level of DNA (Gariaev, 2000 [11]).

iii) The hierarchy of Josephson currents frequency-modulating Josephson currents provides one dynamical correlate of the self hierarchy. Quantum mechanically Josephson current acts as a harmonic perturbation for each super conductor. MEs

can serve as Josephson junctions and corresponding electric field gives rise to harmonic perturbation. When the frequency of the perturbation corresponds to an energy difference for two states of particle in superconductor, quantum jumps become possible. This in turn makes possible 'wake-up' of the super conductor subself (generation of mental image) and quantum self-organization process begins (Ch. "About the problem of identifying quantum correlates of qualia" of Pitkänen, 2000 [15]). Also classical Z^0 fields and gluon fields predicted by TGD are expected to be important.

iv) The observations (Blackman, 1994 [8]) about the effects of oscillating em fields on brain suggest that cyclotron frequencies, and more generally magnetic transition frequencies, of biologically important ions in the magnetic field of Earth correspond to important oscillation frequencies of Josephson currents. Also the magnetic transition frequencies of electronic Cooper pairs seem to be important as also Z^0 magnetic transition frequencies of neutrino and various Z^0 ions, which can be electromagnetically neutral atoms and even molecules. Any harmonic perturbation, be it ELF em field or oscillating Josephson current, can induce quantum transitions which in turn can induce phase transitions of quantum critical macroscopic quantum phases assumed to give rise to primary qualia. Thus one can parametrize sensory modalities and submodalities in terms of magnetic transition frequencies (Ch. "About the problem of identifying quantum correlates of qualia" of Pitkänen, 2000 [15]).

v) The Josephson currents associated with EEG frequencies generate photons which by Uncertainty Principle correspond to topological field quanta with size of Earth. It seems that these topological field quanta identifiable as MEs correspond to higher level selves (Ch. "Genes and Memes" of Pitkänen, 2000 [15]) living in symbiosis with biological life forms and explaining cultural aspects of brain consciousness. This is in accordance with the idea that the flux tubes of Earth's magnetic and Z^0 fields serve as templates for the formation of biostructures.

e) Boolean cognition can be understood as associated with cognitive neutrino pairs. A general model for abstraction process not only explains the basic numbers of the genetic code but also predicts an entire hierarchy of codes (Ch. "Genes and Memes" of Pitkänen, 2000 [15]). The next code in the hierarchy is very attractive candidate for 'memetic code'. The hypothesis predicts correctly the .1 second time scale for the duration of 'our' self (immediate short term memory, duration of psychological moment). Codons corresponds to sequences of 126 bits with duration of one milli second: this is indeed the time scale of nerve pulse. Temporal sequencies of cognitive neutrino pairs having duration of order millisecond realize memetic code and cognition. The frequency of about 10 Hz is in EEG frequency range and also corresponds to ELF topological field quanta with size of Earth representing our cognitive subself.

This article represents shortened and modified version of the paper represented in CASYS'2000 conference in Liege (Pitkänen, 2000 [16]). The identification of MEs as cognitive spacetime sheets is an important new element and leads to an explanation

of those aspects of Blackman's experiments (Blackman, 1994, [8]) which remained poorly understood in CASYS'2000 paper.

2 The effects of ELF fields on brain as a direct evidence for quantum brain and many-sheeted spacetime

The lack of clearcut empirical evidence for the predicted supra phases has been a stumbling block for the quantitative development of the TGD inspired theory of consciousness for a long time. The situation changed dramatically when I learned about the effects of ELF em fields on living matter from the popular article of D. Yarrow[1]. This article provided the ingredients making possible a general quantitative model of quantum control and coordination in which self hierarchy has as its dynamical correlate hierarchy of weakly coupled super conductors. A technical view about the effects can be found from review articles of Adey and Blackman (Adey, 1992 [1]. Blackman. 1994 [8]). The online review article of Cherry (2000 [9]) provides a good technical representation about various effects of weak ELF em fields and ELF modulated radiofrequency em fields on brain and an extensive list of references.

2.1 Summary about effects of ELF em fields on brain

The work by pioneers of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey. Blackman and many others) which began already at sixties led to amazing discoveries about ELF fields on brain. The articles of Blackman listed in references, in particular the review article (1994 [8]) provides a detailed summary of these developments.

The effects of ELF em fields on brain include chemical. physiological and behavioural changes within windows in frequency and field intensity. The following summary is based on the online review article of Cherry (2000, [9]). The results of the work of Bawin. Adey, Blackman and others can be summarized by saying that radio frequency em fields amplitude modulated by ELF frequencies or mere ELF em fields affect in certain frequency and amplitude windows brain tissue (Bawin and Adey. 1975 [2]. Blackman. 1982 [4]. Blackman. 1989 [6]). The function of the radiofrequency carrier wave is to facilitate the penetration of em field into tissue and its frequency is not essential for the occurrence of the effect. Presumably nonlinear effects give rise to a secondary wave with modulation frequency which is the primary source of effects. Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized the role of Earth's magnetic field (Blackman, 1985 [5]).

Two main intensity windows have been seen. one for ELF em fields the values of electric field in tissue are around 10^{-7} V/m. For ELF modulated radio frequency

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[1]I am grateful for Gene Johnson for sending me the article "Spin the tale of the dragon", http://www.ratical.org/ratvlle/RofD2.html.

fields (RF) and microwaves (MW) the intensities are around 10^{-1} V/m. The former is the level associated with navigation and prey detection in marine vertebrates and with the control of human biological rhythms; the latter is the level of the electroencephalogram (EEG) in the brain tissue. In case of brain tissue maximal sensitivity to electromagnetic fields occurs between 6 and 20 Hz.

In order to get grasp about orders of magnitude, it is good to notice that cell membrane electric field has strength about 10^7 V/m whereas EEG electric fields in the range $5 - 10$ V/m. For Schumann resonances electric field is of order .6 mV/m. For sferics (em perturbations associated with lightnings) magnetic field strength is not above nTesla: this corresponds to electric field strength 10 V/m associated also with EEG waves (Schienle, 1996 [17]). Field strength of V/m corresponds roughly to energy flux $\mu W/m^2$.

The presence of windows and weak intensities implies that the effects cannot be thermal. A good metaphor is the effect of radio noise on radio receiver: it occurs at definite frequency and destroys the information content of the original transmission. The well documented and established nonthermal biological effects of EMR include significant alteration of cellular calcium ion homeostasis, reduction of melatonin, and the detection of Schumann Resonances by human and avian brains. A key effect is change in Ca_{--} homeostasis: Ca_{--} it is involved with both pre- and postsynaptic steps of nerve pulse transmission and also with intracellular communication. For instance, Ca_{--} is involved with gene expression, the development and plasticity of nervous system, modulation of synaptic strengths, and with $Ca_{--} - cAMP$ signal transduction process.

Change in Ca_{--} homeostasis has harmful effects in central nervous system, endocrine system and immune system. At the level of CNS this means changes of reaction time and behavioural alternations. At the level of neuro-endocrine system a good example is the reduction of the melatonin production in pineal gland having wide variety of harmful effects since melatonin serves as effective scavenger of free radicals: among the effects are DNA strand breakage, chromosome aberrations and problems with gap junction communications. Melatonin is also crucial for healthy sleep and for the reduction of cholesterol and blood pressure. In case of immune system an example is provided by the change of functioning of lymphosytes in turn reducing the competence of immune system making the subject more vulnerable to allergens, toxins and viruses.

2.2 Cyclotron resonances and quantum brain

In response to the results and speculations of Blackman. Liboff formulated ionic cyclotron resonance (ICR) model (Liboff, 1985 [12]) based on the realization that the frequencies in question correspond to multiples of the cyclotron frequencies of Ca_{--} ion in Earth's magnetic field. This model was classical. Later Blanchard and Blackman proposed so called ionic parametric resonance (IPR) model (Blanchard and Blackman, 19 [7]. This phenomenological model combines ICR model with ideas

about atomic physics. There are several objections against ICR model: classical orbits of ions in Earth's magnetic field have radius of order meters; dissipative effects and Brownian forces do not allow cyclotron orbits; charge-to mass ratios appearing in cyclotron frequencies correspond to vacuum rather than water enviroment characterized by large value of dielectric constant; it is difficult to understand why odd multiples of cyclotron frequencies give rise to stronger effects (Blackman, 1994 [8]). Some of these objections apply also to IPR model.

The pattern of data seems to suggest that the interaction occurs at quantum level. This is in dramatic conflict with the predictions of the standard quantum theory and with the standard view about spacetime but consistent with the manysheeted spacetime concept of TGD. The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field in the direction of axon having same strength as Earth's magnetic field, is supported by the following observations.

a) The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of Ca_{++} ion. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

b) Even multiples of 15 Hz have a weak but nonvanishing effect. Transitions are not possible at all in the lowest order of perturbation theory since the interaction Hamiltonian describing the transitions in question has nonvanishing matrix elements only between states of opposite parities in the dipole approximation applying when the wavelength of the radiation is much larger than the size of the radiating system (Baym, 1969 [3]). Odd and even values of n for cyclotron states have opposite parities so that Δn odd rule results. In higher orders of perturbation theory also transitions for which transition frequency is even multiple of the cyclotron frequency are possible. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

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

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

Here the contribution to energy coming from the free motion in the direction of magnetic field has not been included. For a given value of n the component of angular momentum in direction of B has $n+1$ values $n, n-2, ..., -n$. g is so called Lande factor which for free elementary fermions equals to $g = 2$. The experimental findings suggests strongly that external em field induces resonant transitions between magnetic states. By the quantization of the magnetic flux, predicted by TGD also classically, the minimal size of the magnetic flux tube for the magnetic field of

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Earth is of cell size. An attractive hypothesis is that the magnetic field in question is associated with spacetime sheet parallel to axon.

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

$$r_n \sim \sqrt{2n/eB} \ ,$$

which is of the order of cell size: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the p-adic length scale $L(169) \simeq 4.4 \ \mu m$ rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ (S denotes the area of the flux tube) and $Z = 2e$. $L(169)$ seems to correspond to our sensory consciousness and various macroscopic quantum phases seem to reside at $k = 169$ spacetime sheets probably forming join along boundaries condensates. The binding energies of ions in Earth's magnetic field are extremely small: of order 10^{-14} eV, which is ridiculously small energy when compared with the natural energy scale of one eV.

According to standard quantum physics, Earth's magnetic field should have absolutely no detectable effects in hot, wetty and noisy environment provided by brain. Manysheeted spacetime concept provides the solution to the riddle. Ions are not on the atomic spacetime sheets but have dropped to the cellular spacetime sheet and it is indeed very cold, dry and silent here: an ideal place for the formation of macroscopic quantum phases. The energy scale implies the upper bound $T < 10^{-10}$ Kelvin for the temperature at cellular spacetime sheets. Manysheeted spacetime concept also explains why electric fields having intensity by a factor million weaker than the electric field associated with cell membrane can have biological effects.

The ELF em field used in the experiments have electric field strengths about $1 - 10$ V/m and are by a factor of order million weaker than membrane potential: the notion of many-sheeted spacetime allows to understand why so weak fields can have effects on biomatter. Amplitude windows are a further mystery related with the interaction of ELF em fields with brain tissue: if ELF em field defines potential difference associated Josephson junction and thus serving as frequency of Josephson current, one can understand this effect in terms of quantum jumps induced by Josephson current at certain resonance frequencies.

2.3 Interpretation of the result in terms of a hierarchy of ionic super conductors and massless extremals

The suggested interpretation of the experimental data is in terms of the hierarchies formed by ionic super conductors (Ch. "Biological realization of self hierarchy" of Pitkänen, 2000 cbook) and massless extremals (MEs). Here only the general model for the situation is discussed.

a) Ions and electrons can 'drop' (actually flow along join along boundaries bonds) from atomic spacetime sheets to larger spacetime sheets, where the temperature is extremely low. This leads to a formation of effectively one-dimensional super conductors such that charge carriers behave as free particles only in the direction of magnetic field (Ch. "Biosystems as super conductors" of Pitkänen, 2000 [15]). The mechanism giving rise to effective one-dimensionality, which is essential for the nonvanishing of the gap energy, is magnetic confinement in the magnetic fields associated with the spacetime sheets. The flux tubes of Earth's magnetic field have thickness of order cell size, which suggests that axonal spacetime sheets correspond to flux tubes of Earth's magnetic field. There are in principle macroscopic quantum phase associated with every magnetic quantum number combination since energy differences involved are so small and thermodynamics is not important. Quantum criticality suggests that system is in spin glass phase consisting of regions which correspond to particular magnetic quantum number combinations such that each region is sensitive against phase transition to new phase generated by external harmonic perturbations.

b) Standard time dependent perturbation theory at the limit of infinitely long duration of perturbation predicts quantum jumps to occur only when the frequency of the harmonic perturbation corresponds to energy difference for two states of charge carrier in super conductor. For magnetic superconductors these frequencies are

$$ f \;=\; nf_c + \frac{\Delta S_z}{S} f_L \;. \tag{2} $$

Here f_c denotes cyclotron frequency and f_L Larmor frequency.

c) Magnetic transitions in given region serve as seed for the formation of new phase with altered quantum numbers. The mechanism leading to a generation of a region consisting of a phase with new quantum numbers is analogous to Bose-Einstein condensation. Each region of quantum spin glass is at quantum criticality and unstable against phase transitions. Besides this there are two amplification effects involved. First, the quantum jumps inducing the formation of seed are amplified by quantum coherence. Secondly, if the number of ions in new phase is N, the probability that new ion enters this phase is proportional to N^2. Thus quantum jumps are amplified to phase transitions leading to the 'wake-up' of subsystem and giving rise to conscious experience. The increments of quantum numbers associated with the phase transition characterize the quale associated with the phase transition in question.

One can understand both frequency and intensity windows as quantum effects.

a) If ELF em fields give rise to MEs, the quantum jumps induced by MEs at magnetic transition frequencies explain why anomalous effects occur at frequency windows. Anomalous effects can be identified as phase transitions described above and one can say that tissue perceives the ELF em field. The fact that multiples

of cyclotron frequencies are in the range of EEG frequencies, suggests that EEG provides spectroscopy of consciousness with individual resonant frequencies serving as correlates of the primary qualia. Larmor frequencies are in general of order few hundred Hz and it seems that EEG frequencies amplitude modulate 'Larmor MEs' having frequency which is multiple of Larmor freqeuency.

b) The formation of join along boundaries bonds between different super conducting spacetime sheets makes possible Josephson currents and thus gives rise to weakly coupled super conductors. The oscillatory Josephson current running between the spacetime sheets has basic frequency, which is equal to the difference of time derivatives of the phases of the order parameters associated with the super conductors: $\Omega = \partial_t \phi_{12}$. It will be assumed that $\partial_t \phi_{12}$ satisfies the condition

$$\partial_t \phi_{12} = Z e V_{12} \ .$$

Here V_{12} denotes the potential difference. This condition states covariant constancy of phase in time direction. It is not completely general but could characterize asymptotic states selected by self-organization. Josephson current can serve as a harmonic perturbation characterized by the frequency $\omega_{12} \equiv \langle \partial_t \phi_{12} \rangle = Z e V_{12}$. When ω_{12} corresponds to an energy difference for particles in either spacetime sheet, resonance occurs. This allows to understand amplitude windows. If the MEs associated with ELF em fields can serve as Josephson junctions such that the transversal electric field associated with ME defines potential difference over the junction, the amplitude assciated with ELF em field defines Josephson frequency and thus resonant transitions occur when field intensities are near to magnetic transition frequences or some other important transition frequencies.

3 Conclusions

The understanding of the effects of ELF em fields has led to dramatic developments in understanding of how manysheeted spacetime allows biosystems to be macroscopic quantum systems and suggests what might be called spectroscopy of consciousness (Ch. "Spectroscopy of consciousness" of Pitkänen, 2000 [15]). Spectroscopy of consciousness is work in progress but the general principles are beginning to emerge.

a) Massless extremals (MEs) act as Josephson junctions. The identification of (MEs) as cognitive sheets leads to a hologram model for cognitive representations and for long term memory and forces the hypothesis that MEs define an infinite hierarchy of electromagnetic life forms living in symbiosis with each other and biomatter. EEG can be seen as a direct physical correlate of cognitive spacetimes sheets (MEs) associated with ELF selves and a general vision about the electromagnetic organization of brain as sensory and motor organ of higher level self emerges. Also so called RF (radiofrequency) MEs representing our consciousness as well as MW (microwave) MEs representing our mental images are crucial for the model. ELF MEs act affect RF MEs by amplitude modulation (as in case of Blackman's experiments!). The

model of qualia provides a view about the sizes of RF MEs defining what might be called our electromagnetic body.

b) p-Adic length scale hypothesis allows to understand the basic anatomical structure of central nervous system as reflection of evolution regarded as the emergence of new p-adic length scales in which magnetic transition frequency consciousness is possible. The scaling law $\lambda = v/f$ relating the wavelength λ, frequency f and phase velocity v of EEG wave allows to predict which qualia can be conscious for self at given level of the p-adic self hierarchy. The concepts of id and super ego proposed by Freud, as also levels below and and above them. find identification in terms of the p-adic self hierarchy.

c) The assumption that very many ions are important, is not unrealistic since extremely low ion densities are needed (few ions per cell volume!) to realize supra phases and ions in gas phase tend to reside on non-atomic spacetime sheets. Non-orthogonality of electric and magnetic components for classical em and Z^0 fields induces long range classical $W^{\pm}$ and gluon fields at cellular spacetime sheets. This makes possible color magnetism, nuclear transmutations and exotic nuclear and electronic ionization processes occurring with huge rates as compared with the ordinary weak process: quantum coherence amplifies further these rates.

d) Qualia must be parametrizable by the changes of the quantum numbers in the quantum jump inducing quantum phase transition giving rise to quale. In lowest order the increments of quantum numbers correspond to quantum numbers associated with charged Lie-algebra generators of color, rotational and electroweak symmetries. For instance, 3+3 (1+1) nondiagonal generators of color (rotation) group are identifiable as colors and their complementary colors (black and white). The increment of the integer characterizing cyclotron frequency could give rise to primitive arithmetic consciousness. At fundamental quantum level the generalization suggesting itself is that the Super Algebra associated with the infinite-dimensional group of isometries of the configuration space characterizes all possible qualia with Lie resp. super generators representing sensory resp. Boolean qualia. The possible choices of the quantization axes for spin and color defines product of symplectic flag-manifolds F_2 and F_3. Very attractive hypothesis is that orientation and position qualia and corresponding velocities correspond to points of 1+1-dimensional F_2 and $3 + 3$-dimensional F_3. In infinite-dimensional case one has infinite-dimensional flag manifold.

e) Vision, tactile senses and orientation-position type qualia are tentatively identified as magnetic qualia. Hearing and cognition, tastes and olfaction are Z^0 magnetic qualia. Music is language of emotions and the temporal pattern of ionic EEG defined by the superposition of harmonics of cyclotron frequency is like piece of music. Perhaps emotions are coded to the ionic EEG patterns. Rather unexpectedly, theory suggests that odours are coded into ZEG patterns in similar manner: in fact, odour discrimination is known to rely on spatio-temporal patterns of nerve pulses.

f) The structure of the periodic table manifests itself directly in the spectroscopy

of consciousness. Various full electronic shells (He, Ne, Ar, Kr, Xe) give rise to a hierarchy of qualia with higher levels containing copies of lower level qualia. Amazingly, the periods of the periodic table relate directly with the band structure of EEG and possibly also with the five-layered structure of the sensory cortex.

To sum up, spectroscopy of consciousness promises to be for brain science what atomic and nuclear spectrosopy has been for chemistry and physics. Somewhat astonishingly, this possibility has not been noticed before. After all, spectral lines provide extremely effective, reliable and universal manner to code information and brain is the most refined information processing system we know.

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