

Spectroscopy of Consciousness

M. Pitkänen

Dept. of Physics, University of Helsinki, Helsinki, Finland.

Email: matpitka@rock.helsinki.fi.

<http://www.physics.helsinki.fi/~matpitka/>.

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Abstract

TGD based quantum measurement theory predicts that each quantum jump involves localization in zero modes giving rise to ordinary quantum measurement followed by a state preparation by self measurements leading to an unentangled product state. The sequence of quantum jumps defines a statistical ensemble of prepared states and this suggests strongly a connection between the theory of qualia and thermodynamics supported also by psychophysics. Qualia can be divided to purely geometric ones represented by the zero modes of the lightlike boundary of ME (quantum measurement) and to non-geometric ones allowing statistical description (state preparation).

Non-geometric qualia

Non-geometric qualia of various types correspond to various kinds of quantum phase transitions inducing effectively gradients of various extensive thermodynamical variables with respect to subjective time. The generalization of the decomposition $dE = TdS - PdV + \mu dN + B \cdot dM + ..$ suggests a classification for the basic types of non-geometric qualia to entropic, kinesthetic, and generalized chemical qualia.

a) Entropic qualia. Various kind of entropy gradients (TdS) induce emotions. Negative/positive emotions would correspond to growth/decrease of disorder. The close correlation between emotions and peptides regarded also as information molecules supports this view. Also temperature sense is this kind of quale. Total entropy of subself correlates with the sharpness of mental image and attentiveness, alertness and level of arousal relate strongly with entropy.

b) Kinesthetic qualia. Generalized statistical forces (PdV) induce qualia experienced as physical forces, such as pressure and these qualia reduce to the gradient of momentum with respect to subjective time. Generalizing, the increments of Poincare, color and electroweak quantum numbers label kinesthetic qualia which are universal (independent of context defined by other quantum number increments). The increment of energy (frequency) gives rise to quale which is an essential element of hearing.

c) Generalized chemical qualia. Particle number gradients (μdN) induce generalized chemical qualia including ordinary chemical qualia for which odorants and tastants BE could condense on superconducting magnetic flux tubes. The quantum phase transitions associated with supercanonical representations whose states are labelled by $SU(3)$ color quantum numbers and 2-D spin could give rise to visual colors and polarization quale. BE condensation of $SU(3)$ colored 'configuration space photons' at MEs would in question. The BE condensation of ordinary photons could relate to vibratory sense which can be developed to a level of almost vision. Tactile senses involve also topological phase transitions and the numbers of join along boundaries bonds between skin (sense of touch) and object touched and inside skin (pain) define generalized chemical qualia.

Magnetic quantum phase transitions ($B \cdot dM$) involve changes of magnetization and give rise to both kinesthetic and generalized chemical qualia. MEs could even make possible endogenous NMR and its generalizations for selves of cellular size and chemical qualia could be basically qualia of this kind. The identification Z^0 magnetic spin flips for neutrinos as responsible for an essential aspect of hearing leads to precise quantitative predictions consistent with empirical facts. A varying magnetic field strength along magnetic flux tube makes possible place coding frequency coding by cyclotron frequency scale and magnetic qualia can serve as 'colors' of sensory maps.

d) Boolean qualia. 'This is true' experiences might be understood as supersymmetric counterparts of visual qualia and auditory qualia.

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The primary qualia are induced by EEG frequencies generated by temporal patterns of nerve pulses by a mechanism of amplification analogous to kicking a pendulum on correct half-period. Stochastic resonance provides a reverse of this mechanism.

If p-adic length scales define preferred lengths for MEs, the transition frequencies for the supercanonical representations are constants of Nature and correspond to important resonance frequencies of EEG. Furthermore, the five sensory areas of the neocortex seem to correspond to fundamental frequencies quaternion conformal representations and to the periods of the periodic table. In magnetic case frequency bands defined by the periods of the periodic table correspond to EEG bands.

These observations suggests what might be called spectroscopy of consciousness: each primary quale corresponds to a particular EEG frequency and EEG provides a partial representation of brain state just like atomic transition frequencies serve as finger prints of atoms allowing to deduce information about the physical state of stellar object from its spectrum. The implications of spectroscopy of consciousness, if indeed realized in Nature, are bound to be far reaching.

1 Introduction

Macroscopic quantum phases are an essential element of most quantum theories of consciousness 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 space-time sheets realized as a 4-surface in certain 8-dimensional space. The notion of many-sheeted spacetime indeed predicts new types of macroscopic quantum phases. This has led to guesses for the quantum correlates of sensory qualia (colors, tastes, odours,..) and conscious thought as various macroscopic quantum phases predicted by TGD but the the lack of direct experimental evidence for the macroscopic quantum phases has made more detailed models impossible. During the last years several breakthroughs in the understanding of TGD and TGD inspired theory of consciousness have occurred and inspired the first trials to construct a general theory qualia. Preliminary and incomplete versions of this theory are published in [12] and in [13]. The most recent detailed version of the still incomplete and developing theory of qualia can be found in the chapters "General Theory of Qualia" and "Spectroscopy of Consciousness" of the online book "Genes, Memes, Qualia, and Semitrance" [11].

1.1 TGD in nutshell

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 $p = 2, 3, 5, \dots$) are analogous to real numbers but differ from them in that p-adic numbers are not well-ordered. p-Adic physics describes the physics of cognitive representations and matter-mind decomposition at spacetime level corresponds to the decomposition of spacetime surface to real and p-adic regions. The higher the value of p , the better the resolution of cognitive experience is, so that p serves as kind of intelligence quotient. The mappings of the real geometric structures to their p-adic counterparts interpreted as cognitive mappings plays also key role in TGD inspired theory of consciousness.

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" [8], "TGD and p-Adic Numbers" [9] and "TGD inspired theory of consciousness with applications to biosystems" [10].

1.2 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.

1. *Quantum jump between quantum histories as moment of consciousness and the notion of self*

The identification of quantum jump between quantum histories as 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 (see the chapter "Matter, Mind, Quantum" of [10]). Self is identified as a subsystem effectively behaving like its own subuniverse quantum mechanically (see the chapter "Self and Binding" of [10]). Physically this means that self is a subsystem able to remain unentangled during subsequent quantum jumps. Self property is made possible by the decomposition of spacetime into p-adic and real regions which cannot entangle with each other.

Simple assumptions about how the contents of consciousness of self is 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 (see the chapter "Quantum Model for Conscious Experience" of [10]).

The localization in configuration space zero modes occurring in each quantum jump implies that the world of conscious experience is classical and standard quantum measurement theory follows as a consequence. Also self measurements are possible and each localization in zero modes is followed by a cascade of self measurements leading to a completely unentangled product state: this is nothing but TGD counterpart of the state preparation process which is also part of quantum measurement theory. Self measurements are governed by Negentropy Maximization Principle (see the chapter "Negentropy Maximization Principle" of [10]). Self measurements give rise to quantum level self repair mechanism. In p-adic context NMP is the basic variational principle of cognition.

2. *p-Adic physics as physics of cognition*

TGD spacetime decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, \dots$. p-Adic regions obeys the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive binary digits of arguments just like numerical predictions of any theory always involve decimal cutoff. This means that p-adic spacetime regions are

obtained by glueing together regions for which integration constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. The freedom of imagination is due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. In this vision real mind-like spacetime sheets are interpreted as geometric correlates of experience and corresponding p-adic spacetime sheets correspond to imagined experience.

3. *New view about time*

The understanding of the relationship between subjective and geometric time leads to the notion of psychological time involving in an essential manner the new view about spacetime, in particular the idea about mindlike spacetime sheet (defined as spacetime sheet having finite time-duration) as a geometric correlate of self (see the chapter "Time and Consciousness" of [10]). One can understand psychological time as temporal center of mass coordinate for the cognitive spacetime sheet. The arrow of psychological time can be understood as resulting from a drift towards the geometric future. Diffusion in future lightcone alone is probably not enough, also drifting force is needed and special relativity suggests that this force is fourth component of four-force and could perhaps be identified as proportional to the dissipation rate for energy occurring during the self-organization. This suggests that the average increment of the geometric time per quantum jump is given by $\Delta t = (P/k)\tau$, where P is rate of energy dissipation, k is the coefficient of friction regarded as a Lorentz scalar, and τ some fundamental time scale, most naturally of the order of CP_2 time τ_{CP_2} is CP_2 time about 10^4 Planck times. P/k would determine the fraction of time spent in wake-up state if τ is the average increment of the geometric time in quantum jump.

The notion of psychological time forces to view the entire many-sheeted space-time 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, geometric and subjective, as also two kinds of causalities. Massless extremals, whose lightlike boundaries are identified as geometric correlates of selves, realize the paradigm of 4-dimensional brain concretely.

4. *Selves self-organize*

Subjective time development by quantum jumps implies quantum self-organization which can be regarded as a sequence of quantum jumps between quantum histories (see the chapter "Quantum Theory of Self-Organization" of [10]). 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.

5. *Self hierarchy*

The notion of self hierarchy, starting from elementary particle level and having entire Universe at the top, is a highly nontrivial prediction of TGD inspired

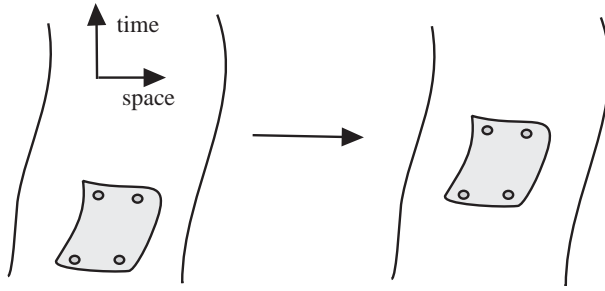


Figure 1: The mechanism giving rise to the arrow of psychological time. What happens is that mindlike spacetime sheet gradually drifts in direction of geometric future. Note that mindlike spacetime sheet has finite time duration.

theory of consciousness. 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 (see the chapter "Quantum Model for Intelligent Systems" of [10]). Topological field quanta of em fields are an part of self hierarchy and this force to give up the view that consciousness is brain centered phenomenon (wavelength of 10 Hz EEG photon has size scale of Earth). Self hierarchy is also crucial for the model of sensory qualia.

1.3 Biological realization of self hierarchy

Self hierarchy has a geometric correlate the hierarchy of spacetime sheets.

1. Massless extremals

The so called massless extremals (MEs) (see the chapter "Quantum Antenna Hypothesis" of [10] and the chapters "Quantum Model of EEG and Nerve Pulse", "General Theory of Qualia", and "Spectroscopy of Consciousness" of [11]) are excellent candidates for mindlike spacetime sheets since the 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 a classical 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 a sensory and motor organ of higher level selves and to a rather detailed view about the general organization of brain.

By general coordinate invariance the lightlike M_+^4 projections of the lightlike boundaries of MEs act as quantum holograms and can be identified as universal (but probably not the only) geometric correlates of selves. The lightlike vacuum currents are optimal for coding information and make MEs dynamical holograms in classical sense.

By Uncertainty Principle ELF MEs correspond to topological field quanta

with size of Earth. It became clear already before the realization of supercanonical representations that MEs could correspond to higher level selves (see the chapter "Genes and Memes" of [11]) living in symbiosis with biological life forms and responsible for the cultural aspects of human 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. Contrary to the Newtonian intuition, the only sensible view seems to be that we ourselves correspond to lifeforms of electromagnetic size not smaller than Earth size: the illusory identification of 'me' with brain is created by the erroneous identification of self with the contents of sensory experience. This view stimulates also rather concrete ideas about physical death and life after physical death (see the chapter "Biological realization of self hierarchy" of [10] and the chapters "General Theory of Qualia" and "Spectroscopy of Consciousness" of [11]).

2. Hierarchy of magnetic superconductors

The empirical results [2, 4] 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 and MEs. 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.

Second empirical ingredient supporting the view about hierarchy of magnetic superconductors are the puzzling observations of cell biology (for a summary see the first chapter of [14]) challenging the association of ionic channels and pumps to cell membrane. The paradoxes disappear if cell and its exterior are assumed to be in a many-sheeted ionic flow equilibrium with ionic currents flowing from superconducting spacetime sheets to atomic spacetime sheets and back, so that the densities of ions at atomic spacetime sheets are controlled by the very small densities and quantized currents of the ions at superconducting magnetic flux tube spacetime sheets and coding the information about homeostasis of biomatter (see the chapter "Biosystems as superconductors" of [10]). Also a reason why for liquid crystal and electret properties of biomatter emerges and one can understand the function of electric circuitry associated with body [1].

3. How MEs interact with magnetic superconductors

MEs induce super currents in superconducting magnetic circuits by magnetic induction mechanism, serve as Josephson junctions between magnetic flux tubes, and induce magnetic quantum phase transitions. MEs can generate reference waves or their phase conjugates (time reversals) acting on lower level MEs serving as dynamical holograms. The induced coherent light pattern and its phase conjugate could act as a control command and its time reversed version. Conjugate reference waves provide an extremely simple mechanism of healing by time reversal allowing the living matter to fight against second law. MEs can read DNA strand to the lightlike vacuum current by moving along it and thus code DNA strand/conjugate strand to a hologram or its phase conjugate in turn acting as a control command or its time reversal. ELF MEs could do the same at the level of axons: instead of DNA sequences nerve pulse patterns would be read now. Thus living matter could be regarded as a symbiosis in which MEs control superconducting magnetic flux tubes controlling ordinary matter at atomic spacetime sheets via many-sheeted ionic flow equilibrium. DNA would

represent the ROM of this system.

4. *MEs as carriers of supercanonical and quaternion conformal representations*

TGD predicts two kinds of superconformal symmetries (see chapter "TGD as a generalized number theory" of [8]). Quaternion conformal symmetries correspond to the gauge symmetries of fundamental interactions. Cosmological supercanonical symmetries act on the boundary of lightcone and are cosmological symmetries. The non-determinism of Kähler action however implies that the lightlike M_+^4 projections of lightlike boundaries of MEs take the role of the boundary of future lightcone as quantum holograms and supercanonical symmetry becomes ordinary macroscopic symmetry. Thus there is a fractal hierarchy of quantum holograms inside quantum holograms. One can identify the lightlike boundaries of MEs as geometric correlates for selves. Also spacelike selves are very probably needed and magnetic flux tube structures could represent them. Indeed, the non-determinism of CP_2 type extremals representing elementary particles (their M_+^4 projections are random lightlike curves) makes it impossible to characterize the quantum state completely by the data on the lightlike boundaries of MEs.

Supercanonical degrees of freedom makes MEs ideal candidates for the correlates of higher level consciousness.

a) The states of supercanonical representations have gigantic almost-degeneracies broken only by non-commutativity of supercanonical and Poincare symmetries which means huge information storage capacities. Supercanonical representations can be realized in real context using Bose Einstein condensates of massless elementary particles on MEs. Supercanonical representations correspond to genuine quantum gravitational effects since wave functionals in the space of three-surfaces are involved: spacetime ceases to be a passive arena of quantum dynamics. In fact, canonical transformations of CP_2 are approximate symmetries of the theory broken only by classical gravitation. The notion of 'configuration space photon' having nontrivial dependence on configuration space degrees of freedom characterized by Hamiltonian suggests strongly itself and seems to be crucial for understanding of the visual colors.

b) Supercanonical representations have universal transition frequency spectrum given as multiples of the fundamental frequency determined by the length of ME. If one assumes that MEs have lengths given by p-adic length scale hypothesis, fundamental frequencies turn out to correspond to important resonance frequencies in EEG.

For these reasons supercanonical representations are ideal candidates for an infinite hierarchy of lifeforms associated with MEs. The great vision is that MEs and magnetic superconductors associated with the magnetic flux tube structures form a fractal hierarchy interacting with the ordinary biomatter via the classical gauge fields associated with MEs (see the chapters "General Theory of Qualia" and "Spectroscopy of Consciousness" of [11]).

2 General theory of qualia

The theory of qualia has gradually developed from mere guesses to the identification of possible underlying great principles. In the following these principles are represented in the order of how they have emerged, a possible identification of qualia is proposed, and the notion of place and time coding is discussed.

2.1 Qualia as quantum phase transitions

Various types of quantum phase transitions are natural candidates for qualia. In accordance with 'Where-What' decomposition of brain information processing, one can decompose qualia into geometric ('Where' and 'When': position, orientation,...) and non-geometric ('What': colors, tastes,..) qualia. Geometric qualia correspond to the zero modes of configuration space in which a localization takes place in each quantum jump. Non-geometric qualia correspond to non-zero modes and hence to quantum jumps between states of supercanonical and quaternion conformal representations.

This suggests that non-geometric sensory qualia can be classified at brain level into supercanonical qualia and magnetic and Z^0 magnetic qualia on one hand (more generally, quaternion-conformal qualia).

a) Supercanonical qualia are higher level qualia in the sense that quantum jump occurs at the level of the entire configuration space rather than at the level of spacetime only. The quantum number increments (spin and color quantum numbers) associated with BE-condensing supercanonical boson characterize the quale. BE-condensation occurs for 'configuration space photons' rather than ordinary photons whose configuration space dependence is characterized by color $SU(3)$ and spin quantum numbers.

b) Magnetic qualia could be much more primitive. Endogenous NMR or its generalizations could give rise to entire spectrum of magnetic qualia and chemical qualia could correspond to magnetic quantum phase transitions.

Geometric data from external can be coded to zero modes of MEs, in particular the position and other geometric characteristics of subself (ME) representing an object of the perceptive field. Most naturally the portion of a magnetic flux tube at which ME is glued to the magnetic flux tube codes the information classically to the properties of ME, especially the lightlike vacuum current and classical gauge fields associated with it. Note that this picture leaves open the identification of emotional qualia which seem to something different from sensory qualia.

2.2 Non-geometric sensory qualia and superalgebras

Quite generally, discrete non-geometric sensory qualia (such as colors) must correspond to the changes of the quantum numbers in quantum jumps serving as seeds of quantum phase transitions of the quantum critical macroscopic quantum phases combining to form quantum spin glass phase. This allows to interpret the sequence of quantum jumps giving rise to a quale as a process analogous to what we do when we explore room in total darkness or what physicist does when she studies unknown system by perturbing it slightly again and again and finding the reaction. The 'world of worlds' character of supercanonical states corresponds to this idea at the level of physical states.

Lie-algebras mathematize the notion of infinitesimal change (small perturbation) induced by symmetry transformation and thus they are expected to characterize fundamental qualia. The reduction of non-geometric qualia to the representations of quaternion conformal and supercanonical algebras¹, the latter being related to the isometries of the configuration space of 3-surfaces and acting at the lightlike boundaries of MEs, seems indeed possible. What is nice

¹Superconformal and related super algebras are generalized Lie-algebras introduced in seventies and are encountered in both super string models and TGD.

that super generators of the algebra could correspond to Boolean 'this is true' qualia in one-one correspondence with sensory qualia.

Poincare algebra is closely related to the quaternion conformal algebra. A natural expectation is that the increment of momentum should basically characterize the qualia induced by forces and torques (pressure sense, and sensations caused by ordinary and angular acceleration). More generally, the increments of Poincare, color, and electroweak quantum numbers should define universal qualia. Universality hypothesis states that the quale defined by quantum number increment does not depend on context (other quantum numbers). For instance, the sensation of force or torque can be associated with all kinds of quantum phase transitions.

2.3 Qualia and thermodynamics

The connection between thermodynamics and qualia was the real breakthrough in the development of ideas. In some sense this finding is not a news: the close connection between pressure sense and temperature sense and thermodynamics is basic facts of psychophysics. In TGD framework the contents of consciousness is determined as some kind of average over the sequence of very large number of quantum jump and this suggests strongly that qualia allow statistical description generalizing ordinary thermodynamical ensemble to the ensemble formed by the prepared states in the sequence of quantum jumps after the last 'wake-up' of self. This picture allows to see the ageing of self with respect to subjective time as an approach to thermal equilibrium.

a) Geometric qualia. There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about spacetime surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about increments of zero modes in quantum jump. Self experiences the average of the increments but the possibility of a sequence of subselves, whose experiences are not averaged, makes it possible to remember the digits of a phonenumber.

b) Non-geometric qualia. The sequence of the prepared states can be modelled as a statistical ensemble of Fock states, which suggests that thermodynamics is basically part of theory of consciousness. The ensemble of prepared states gives rise to a large number of statistical qualia. The relationship $dE = TdS - PdV + \mu dN + B \cdot dM \dots$ generalizes to TGD context: note however that in case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the lightcone boundary of ME. Each intensive-extensive variable pair in the differential should correspond to a non-geometric quale, which results only when there is gradient (flow) of the extensive variable in the direction of the subjective time. Supercanonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

The thermodynamical expression for dE suggests a general classification of qualia to entropic, kinesthetic and chemical qualia consistent with the 'holy trinity' of existences implied by TGD.

a) Entropic qualia. $T - S$ pair correspond 'subjective existence' and generalizes to disorder-order type, information theoretic qualia about the state of self: hot-cold and pain-pleasure type experience and also more abstract experiences associated with various subselves of self. These qualia are strongly emotional single-pixel holistic qualia measuring whether some kind of entropy

variables associated with self is increasing or decreasing. Emotional qualia are associated with both geometric and non-geometric qualia and could correspond to emotions about state of external world (say aesthetic experiences) and about body (pain, pleasure).

b) Kinesthetic qualia. p - V pair corresponds to the 'geometric existence' and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. Generalized forces reduces to increments of Poincare, color and electroweak quantum numbers and are universal qualia accompanying all quantum phase transitions. In particular, energy increment defines time-like component of sense of force and corresponds to key quale associated with hearing. Also $B - M$ pair gives rise to kinesthetic qualia.

c) Generalized chemical qualia. $\mu - N$ pair corresponds to 'objective existence' defined by quantum histories and N is generalized to a number of particle like excitations in the Fock state resulting in the state preparation. In this case there must be a gradient of particle number associated with self with respect to subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs.

i) Chemical qualia would very naturally correspond to the Bose-Einstein condensation of ions to the superconducting magnetic flux tubes. In principle, endoneous NMR and its generalizations induced by the interaction of magnetic and Z^0 magnetic fields of MEs with magnetic and Z^0 magnetic flux tube structures are possible.

ii) For super canonical qualia the number of Bose-Einstein condensed 'configuration space photons' having nontrivial dependence on configuration space degrees of freedom replaces number of molecules. Supercanonical qualia could actually reduce to visual colors and polarization quale since color $SU(3)$ and two-dimensional spin label the elements of supercanonical algebra. Also the BE condensation of the ordinary coherent light could give rise to some kind of quale: perhaps vibratory sense which can be developed to effective vision, could correspond to non-colored vision.

iii) Particle number could be also topological, say the number of join along boundaries bonds as in case of sense of touch or physical pain.

2.4 Possible identification of qualia

The proposed general classification leads to rather detailed identifications of quantum correlates of qualia.

1. Color vision and supercanonical algebra

Supercanonical algebra contains infinite number of Hamiltonians in representations of color group and possessing definite two-dimensional spin. For color octet representations, which is the lowest one, there are 3+3 nondiagonal oscillator operator like color generators with opposite quantum numbers. Perhaps the discoverers of color symmetry had some precognition about the possible role of this symmetry when they jokingly choose to call it color symmetry. The 3+3 color generators carrying opposite quantum numbers indeed can be related to the six primary colors forming complementary pairs (with black and white included). This identification, originally stimulated by the observations of mathematician Barbara Shipman [15] about the dance of honeybee, makes sense since TGD predicts that classical em field are accompanied by classical long range color fields and super canonical representation can give rise to colored states.

A very strong support for the correctness of the prediction is that it nicely explains the basic characteristics of color vision (color contrast, color opponency, color constancy) besides reducing the existence of six primary colors to the symmetries of the 8-dimensional imbedding space (the structure of which can thus be deduced from the basic properties of color vision!, see the chapter "General theory of qualia" of [11]). Perhaps the most realistic interpretation of the higher color representations is as higher level colors. Spin increment corresponds naturally to polarization sense.

2. Chemical qualia as magnetic qualia?

Chemical qualia (tastes and odours) are in a well defined sense more primitive than visual qualia. This suggests that 'our' chemical qualia can be assigned with the Bose-Einstein condensation of superconducting ions. These transitions can occur also at the level of sensory representations so that tastants and odorants would be classified to equivalence classes represented by light biologically important ions.

NMR at superconducting magnetic flux tubes with varying thickness induce automatically the coding of the densities of superconducting ions at magnetic flux tubes to the quantum holograms provided by MEs. ME could induce the rotating part of the magnetic field associated with flux tube inducing magnetic transitions. There is entire hierarchy of sensory selves and these sensations need not correspond to our experiences directly but perhaps contribute to proprioception after several averagings implied by the lower position of the cell sized selves in the self hierarchy. Magnetic quantum phase transitions induce an emission of coherent light topologically condensing at MEs perhaps contributing to proprioception.

3. Tactile senses

Tactile senses involve mixture of all types of qualia. Kinesthetic aspect is present especially clearly in pressure sense and sensation of force and torque. Also energy sense aspect (energy increment) is involved: some blind people learn to 'hear' by vibrational sense.

Chemical (in generalized sense) aspects are also present. Sense of touch involves a topological phase transition involving the formation of join along boundaries contacts with the object is involved. Thus the number of join along boundaries contacts between skin and object could play the number of particles in this case so that a generalized chemical quale is in question. In case of physical pain (nociception) also the splitting of join along boundaries contacts associated with the tissue or its sensory representative occurs and the number of these contacts could also define a relevant particle number. It is quite possible that objects of perceptive field are represented at cortex and join along boundaries bonds are split at this level.

Nociception is usually accompanied by a strong emotional pain and is due to the strong entropic gradients implied by the splitting of the join along boundaries bonds in the tissue. These gradients could be even amplified at the level of sensory representations. Also temperature sense involves emotional aspect strongly for obvious reasons.

4. Hearing

Hearing involves strongly the timelike component of sense of four-force, energy or frequency sense, and thus gradient of total energy of subself with respect

to subjective time is essentially involved. By its universality this aspect of hearing is involved with all senses but since hearing involves so wide a frequency range it dominates hearing and allows auditory sensation to provide information about entire time interval.

This universal aspect of hearing does not completely explain what it is to hear. The model of hearing and memetic code based on cognitive neutrino pairs was the first decisive step of progress in the modelling qualia (see the chapter "Quantum model of hearing and memetic code" of [11]). Verbal cognition and hearing involve Z^0 magnetic phase spinflip transitions of cognitive neutrinos. The upper bound of audible frequencies is predicted correctly in terms of the anomalous Z^0 magnetic moment of neutrino.

5. Emotions

The thermodynamical approach suggests that emotions correspond to the gradients with respect to subjective time for various entropy like variables associated with subsystems of self. Thus positive/negative emotions should reflect the increase/decrease of order. This identification is supported by the general characteristics of emotions.

Emotions contain only few bits of information but this information is very important for survival. Emotions are holistic, 'single-pixel' qualia and about the state of the entire body or relatively large part of body. Emotions are very much like conscious representations for time rates for the deviations from homeostasis realized as many-sheeted ionic flow equilibrium and appear in complementary pairs. Emotions correlate very strongly with the chemical state of the body. In particular, peptides are often regarded as both the molecules of emotion as well as of information. Since peptides perform biocontrol as information molecules they must induce especially intense entropy gradients with respect to subjective time and thus strong emotions.

The total entropy of subself tells how sharp the mental image is. Alertness, attention and level of arousal obviously strongly correlate with the total entropy. To keep mental images sharp (to attend) is to fight against second law with help of metabolism and 7 ± 2 law for cognition expresses the maximum number of mental images which can be kept in low entropy state simultaneously.

6. Boolean qualia

Super algebra contains also super generators carrying fermion number and having otherwise same quantum numbers Lie algebra generators. Depending on whether ordinary Lie-algebra generator or super generator is in question, quale corresponds to sensory or Boolean quale (fermion number $1/0 \leftrightarrow$, 'this is true/false' sensation): thus sensory and Boolean qualia are in one-one correspondence which suggests that the contents of a Boolean statement associated with a given fermionic generator relates closely to the sensory quale represented by the corresponding bosonic generator. Thus bosons would correspond to sensory consciousness and fermions to logical mind and the structure of the super canonical and quaternion conformal algebra would relate directly to the general structure of conscious mind.

The obvious problem is that Bose-Einstein condensation is not possible for fermions.

a) In case of vision the colored superpartners of 'configuration space photons' obtained by adding right handed neutrino and its antiparticle to the boundary of ME could define Boolean counterparts of visual qualia and could be created

as collinear pairs in the decay of colored 'configuration space photon': note that color quantum numbers are absolutely essential here since ordinary right-handed neutrino couples only to gravitational field. In the model of hearing cognitive neutrino-antineutrino pairs condensed on different spacetime sheets and having vanishing net energy, are in a key role. In this case the classical lightlike Z^0 currents associated with MEs could create correlated neutrino-antineutrino pairs (it is not clear whether they are massive when topologically condensed on MEs).

b) In TGD also spacetime sheets with negative time orientation and negative energy are possible and if MEs can appear as pairs then positive and negative energy fermions could appear as correlated pairs condensed at different spacetime sheets: BE condensation for these states could occur. Cognitive neutrino pairs are assumed to be this kind of states topologically condensed and cellular and cell membrane spacetime sheets.

c) One possibility is that magnetic quantum phase transition for fermions inducing spin flip is responsible for the Boolean quale. In case of cognitive neutrino pairs spin flip indeed occurs.

2.5 Place and time coding

Our qualia seem to be qualia about the virtual world formed by the representations of the external world. Geometric '*Where*' type qualia (position, orientation, velocity,..) result when sensory input from a particular position of external world wakes-up a particular part of brain (place-coding): thus the position and orientation of subself inside self codes for the position and orientation of an object of the perceptive field.

a) Somatosensory pathways defining somatosensory maps of body in cortex take care of this coding automatically.

b) Frequency coding of geometric variables to a position or orientation of subself inside brain using a variable cyclotron frequency scale is a natural higher level coding of geometric data. Magnetic homeostasis should control the value of the local magnetic field of Earth inside brain to achieve the coding.

The paradigm of 4-dimensional brain implied by TGD allows to understand long term geometric memories as '*When*' type qualia (time-coding): memories are stored in the temporal position where they were first experienced. Identification of the lightlike boundaries of MEs as selves realizes this idea concretely.

a) The notion of four-dimensional neural circuits might make sense. Indeed, the selves associated with MEs correspond to lightlike 3-surfaces. MEs acting quantum holograms might make information transfer between future and past possible by quantum teleportation. To remember actively would be to send a question to the geometric past and to receive the answer. The fact that sensory experiences receiver usually content from single moment of the geometric time, however suggests that this rarely occurs. In the p-adic case signalling between past and recent is allowed by the conservation laws: p-adic ME can be spontaneously reflected in time direction yielding phase conjugate ME. Interestingly, our long term memories are mostly cognitive. Also passive memories communicated to us by higher level MEs are possible.

b) The frequency coding of temporal position using EEG waves using time dependent cyclotron frequency scale made possible by slow time dependence of the local magnetic fields is possible.

2.6 Where me is?

The motion of eye or head does not induce the sensation that the world is moving although the sensory image moves around the cortex. Rather, brain acts like a (possibly moving) canvas at which the sensory input is projected and monitored by an external observer. This very simple observation is a strong objection against the idea that the ultimate sensory representations reside inside brain, and leads to the view that the magnetic flux tube structures associated with the primary and secondary sensory organs define a hierarchy of sensory representations outside brain. Magnetic flux tube structures would serve as the sensory canvas to which sensory images are projected from brain and possibly sensory organs and even neurons. MEs serve as projectors and place coding by magnetic transition frequency associated with ME wakes-up sensory subselves at various positions of magnetic flux tubes having varying thickness and associate thus various sensory qualia and even more complex attributes to the objects of the perceptive field.

EEG MEs correspond to our level in this hierarchy of projections. The simplest possibility is that the sizes of these sensory selves are of the order of EEG ME sizes ($L(EEG) = c/f(EEG)$) and thus can be of the order of Earth size! Thus the ultimate sensory representations are magnetic giants in TGD and diametrical opposites of the neurophysiological dwarfs of standard neuroscience populating also TGD brain. The known strange effects of large scale perturbations of Earth's magnetic field on consciousness (say, statistics about the effects of magnetic storms in mental state and tectonic activity inducing UFO experiences) provide a rich palette of anomalies supporting this view. The conservation of magnetic flux makes magnetic flux tube structures of Earth size very stable: thus physical death presumably means only that our magnetic body redirects its attention to something more interesting. Near death experience indeed support this view.

2.7 Cortex as a collection of attributes assigned to the objects of perceptive field represented on magnetic canvas

One of the basic problems related to the understanding of the information processing in brain is how various attributes are assigned to the object of the perceptive field. What is known that brain recognizes features and these features/attributes seem to be located in a more or less random looking manner all around cortex. This brings strongly in mind random access memory or computer game in which various little program modules realized as records in random access memory assign represent collection of standard sound effects. A strong hint is the empirical evidence for the view that the frequencies associated with the nerve pulse patterns, and thus presumably also coding EEG frequencies, are same for the features associated with a given object of the perceptive field. The challenge is to understand how the picture based on a collection of MEs projecting features to the magnetic canvas could allow to understand what is behind these observations.

2. How MEs can be used to assign position information to features

The view about MEs associating attributes to the object of the perceptive field by waking up subselves in the magnetic flux tube structure serving as a

sensory canvas suggests an elegant interpretation for these facts.

a) Cortex can be regarded as a collection of regions specialized to represent various kinds of standard features. Features need not be simple qualia: arbitrary complicated collections of them, such as familiar faces are also possible features. Even entire dynamical processes could serve as features.

b) Basic feature-regions are like computer records containing besides the standard feature data also information about the position of the object of the perceptive field with which this feature is to be associated. The information about the position could be variable but a more attractive view is that also this information is completely fixed. Thus feature records would be fixed triplets (*feature, d, Ω*) where *d* and Ω code for the distances and direction angles of the object of the perceptive field to which the feature is assigned. Frequency coding could be used to wake-up these feature selves and this could give rise to the sensory representation.

c) Features must somehow be represented by MEs. The activated ME associated with the feature record codes the direction and distance of the object of the perceptive field to which this particular attribute is to be associated. Basically the direction and frequency of ME code for the direction and distance of the object of perceptive field. Feature becomes conscious when magnetic quantum phase transition occurs. The distance dependence of the magnetic flux tube thickness makes possible the cyclotron frequency scale coding of the distance.

3. Dynamical MEs or pre-existing MEs?

The problem is to understand how feature MEs could be activated selectively. There are two basic options.

a) ME is created when the feature is assigned with the object of the perceptive field. The realization of this option is difficult to imagine since it is not easy to understand how ME with a definite frequency and orientation could be created from scratch in a controlled and reliable manner. For this reason this option is not discussed in the sequel.

b) MEs (records) form pre-existing dynamical radial bundles (files) associated with a fixed feature and a specific ME (particular record in file) is activated selectively by frequency coding. The radial bundle of MEs has a natural interpretation as a topological field quantization for the classical Z^0 radiation field whose individual rays are transformable to classical em radiation field by a color rotation induced by a reference beam of configuration space photons. The activated ME generates a hologram and control command. The realization of the this option seems relatively straightforward. This option looks also relatively reliable as compared to the first option.

4. How pre-existing feature MEs are activated?

Consider now in a more detail the coding based on pre-existing radial bundles of MEs.

a) There is a radial bundle of pre-existing MEs (file consisting of records) associated with each feature with a fixed distance *d* such that in the passive state these MEs are Z^0 MEs and are transformed to em MEs when activated and in turn waking up magnetic 'position-self' and assigning the feature with it. Feature files with a fixed distance *d* of object could form linear stripe like structures for which *d* corresponds to linear distance along stripe and coded to EEG frequency of MEs varying with this distance. Thus there is a coding of the distance of the object by the distance along the linear structure. These

stripe like regions could in turn correspond to linear or at most two-dimensional regions coding for the variants of feature, such as colors. One-dimensional coding by frequency is in principle always possible. Strictly speaking, topographic organization of records is not necessary but presumably present.

b) The problem is to selectively activate a ME corresponding to a given distance and orientation. Frequency coding is a universal manner to achieve this. Each distance corresponds to a frequency interval such that the ordering of the intervals reflects the ordering of distances. The direction angles for the object of the perceptive field corresponding to a fixed distance are coded by the frequencies in the corresponding frequency interval. Therefore a given EEG frequency activates definite ME. Note that the frequency activating ME, is variable in some range, and is not the same as the frequency at which ME activates magnetic quantum phase transition.

c) There is an important consistency constraint on this picture. If the orientation of the cortex changes, the frequency coding for orientations is altered and the perceptive field is experienced to rotate if ME is fixed to the reference system of head. Thus feature files should not corotate with head but should be fixed to a kind of a compass needle. This suggests that ME bundles are anchored to the magnetic crystals filling the brain whose orientations are fixed by the orientation of Earth's magnetic field.

d) In this coding EEG MES would contain essentially all information about perceptive field and the spectroscopy of consciousness would be realized in a strong sense.

There are certainly variants about this basic option. For instance, the sphere defined by orientation angles could be decomposed into sectors of fixed solid angle coded spatially so that ME bundles would span only a fixed solid angle. The extreme situation is the one in which direction angles are coded spatially. Thus one would have three-dimensional gridlike structure coding the directions and distance of MEs. In this case each point would contain only single ME which does not mean very effective information representation capacity.

By fractality of consciousness, this architecture is expected to be realized at various length scales. Perhaps even at the length scale of genes. The remaining question is how motor activities are realized in this picture. The metaphor for consciousness as a computer sitting on its own terminal which originally stimulated my personal attempts to understand consciousness, might help here. Computer screen corresponds to the magnetic canvas. The one who sits presumably corresponds to higher level in fractal magnetic hierarchy (flux tubes inside flux tubes). The central unit corresponds to the brain. Sensory projector MEs correspond to records organized as files formed by the radial bundles of MEs and coding the picture on the monitor. MEs as active quantum holograms acting as control commands seem to provide a realization of keyboard. Note that the magnetic canvas outside body is in a passive role as far as control is considered: it is magnetic flux tube structures inside body which are tools of quantum control for MEs. Thus it would seem that those aspects of computer which are usually not regarded as fundamental in Turing machine paradigm are the most crucial for understanding the brain consciousness and computer programmers imitate what happens inside (and outside) their own brain.

3 Nerve pulses, EEG, and qualia

3.1 How nerve pulse patterns are coded to sensory qualia?

Nerve pulse patterns generate qualia and there must be some kind of coding mechanism. Since EEG frequencies are involved temporal coding must be in question. This is in conflict with the most standard wisdom that only the rate of firing determines the content of sensory experience. There is indeed strong empirical evidence for various kind of temporal coding mechanisms: the oldest evidence comes from Benham top [3]: suitable temporal pattern of stimulation by achromatic light is able to produce color sensations. Stochastic resonance [5] allows a realization of the temporal coding by phase locking the output of a bistable system with a weak periodic input when the level of white noise is correct. Stochastic resonance has been indeed verified in neuronal systems [5].

1. *Music metaphor*

Music metaphor has turned out to be very powerful in attempts to understand qualia. Brain can be regarded as an orchestra formed by the instruments represented by various neural circuits carrying some characteristic macroscopic quantum phases. Nerve pulse patterns are players picking the strings of this instrument. Each ion defines characteristic key and cyclotron frequency and its harmonics modulo octave are like notes of the scale. In case of super canonical Algebras same applies although now all fundamental frequencies differ by powers of $\sqrt{2}$. The dominating multiple of the fundamental transition frequency defines note representing a particular variant of the same quale. One can say that the presence of the harmonics gives the quale a special personal character transforming monotonic beep to a personal voice. This could make it possible for subself to distinguish between subselves using same key (ion) just as in music overtones allow to distinguish between instruments: this might have significance in intrabrain communications.

2. *ELF selves scanning the quale selves in the cortex*

The physical model for how sensory experience is generated is roughly the following. There is entire hierarchy of MEs but ELF selves (EEG frequencies) and 'quale selves' with size of order brain or smaller (microwave and infrared frequencies) are especially important. ELF selves with sizes of order Earth size represented by MEs with thickness which is perhaps of order cell size, move along quale self and scan them, roughly once in time interval of order .1 seconds. A Lorentz boost in the direction of axon give rise to a moving ME. An alternative possibility is that MEs drift. If magnetic flux tubes have varying thickness and if ELF selves contain constant component of magnetic field then the interaction energy of the magnetic moment of ELF self with magnetic flux tube gives rise to a drifting force.

The scanning activity would be very much like the reading of DNA by MEs and coding the information to the lightlike vacuum current and thus to quantum hologram. The contribution of the reference wave to the hologram would correspond to the sourceless part of the induced gauge field and reference waves would correspond to various EEG rhythms. During sleep reference waves would dominate EEG. ELF selves are like chords of music instrument: when nerve pulse activity creates periodic perturbation inside quale self with correct frequency, strong ELF em wave is generated inside ELF self, and leads to conscious quale. Thus each ELF self is specialized to detect whether particular part of

brain contains the neural activity waking-up it and generating primary quale.

3. *Pendulum metaphor for how nerve pulse patterns induce EEG waves*

ELF selves carry only multiples of fundamental frequencies and are like strings of music instrument. Nerve pulse patterns amplify ELF wave like periodic kicks of pendulum at correct half period give it large energy: thus the mechanism is extremely robust. What happens is that although pendulum is reset but continues to oscillate with same frequency: this results in the observed loss of synchrony of EEG during sensory arousal. The frequency of ELF self specialized to experience particular part of brain code for positions of brain structures. It is natural to expect that these frequencies are ordered geometrically. For instance, frequency could decrease when one moves from primary sensory areas to secondary, tertiary,... areas since lower frequencies represent longer p-adic time scales and correspond to higher p-adic 'intelligence quotient'.

4. *Stochastic resonance and coding of EEG frequencies to spike sequences*

Stochastic resonance [5] is an excellent candidate for a mechanism allowing to code EEG frequencies to the spike sequences. Non-linear oscillator in double well potential is driven by a periodic force and white noise amplifies the periodic perturbation resonantly if white noise has correct intensity. At resonance phase locking occurs but resonance in the ordinary sense of the word is not in question.

Stochastic resonance has been verified for both SQUIDs and neuronal level [5]. Stochastic resonance provides a mechanism of temporal coding and a manner to detect very weak periodic signals from a noisy background. It is however not at all obvious that excitable media, which do not allow bistable states, allow stochastic resonance. This inspires the hypothesis that bistable stochastic resonance occurs at quantum control level. Stochastic resonance is indeed possible for superconducting circuits containing Josephson currents and could be the basic amplification mechanism for weak EEG waves in TGD framework. At stochastic resonance, each period of the oscillating Josephson current generates with a high probability a spike and EEG period is coded as a peak in the distribution for the time interval between two spikes (see the chapter "TGD based model for EEG and nerve pulse" of [11]).

5. *Scaling law*

The scaling law relates the size L of the sensory subself in brain or CNS and the length $L(EEG)$ of EEG ME associating with the sensory subself a point of the magnetic canvas providing the ultimate sensory representation (ME induces magnetic quantum phase transition at that point). Also the size of the magnetic flux tube structure is assumed to be of order $L(EEG)$. The scaling law reads as

$$L(EEG) = \frac{c}{f} = \frac{c}{v}L \quad , \quad L = \lambda = \frac{v}{f} \quad .$$

f denotes EEG frequency and v the apparent phase velocity v of EEG wave, which actually corresponds to the velocity of motion for EEG ME along axon and is equal to the nerve pulse velocity. L is identified as the apparent wavelength λ of EEG wave and cannot be larger than brain size. The known ranges of variation for v (3 – 7 Hz on surface of scalp [6]) and λ (below 30 cm) imply that EEG frequencies representing our conscious experiences should be in

the range 8 – 40 Hz during ordinary wake-up consciousness. During meditative states lower frequencies represent experiences conscious-to-us.

Once the value of the cyclotron frequency is fixed, scaling law fixes the size L of the generalized sensory organ from which the radial magnetic flux tubes defining the sensory canvas of size of order $L(EEG)$ emanate. Interestingly, the sizes of lense and retina correspond to proton and deuteron cyclotron frequencies and thus to the lowest levels of nuclear magnetic consciousness. The length scale of 5 microns corresponds to the electronic cyclotron consciousness: this suggests that already neurons have sensory representations based on magnetic flux tube structures with size of order 10^4 meters.

3.2 Periodic table, supercanonical algebra algebras, EEG bands and the areas of sensory cortex

Music metaphor suggests that cyclotron frequency scale as such should not have much significance for magnetic qualia (which need not be 'ours'). The ratio of Larmor frequency and cyclotron frequency could however matter. For instance, ions with vanishing electronic angular momentum J_e have much lower Larmor frequencies and spin qualia must be different for ions having $J_e = 0$ and $J_e > 0$. As long as ions behave as magnetic rigid bodies in quantum jumps, the electronic structure should not however affect the quale.

1. What periods of the periodic table have to do with the hierarchy of sensory areas?

The cyclotron frequencies associated with singly ionized atoms can be obtained by the formula

$$f = \frac{A}{20} \times f(Ca_{++}) \quad f(Ca_{++}) \simeq 15 \text{ Hz} . \quad (1)$$

Here the strength of Earth's magnetic field is assumed to be .5 Gauss = 5×10^{-5} Tesla. A denotes atomic weight. Frequencies vary roughly in the range 1.5 – 90 Hz such that lowest periods of the periodic correspond to gamma and beta frequencies and highest periods to delta frequencies. Astonishingly, the periods of the periodic table turn out to correspond to various bands of EEG (see the table below and tables in (see the chapter "Spectroscopy of consciousness" of [11]).

The independence of the magnetic quale on frequency scale inspires the hypothesis that the five periods of the periodic table define a hierarchy of magnetic qualia such that higher periods contain the copies of the lower periods. An interesting hypothesis is that periods also correlate with the five layers of the sensory cortex (primary, secondary, tertiary, etc... sensory cortices). The number of frequencies conscious-to-us (or some-one) increases when one moves from Helium period to Xenon period. The sensory acuity determined by negentropic resources obviously improves when the number of conscious-to-us harmonics playable by quale instrument increases.

2. Supercanonical qualia correspond to important resonance frequencies of EEG and to the hierarchy of sensory areas

Supercanonical (presumably visual) qualia can be classified the properties of $X^2 \times CP_2$ Hamiltonians, where X^2 is the lightlike coordinate=constant section

of the M_+^4 projection of the lightlike boundary of ME. That is, by the color representation and value of the component of angular momentum associated with the function of X^2 coordinates. If the classical gauge fields associated with ELF MEs with lengths given by p-adic length scale hypothesis induce the quantum transitions of massless states associated with MEs, transition frequencies come as harmonics of the fundamental frequency $f(n, k)$ associated with SCA

$$f(n, k) = 1/T_n(k) = \frac{c}{L_n(k)} = 2^{-\frac{nk}{2}+127} \times 10 \text{ Hz} ,$$

where $T_n(k)$ is the n-ary p-adic time scale associated with p-adic prime $p \simeq 2^k$ and constant of Nature. $f(2, 127) = 10 \text{ Hz}$ serves as a natural reference frequency and defines a fundamental rhythm in biosystems. All these frequencies are positive or negative octaves of $f(2, 127)$ or $\sqrt{2}f(2, 127)$ and should have anomalous effects on biosystem also in radiowave, infrared, visible and ultraviolet ranges.

The primary, secondary, etc... areas of neocortex seem to correspond to definite Super Virasoro ELF selves containing at least the p-adic length scales $L_2(2^5)$, $L(251)$, $L_2(127)$, $L(2^8)$, $L(257)$, $L_2(131)$, ... with fundamental Super Virasoro frequencies $f(k, n)$ equal to 40 Hz, 28.2 Hz, 10 Hz, 5.0 Hz, 3.5 Hz, .63 Hz,... Note that these fundamental frequencies correspond to gamma, beta, alpha, theta and delta bands. Even to my nonprofessional best knowledge most of these frequencies and their harmonics are important resonance frequencies in EEG so that EEG provides direct support for the supercanonical (assuming p-adic quantization of the preferred length of ME), which represent the most advanced mathematical constructs of unified quantum field theories usually believed to have direct implications only in Planck length scales.

The $v = Lf$ scaling law described earlier implies the existence of a mapping

$$L(k(\text{bio})) \rightarrow L(k(\text{ELF}))$$

between biological length scales $L(k(\text{bio}))$ and cultural length scales $L(k(\text{ELF}))$. The mapping means that ELF self characterized by $k(\text{ELF})$ receives sensory input from corresponding biological length scale $L(k(\text{bio}))$ and presumably has corresponding biological selves as subselves. This mapping is illustrated in the table below. For instance, the bioselves at length range 8-16 cm corresponding to the size of brain hemisphere and to tertiary sensory areas are scanned by ELF selves at theta frequencies.

The table below provides a concise summary of the proposed correspondences. The length scale $L_3(83)$ corresponds to $f(1, 0) = 56 \text{ Hz}$ contained also in the EEG range and is not given in the table.

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 ³	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	

Table 1. The table 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).

4 Summary and possible implications

The philosophical implications of the theory of qualia and closely related theory of quantum control and coordination are rather interesting. The only logical conclusion seems to be that we are much more than our physical bodies. We have electromagnetic body and sizes of ELF MEs are of order Earth size and Uncertainty Principle suggests sizes of order light life for the MEs associated with our consciousness.

At the level of neural sciences the most important consequences relate, besides qualia, to the understanding of long term memory which is one of the bottlenecks of neuroscience. Theory indeed solves the paradoxes of standard theories of memory: there is complete spacetime democracy in TGD and memories are simply experiences with contents in the geometric past. Memories are temporally located to the temporal position where they occurred for the first time and there is no need to store memories about several moments of time to single moment of time. The lightlike boundaries of MEs as geometric correlates of higher level selves realize this vision concretely.

The technological and medical implications of the proposed identification of sensory, emotional, geometric and cognitive qualia, if correct, are rather dramatic.

a) EEG provides a partial coding of sensory experience and motor activities. The knowledge of frequency coding might make it possible to construct electric technology allowing to control, say robots, by mere power of thought. First examples of this kind of technology already exists. It could be possible to generate conscious experience by stimulating brain electronically or using sound at important resonance frequencies. Neurofeedback is already now surprisingly successful therapy and precise knowledge for the correlates of EEG frequencies could make neurofeedback [7] high precision science. Direct communications between brains could become in principle possible using amplified EEG signals send electronically and received at the second end of communication line. These communications could involve direct transfer of sensory experience, emotions and thoughts.

b) If memories are what TGD claims them to be, it might be possible to remember artificially by using high precision tuning of appropriate EEG frequencies to wake-up mental image at precisely correct moment of the geometric past.

c) MEs are predicted to exist in all length scales and to be the core element of life. Generation of MEs means generation of life so that the question how to generate genuine artificial life reduces to the question how to generate MEs. An especially fascinating potential implication is the universal healing mechanism based on time reversal induced by phase conjugated reference waves.

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References

- [1] R. O. Becker and G. Selden (1990) *The Body Electric: Electromagnetism and the Foundation of Life*. William Morrow & Company, Inc., New York.
- [2] C. F. Blackman (1994), "Effect of Electrical and Magnetic Fields on the Nervous System" in *The Vulnerable Brain and Environmental Risks, Vol. 3, Toxins in Air and Water* (eds. R. L. Isaacson and K. F. Jensen). Plenum Press, New York, pp. 331-355.
- [3] P. Cariani (1995), *As if time really mattered: Temporal strategies for neural coding of sensory information*, *Communican and Cognition-Artificial Intelligence (CC-AI)*, March, Vol 12, nos. 1-2, pp. 157-219.
- [4] N. Cherry (2000), Conference report on effects of ELF fields on brain, <http://www.tassie.net.au/emfacts/icnirp.txt> .
- [5] Luca Gammaitoni *et al* (1998) *Stochastic Resonance*, *Rev. Mod. Phys.* 70, 223-288, January. <http://www.umbrars.com/sr/> .
- [6] P. L. Nunez (2000), *Toward a Quantitative Description of Large Scale Neocortical Dynamic Function and EEG*, *Behavioral and Brain Sciences*, 23, (3): XX.
- [7] S. Othmer, S..F Othmer and D. A. Kaiser (2000), *EEG Biofeedback: A Generalized Approach to Neuroregulation*, to appear in "Applied Neurophysiology & Brain Biofeedback".
- [8] M. Pitkänen (1995). *Topological Geometroynamics*. Internal Report HU-TFT-IR-95-4 (Helsinki University).
Online book at <http://www.physics.helsinki.fi/~matpitka/tgd.html>.
- [9] M. Pitkänen. (1995). *Topological Geometroynamics and p-Adic Numbers*. Internal Report HU-TFT-IR-95-5 (Helsinki University).
Online book at <http://www.physics.helsinki.fi/~matpitka/padtgd.html>.
- [10] M. Pitkänen (1998) *TGD inspired theory of consciousness with applications to biosystems*.
Online book at <http://www.physics.helsinki.fi/~matpitka/cbookI.html>.
- [11] M. Pitkänen (2001) *Genes, Memes, Qualia, and Semitrance*.
Online book at <http://www.physics.helsinki.fi/~matpitka/cbookII.html>.
- [12] M. Pitkänen (2000) *About identification of the quantum correlates of sensory qualia* .
CASYS'2000, Fourth International Conference on Computing Anticipatory Systems, Liege, 2000. Abstract Book, Ed. M. Dubois.

- [13] M. Pitkänen (2001), *Spectroscopy of consciousness*, International Journal of Computing Anticipatory Systems (to be published).
- [14] G. Pollack (2001), *Cells, Gels and the Engines of Life*, Ebner and Sons.
<http://www.cellsandgels.com/> .
- [15] B. Shipman (1998) *The geometry of momentum mappings on generalized flag manifolds, connections with a dynamical system, quantum mechanics and the dance of honeybee.*
<http://math.cornell.edu/oliver/Shipman.gif> .
B. Shipman (1998), *On the geometry of certain isospectral sets in the full Kostant-Toda lattice.*
<http://nyjm.albany.edu:8000/PacJ/1997/Shipman.html> .
B. Shipman (1998), *A symmetry of order two in the full Kostant-Toda lattice.*
<http://www.math.rochester.edu:8080/u/shipman/symmetrypaper/> .