Quantum Model for EEG: part I

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Abstract

The basic philosophy behind the attempts to understand EEG is the view about personal magnetic body as an intentional agent receiving information from brain and body both by sharing of mental images and by classical communications by time mirror mechanism. Information can be received in the similar manner also by other magnetic bodies, say that of magnetic Mother Gaia.

The vision about dark matter hierarchy and p-adic length scale hierarchy leads to the conclusion that there is a wide variety of EEG and ZEG MEs involved differing by p-adic scalings and by the scalings of Planck constant. One can make guesses about the functions of various MEs only if some general vision about sensory perception, motor action, and memory is available.

1. Overall view

a) Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism.

b) Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images associated with the primary sensory organs are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic representations, writes the sensory music to notes. The mental images defined by these representations can be shared by personal magnetic body or magnetic bodies associated with the sensory organs in a similar manner by quantum entanglement and charge entanglement by W MEs provides a good candidate in this respect. The selective entanglement by negative energy MEs allows to understand the active aspects of sensory experience involving direction of attention and selection between percepts at various levels.

c) The cyclotron radiation and Josephson radiation from biological body induces cyclotron phase transitions of dark ions at the magnetic body and generates higher level sensory experiences. The most plausible interpretation of these qualia is as emotional and cognitive qualia.

2. Basic contributions to EEG and ZEG

There are three fundamental contributions to EEG (or hierarchy of EEGs) besides the neuronal noise. This picture applies more or less as such also to ZEG.

a) Schumann resonances whose interpretation should be clear.
These frequencies do not depend on magnetic field strengths assignable with magnetic flux sheets and characterize Earth's magnetic field and collective aspects of consciousness.

b) Cyclotron frequencies generated in cyclotron transitions of dark ions.
Dark cyclotron photons result naturally in the dropping of dark ions to excited cyclotron states at dark magnetic flux sheets. This assumption explains the findings of the pioneers of bio-electromagnetism. A similar mechanism is suggested to work at the gene level and perhaps also in the intermediate length scales and the experimental findings of Gariaev support this picture, in particular scaled up version of the band structure seems to be present at radio frequencies.

The dropping ions would liberate part of their zero point kinetic energy as a metabolic energy: note however that dark photon cyclotron frequencies correspond to energies above thermal threshold. The generation of EEG at cyclotron frequencies would be a side product of the control actions of the magnetic body inducing metabolic activities and would be a correlate for the motor control by the magnetic body. These frequencies can be classified to those associated with bosonic and fermionic ions respectively. The transitions of Bose-Einstein condensates of bosonic ions are of special interest. The scale of these frequencies could be be subject to homeostatic regulation which is local and can vary even inside genes of a given nucleus.

c) The frequencies generated by Josephson currents as coherent photons.
The analysis of the Josephson current leads to the conclusion that the frequencies in the coherent state of photons are in general sums and differences of Josephson frequency $f_J = 5$ Hz and harmonics of cyclotron frequencies. For small amplitudes this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions correspond, has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

d) In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. One explanation is that right *resp.* left brain hemisphere corresponds to $Z = 2$ *resp.* $Z = 1$ quantization condition $Z \int BdS = n\hbar$ for the magnetic flux. $Z = 2$ case allows only doubly charged bosonic ions at magnetic flux sheets. $Z = 1$ case also also singly charged ions be their bosons or fermions and for this option magnetic field is scaled down by a factor of 1/2. The alternative explanation is that during sleep only Bose-Einstein condensates of singly charged exotic ions resulting when color bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves

only theta and delta bands.

During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. For $k_{em} = 3$ and magnetic field scaled up by λ and flux tube area scaled down by λ^{-2} DNA frequencies are scaled up to kHz for $Z = 2$ flux quantization and might define neuronal synchronization frequencies.

3. Emotions and cognition as sensory qualia of magnetic body

Cyclotron transitions seem to correspond to sensory qualia of magnetic body whereas ordinary sensory qualia are assignable to sensory organs. The identification of emotions and cognition as sensory qualia associated with the magnetic bodies at various levels of dark matter hierarchy seems to be the most appropriate one, and leads to a detailed view about various aspects of music experience giving justification for the music metaphor.

4. Right brain sings and left brain talks

Right brain signs and left brain talks is a good metaphoric characterization of brain hemispheres. This metaphor also characterizes the difference between emotional and cognitive representations, and leads to a concrete idea about how the presentations defined by Josephson radiation from right and left brain hemispheres differ. Speech like representations identifiable as cognitive representations can be assigned with the left magnetic body and music like cognitive representations identifiable as emotions with the right magnetic body.

These representations are local representations at the level of magnetic body and correspond to slow variations of the membrane resting potential determining the Josephson frequency of the Josephson junction determining ordinary EEG and its generalizations. Speech like variations correspond to characteristic temporal patterns for the modification of membrane voltage lasting some time interval and define analogs of phonemes. Music like variations are constant shifts of membrane voltage and are coded to a variation of the pitch of the Josephson frequency. The deviations from the standard value of the resting potential are analogous to musical notes. The rhythm defined by the durational patterns of the notes is second essential element of the EEG music.

Miniature- and micro-potentials are natural candidates for the deviations of the resting voltage determining these representations.

5. p-Adic cognitive codes

The conventional view that the information content of conscious experience is determined completely by rate coding from nerve pulse patterns does not seem plausible in TGD framework. Indeed, p-adic cognitive codes define an entire hierarchy of binary codes associated with the p-adic frequencies and frequency coding would apply only to the average intensity of the sensory input.

The hypothesis is that the primary and also n-ary p-adic frequencies associated with the primes $p \simeq 2^k$, k prime or power of prime, define a hierarchy cognitive codes such that the number of the bits of the codeword is k. These codes, which can be regarded as special case of music

like representations of Josephson radiation at magnetic body, define the phoneme like basic units of speech like representations as modulation patterns of EEG frequency reducible to corresponding modulation patterns for membrane resting potential.

1 Introduction

The model of EEG and nerve pulse has developed through several tortuous twists reflecting the development of basic ideas of TGD inspired theory of consciousness and of bio-systems as macroscopic quantum systems. The general vision about living system as a conscious hologram and the view about how "topological light rays" (massless extremals, MEs) serve as remote entanglers and induce self-organization via the leakage of ionic currents between various space-time sheets implies that several space-time sheet pairs are involved with the bio-control. Perhaps the most radical deviation from the standard neuroscience thinking came with the realization that in TGD Universe every physical system has also magnetic/field body of size much larger than the material body and that material bodies can be seen as motor and sensor organs of the personal magnetic body. This counter intuitive conclusion is unavoidable if one accepts many-sheeted macroscopic quantum coherence, Uncertainty Principle and topological field quantization. p-Adic physics as physics of intention and cognition provides an additional support for this view: the smaller the space-time sheet is p-adically, the larger it is in the real sense so that cognition and intentionality are predicted to be astrophysical phenomena and evolve from long to short length and time scales just as it indeed occurs when motor activity is learned.

1.1 Magnetic canvas hypothesis

Very general objections against the idea that sensory, symbolic and cognitive representations are realized completely inside brain lead 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 with magnetic flux tubes serving as the canvas to which place coding by magnetic frequency generates sub-selves and associates with them various sensory, symbolic and cognitive representations by quantum entanglement.

The original hypothesis was that the mental images at magnetic canvas correspond to a sensation of "simple feeling of existence". Be as it may, a plausible identification for the patterns of cyclotron phase transitions at the magnetic body is as giving rise to higher level sensory qualia responsible for the emotional and cognitive aspects of our conscious experience.

MEs define the sensory projection and EEG MEs correspond to our level in this hierarchy of projections. The sizes of these sensory selves are of order ME sizes ($L(EEG) = c/f(EEG)$) and thus or order Earth size. One can say that entire magnetic body is the experiencing entity and also the ultimate motor actor. Actually the personal magnetic body decomposes to a fractal hierarchy

of magnetic bodies associated with body parts and even cell nucleus has magnetic body responsible for sensory experiencing and motor control at this level. Clearly, the TGD based view about sensory representations and motor actions is a diametrical opposite of the standard view.

An important element of the magnetic canvas hypothesis is the assumption that primary sensory organs carry the fundamental sensory qualia: magnetic body could be seen as a tree having roots at the sensory organs and trunk and branches emanating from the cortex. The capacitor model of sensory receptor suggests that also neurons have sensory qualia: these qualia are however not ours. It is necessary to assume quantum entanglement sequences starting from the level of the personal magnetic body and going down to the magnetic bodies of sensory organs in order to circumvent various objections against this hypothesis.

Also the TGD based view about geometric memory is essential. Using Libet's classical findings relating to the active and passive aspects of consciousness as constraints, one ends up with the view that sensory experiencing is a particular case of geometric memory with time span of order .5 seconds.

Magnetic body is also an intentional agent. Generalized motor action is realized in terms of the charge entanglement induced by negative energy W MEs which induce exotic charging of nuclei and in this manner induce dark plasmoids affecting classical em fields at dark space-time sheets and via the many-sheeted variant of Faraday's law also at the space-time sheets carrying ordinary matter. This induces currents giving rise to nerve pulse patterns, ionic waves, etc...

1.2 Dark matter hierarchy, sensory representations, and motor action

Dark matter hierarchy allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [M3] leading among other things to a generalization of the notion of genome.

For ordinary quantum mechanics photons at EEG frequencies correspond to ridiculously small energies. Dark matter hierarchy is accompanied by a hierarchy of EEGs and its generalizations with the scalings of frequencies predicted to come in powers of $\lambda \simeq 2^{11}$ [M3]. For $k_{em} = 4$ the energies of EEG photons are above thermal threshold at room temperature for $f \geq 1$ Hz, and 5 Hz frequency corresponds to 86 meV energy.

The fact that arbitrarily small frequencies can correspond to energies above thermal threshold at higher levels of dark matter hierarchy implies that photons with arbitrarily low frequencies can have sizable physical effects on matter. This conforms with the findings about the effects of ELF em fields on living matter [M3], and these effects allow to develop a rather detailed model for EEG and identify the parts of EEG correlating with communications of sensory data to the magnetic body and with quantum control performed by the magnetic body [M3].

1.2.1 Bose-Einstein condensates at magnetic flux quanta in astrophysical length scales

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B_{end} = .2$ Gauss (earlier model assumed Earth's magnetic field $B_E = .5$ Gauss since there was error in overall scale of cyclotron frequencies) is based on the dark matter hierarchy with levels characterized by the value of $\hbar(k_{em}) = \lambda^{k_{em}}\hbar_0$, $\lambda \simeq 2^{11}$.

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at $k_{em} = 1$ level of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_{em} > 1$ dynamics.

2. Cyclotron energies scale as as $\lambda^{k_{em}}$ so that for a sufficiently high value of k thermal stability of cyclotron states at room temperature is achieved. Spin interaction energy $\mu \cdot B \propto S \cdot B$ scales as $1/\hbar$ since four-momentum and angular momentum are by Poincare symmetry invariant under the scaling of $\hbar$ (the highly non-trivial implications of the invariance of angular momentum are discussed in [C6]). Hence spin interaction energy has the ordinary value. Unless thermal isolation is assumed, spin degrees of freedom are thermalized, and only cyclotron degrees of freedom can be quantum coherent. This is a testable prediction distinguishing between the new and old model.

3. If the flux quanta of $B_{end} = .2$ Gauss correspond to $k_{em} = 4$ level of dark matter hierarchy, cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $\lambda^4 \simeq 2^{44}$ from their ordinary values and are above thermal energy at room temperature for $A \leq 233Z$, where Z is the charge of the ion. Even for $Z = 1$ this includes all stable nuclei. Bose-Einstein condensates of bosonic ions are thus possible at room temperatures at Earth's surface. Cooper pairs of fermionic ions are possible only for $A \leq 4$ leaving in practice only protons into consideration. Also bosonic molecular ions can suffer BE condensation.

1.2.2 Fractal hierarchy of magnetic flux sheets

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be hierarchy of these bodies with even much larger sizes. Therefore the question arises what distinguishes between the magnetic bodies of Earth and human body. The quantization of magnetic flux suggests an answer to this question.

There are several manners to achieve quantization of magnetic flux with dynamical $\hbar$. From the point of view of EEG and ZEG especially interesting

are dark $k = 169$ magnetic flux sheets carrying endogenous magnetic field having strength $B_{end} = 0.2$ Gauss, corresponding to $\hbar = 5\hbar_0$, and carrying magnetic flux $2h_5$, where the unit of magnetic flux is $h_5 = 5h_0$. $n = 5$ is the minimal value required by universal topological quantum computation [E9]. Their scaled down versions have thickness $5L(169)/\lambda = (5/4) \times L(151) = 12.5$ nm (slightly more than cell membrane thickness). These flux sheets have total transversal length $5L(169 + 5 \times 22) = 5L(257) = 8.9 \times 10^8$ km from flux quantization at $k_{em} = 4$ level of dark matter hierarchy necessary in order that the energies associated with cyclotron frequencies are above thermal threshold. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure.

Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seem that single brain cannot provide the needed total length of DNA if DNA dominates the contribution: this if of course not at all necessarily. Even for $k_{em} < 4$ levels magnetic flux sheets could traverse nuclei belonging to different organisms.

This leads to the notion of super- and hyper genes. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

1.2.3 Charge entanglement as a tool of generalized motor action

The charge entanglement by W MEs is an essentially new element in the model for generalized motor actions by magnetic body. Also the telepathic sharing of mental images could rely on charge entanglement. The notion was originally applied in the model of nerve pulse generation [M2]. Neutral MEs would in turn be related to communications and memory. The reduction of charge entanglement can induce a quantum jump to a state in which local Bose-Einstein condensates become exotically ionized with certain probability depending on the intensity of W field. Bose-Einstein condensates define pixels of generalized motor maps.

Exotic ionization induces dark plasma oscillations in turn generating various physiological responses such as Ca^{++}, Mg^{++} waves, and nerve pulse patterns giving rise to the motor action as an asymptotic self-organization pattern. Plasma oscillation patterns utilize typically dark microwave photons as metabolic energy. Field code is the correspondence between the spatio-temporal pattern of plasma oscillations and generalized motor action and the number theoretical model for genetic code [L3] generalizes to this context.

1.2.4 Overview about quantum control and coordination

The following general overview about quantum communication and control emerges in this framework.

1. Cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control.

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter ionolito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere.

3. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

4. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a nonlocal charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy. This provides a nonlocal quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control.

5. Massless extremals (MEs, topological light rays) serve as correlates for dark bosons. Besides neutral massless extremals (em and Z^0 MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The interpretation of the charged MEs has remained open hitherto. Charged W MEs (hierarchy of WEGs!) could induce long length scale charge entanglement of Bose-Einstein condensates by inducing exotic ionization of ionic nuclei. State function reduction could lead to a state containing a Bose-Einstein condensate in exotically ionized state.

In this manner the dark charge inside neuron and thus by Faraday's law also membrane potential could be affected by magnetic body. The generation of nerve pulse could rely on the reduction of the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. The mechanism might apply even in the scale of magnetic body and make possible the control of central nervous system. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

Summarizing, charged massless extremals could be seen as correlates for nonlocal quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K3].

1.3 General vision about EEG and ZEG

There is a wide variety of EEG and ZEG MEs involved, and one can make guesses about the functions of various MEs only if some general vision about sensory perception, motor action, and memory is available. The following assumptions summarize the most general vision achieved hitherto and consistent with the findings of Libet about strange time delays of consciousness [26, 27] discussed in [17] and [K1].

1.3.1 Overall view

1. Magnetic bodies forming a hierarchy are the fundamental volitional agents transforming intentions to actions. Intentions are represented by p-adic MEs transformed to negative energy MEs representing the desire about particular activity communicated to the lower level magnetic bodies in the geometric past and eventually to the material body. Each negative energy ME in the cascade represents a desire to realize some submodule in motor program. Eventually the desired action is generated in terms of neural communications and of positive energy MEs both representing classical communications to the geometric future. The desire in question could be a desire to perform a particular motor action, a desire to direct attention or select among sensory percepts (binocular rivalry is the standard example), or a desire to remember something. Sensory perception, motor action, and memory would thus be based on essentially the same basic mechanism.

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1.3.2 Basic contributions to EEG and ZEG

There are three fundamental contributions to EEG (or hierarchy of EEGs) besides the neuronal noise. This picture applies more or less as such also to ZEG.

1. Schumann resonances whose interpretation should be clear.
   These frequencies do not depend on magnetic field strengths assignable with magnetic flux sheets and characterize Earth's magnetic field and collective aspects of consciousness.

2. Cyclotron frequencies generated in cyclotron transitions of dark ions.
   Dark cyclotron photons result naturally in the dropping of dark ions to excited cyclotron states at dark magnetic flux sheets. This assumption explains the findings of the pioneers of bio-electromagnetism [63]. A similar mechanism is suggested to work at the gene level and perhaps also in the intermediate length scales and the experimental findings of Gariaev [64] support this picture, in particular scaled up version of the band structure seems to be present at radio frequencies.

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4. In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. One explanation is that right *resp.* left brain hemisphere corresponds to $Z = 2$ *resp.* $Z = 1$ quantization condition $Z \int BdS = n\hbar$ for the magnetic flux. $Z = 2$ case allows only doubly charged bosonic ions at magnetic flux sheets. $Z = 1$ case also also singly charged ions be their bosons or fermions and for this option magnetic field is scaled down by a factor of 1/2. The alternative explanation is that during sleep only Bose-Einstein condensates of singly charged exotic ions resulting when color bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves only theta and delta bands.

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1.4.1 Right brain sings and left brain talks

Right brain signs and left brain talks is a good metaphoric characterization of brain hemispheres. This metaphor also characterizes the difference between emotional and cognitive representations, and leads to a concrete idea about how the presentations defined by Josephson radiation from right and left brain hemispheres differ. Speech like representations identifiable as cognitive representations can be assigned with the left magnetic body and music like cognitive representations identifiable as emotions with the right magnetic body.

These representations are local representations at the level of magnetic body and correspond to slow variations of the membrane resting potential determining the Josephson frequency of the Josephson junction determining ordinary EEG and its generalizations. Speech like variations correspond to characteristic temporal patterns for the modification of membrane voltage lasting some time interval and define analogs of phonemes. Music like variations are constant shifts of membrane voltage and are coded to a variation of the pitch of the Josephson frequency. The deviations from the standard value of the resting potential are analogous to musical notes. The rhythm defined by the durational patterns of the notes is second essential element of the EEG music.

Miniature- and micro-potentials are natural candidates for the deviations of the resting voltage determining these representations.

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The hypothesis is that the primary and also n-ary p-adic frequencies associated with the primes $p \simeq 2^k$, k prime or power of prime, define a hierarchy cognitive codes such that the number of the bits of the codeword is k. These codes, which can be regarded as special case of music like representations of Josephson radiation at magnetic body, define the phoneme like basic units of speech like representations as modulation patterns of EEG frequency reducible to corresponding modulation patterns for membrane resting potential.

1.5 Scaling law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. The law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form $L = v/f$ and relates ELF self size characterized by ELF frequency f to the self size L and to the effective phase velocity v of the EEG wave.

Scaling law also suggested by the experimental work with the effects of ELF radiation in water [62]. A discussed in [K5] scaling law can be explained in terms of the basic model for generalized motor action based on charge entanglement induced by W MEs. The chapter ends with the discussion about possible implications of the scaling law concerning EEG.

2 EEG, MEG, nerve pulse and mini-potentials

In this section the basic facts about EEG, MEG, nerve pulse and mini-potentials are briefly reviewed.

2.1 EEG

E(lectro)E(ncephalo)G(ram) is the study (or graphing) of the electric potential on the surface of the skull [30]. EEG waves are oscillations of the membrane potential with frequency varying in the range 1-100 Hz. The amplitude of the oscillating membrane potential is typically 10^{-4} Volts and by a factor 10 smaller than postsynaptic potential and by a factor 100 than the threshold potential for the generation of the nerve pulse. EEG waves is a vertebrate phenomenon, insect ganglia do not exhibit comparable potentials.

Four basic rhythms have been identified in EEG wave spectrum and their amplitude and frequency correlate strongly with the state of awareness [30]. It must be emphasized that the the boundaries of frequency ranges vary by few Hz depending on author.
i) α rhythm. f = 8-13 Hz and amplitude is about 20 micro-volts. α dominates in rest but not in the sleep state. A sudden illumination by light leads to the disappearance of the α component of EEG.
ii) β rhythm. f = 14-30 Hz with amplitude about 40-100 micro-volts. β dominates during a conceptual thinking.
iii) γ rhythm. f = 30-90 Hz with. Gamma rhythm is associated with temporal coding of sensory information.
iv) θ rhythm. f = 4-7 Hz. θ dominates during sleeping without dreams. Dreams in turn correspond to β waves.
v) δ rhythm. f = 0.5-3 Hz. δ corresponds to deep sleeping without dreaming. In general the amplitude is smaller the larger the frequency is.

EEG reflects also alarm reaction and sensory responses. Various mental disorders, brain tumors and brain injuries reflect themselves in EEG. Epilepsy, which corresponds to hyperexcitability of some part of the nervous system induces characteristic changes in the EEG pattern. EEG varies also considerably during the development. EEG appears at the age of year as occasional bursts with frequency 4-8 Hz and the adult form of EEG is established before the age of 19.

The question whether all EEG waves genuinely propagate or not is not resolved experimentally yet. It is known that alpha waves propagate and that the propagation velocity is about $v \sim 10$ m/s. There is also evidence for the propagation of 40 Hz EEG waves [31, 32].

There is no doubt that EEG waves are deeply involved with the basic functioning of the brain but the origin and the exact function of EEG has remained a mystery. The EEG waves associated with two distant neurons are strongly correlated and this supports the view that EEG waves are related to the properties of the brain as a coherent quantum system.

2.2 MEG

This subsection gives a brief summary about magnetoencephalography (MEG). The motivation is that brain could act with MEs by acting effectively like magnetometer somewhat in the same way as SQUID magnetometer measures the magnetic fields generated by brain.

2.2.1 SQUIDs

SQUIDs [33, 34, 35] are instruments used to measure extremely weak magnetic field in the case that the resolution needed is below the magnetic flux quantum $h/2e$ ($\hbar = c = 1$) for magnetic flux in super conductor. An important application of SQUIDs is to the measurement of the weak magnetic fields generated by brain and having strengths as weak as fT. SQUID technology has been used to detect the weak magnetic fields created by brain (10^{-13} Tesla region) and quite an impressive knowledge exists about the magnetic correlates of the brain activity in ELF region [35].

A rough description of SQUIDs goes as follows.

1. The current in SQUID measures the deviation of the external magnetic field from a multiple of magnetic flux quanta which is reflected as a presence of a current in SQUID which creates magnetic field compensating this deviation.

2. The circuit equations can be written for the magnetic flux through SQUID and differ from the equations for RCL resonance circuit only by the presence of Josephson current non-linear with respect to the magnetic flux. If the super current is accompanied by a white noise with a correct intensity, SQUID amplifies the periodic signal in resonant manner. The stochastic resonance in SQUIDs has been demonstrated experimentally [36].

3. SQUID consists of a closed current loop decomposing to two parts connected by thin non-super-conducting insulators. This makes possible rapid dissipation of the current to the minimal value needed by flux quantization. Small deviations from the quantized flux can be accurately measured by measuring the persistent supra current.

The basic equation governing the behavior of SQUID relies in the following simple model. SQUID is characterized by inductance L relating magnetic flux to current ($\Phi = LI$ modulo integer number of flux quanta). The potential difference around SQUID is by Faraday's induction law equal to $eV = d\Phi/dt$. SQUID can be regarded as a capacitor (capacitance C) formed by the two halves of SQUID coupled by the insulators to which one can assign internal resistance R. Insulating parts serve as Josephson junctions through which ordinary Ohmic currents run besides the Josephson current depending sinusoidally on the magnetic flux. The equation for the time derivative of the potential difference around the SQUID loop reads as

$$LC\frac{d^2\Phi}{dt^2} = -\tau\frac{d\Phi}{dt} - \Phi - \beta sin(\Phi) - \xi \ ,$$
$$\beta = \frac{Li_c}{\Phi_0} \ , \quad \tau = \frac{L}{R} \ , \quad \Phi_0 = \frac{\hbar}{2e} \ . \tag{1}$$

Here ξ denotes the white noise contribution to the Josephson current. Φ is measured in units of Φ_0 and in the equation above Φ denotes the deviation of Φ from an integer multiple of Φ_0. The equation is obviously invariant under the symmetry $\Phi \to \Phi + n2\pi$. i_c denotes the critical current for which the super current in the circuit becomes dissipative. Usually also an additional external current guaranteing a slight over-criticality is added. If the inertial term proportional to LC can be made small, the system rapidly dissipates to equilibrium configuration. For small deviations of Φ from a valued corresponding to a quantized magnetic flux system indeed exhibits stochastic resonance [36].

2.2.2 Magnetic fields associated with brain activity

SQUIDs (super-conducting quantum interference devices) have made it possible to measure the magnetic fields associated with the brain activity. The magnetic fields accompanying the evoked responses [37] and the background activity of brain are in the range $10 - 10^3$ fT, in general below the level of the geomagnetic noise but above the thermal magnetic noise produced by body which is roughly .1 fT. The frequency range is typically between 0-100 Hz in these measurements and corresponds to the frequency range of EEG. Alpha rhythm at 10 Hz generates a sharp peak with a peak value about 1-2 pT, which is slightly above the level of the geomagnetic noise. Eyes create static magnetic fields of about 10^{-11} T. Heart creates an oscillatory field with somewhat stronger intensity below 10^{-10} T and with the frequency of heart beat: this field is in the intensity region of the geomagnetic noise having frequencies above .01 Hz. Sensory stimuli generate typically responses with a strength of few hundred fT consisting of oscillations which start few tens of milliseconds after the stimulus and end few hundreds of milliseconds after the beginning of the stimulus (natural time scale is .1 seconds for the duration of the magnetic response.

The simplest model for the magnetic field associated with an evoked response is as being generated by a point like magnetic dipole or a collection of point like magnetic dipoles. This means that the measured fields are essentially superpositions of radiation fields generated by dipoles. It is possible to determine rather accurately the positions of these effective dipoles in brain and thus to localize various brain functions. Also the dependence of the shape of the frequency spectrum on brain function can be studied and the distribution of the net power in a given frequency range as a function of the location can be studied. Often the ratio of the responses before and after stimulus is measured as a function of position near the surface of the skull.

The simplest hypothesis is that far-away radiation fields decompose into MEs propagating in the radial direction. In TGD based model of EEG, brain is in electromagnetic bath provided by 'free' ELF MEs moving along the surface of cortex with the velocity of nerve pulse, and generating electromagnetic

responses which decompose in far-away region into MEs propagating into the radial directions. In the induction region more complex flux quanta are possible. The criterion for the radiation region reads as $r \geq \sqrt{\lambda L}$ and relates the distance r between observation point and source, the size L of the source region, and the wavelength. For a point like source this criterion holds everywhere.

Dipole approximation is used in the analysis of the data to determine the position of evoked response. If λ corresponds to the wavelength of 10 Hz radiation and L is of order 10 microns, the the criterion for faraway region is roughly $r > 10$ meters and classical radiation fields measured in the region near brain are induction fields. Hence one cannot regard the magnetic fields induced by the brain activity as consisting of MEs in the measurement region. This is of course natural, since in radiation region a lot of information is lost since the system looks point like in this region.

On basis of EEG one can expect that the intensities of the magnetic fields associated with MEs providing the electromagnetic bath for brain are weaker than the intensities of the evoked fields. The intensity of ELF em radiation in delta band, which is of the same order of magnitude as the radiation associated with sferics [21], provides the first guess.

2.3 Nerve pulse

Nerve pulse is the tool used by the nerve cells to communicate information to each other [24, 38]. Nerve pulse is generated, when the potential difference through the cell membrane, rest potential, changes from its rest value about of -80 millivolts to about -50 millivolts, the threshold potential: after this the action potential about 40 millivolts is generated and begins to propagate along the axon with approximately constant velocity varying between 1-100 meters.

For resting potential the concentration of Na_+ ions, Ca_{++} and Cl_- concentrations are much larger outside the cell than in its interior whereas K_+ concentration is larger inside the cell. Thus in absence of constraints ($Na_+ - K_+$ pump) forcing membrane potential to its resting value Na_+, Ca_{++} and Cl_- would flow to cell interior: obviously, the flow of first two tends to reduce the resting potential. K_+ in turn would would flow out of cell interior. Nerve pulse is indeed generated when Na_+ conductance increase and Na_+ rush to cell interior, the return to resting state involves temporal flow of K_+ ions to cell exterior.

The generation of the nerve pulse involves the increase of Na and K conductivity through the cell membrane so that a flow of K and Na ions through cell membrane takes place and action potential is generated. The increase of the conductivity is caused by the opening of Na and K channels. According to the classical model of Hogkin and Huxley [24] the opening of the Na channels involves the participation of three so called m particles and one so called h particle. The rapid increase of Na conductivity is possible to understand only provided the charge of the m particles is -2 and they are electron pairs [24]. A possible identification is as Cooper pairs.

The axon consists of two kinds of segments. The first segment having typically a length of the order of 10^{-3} meters is surrounded by a myelin shell: in this region no Na and K currents appear. The velocity of the nerve pulse is of the order of 10^2 m/s in these regions. Between the myelinated regions appear unshielded regions, where Na and K flow appears: these have length of order of 10^{-6} meters: velocity is in general smaller in these regions. The function of the unmyelinated regions is probably to refresh the nerve pulse since the dissipation causes the decrease of the height of the pulse during the propagation through the myelinated regions. The completely unshielded propagation is not economical since metabolic energy gets wasted.

Nerve pulse either ends up to a muscle or is transferred to a neighboring cell through a synaptic connection. There are two kinds of synaptic connections. Gap junctions are direct contacts between two cells and the nerve pulse is transferred electrically to the second cell. In chemical synapses the axon is separated from the dendrite of the receiving cell by a synaptic cleft having width of the order of $10^{-8} - 10^{-7}$ meters. The nerve pulse is transferred chemically via the so called synaptic transmitter substance. The nerve pulse generated in the dendrite can be either excitatory or inhibitory depending on whether the sign of the voltage difference is favorable for the generation of the action potential or not. The value of the postsynaptic potential is about 10 millivolts.

Whether the nerve pulse is generated depends on the inputs received by the nerve cell. In neural network models the output is generated provided the sum of the inputs exceeds a certain threshold value. It is not at all clear however whether the inputs correspond to potentials or something else, but closely related to postsynaptic potentials. What seems to be clear is that this quantity can have only two values corresponding to exhibitory and inhibitory inputs respectively. The nerve pulses coming from the sensory organs obey frequency coding. The stronger the sensory input the greater the frequency of the nerve pulses. The duration of the nerve pulse, about few milliseconds, sets of course a limit for the frequency of the pulses.

To summarize, the propagation of the nerve pulse is a well understood process and the interpretation of the action potential as one bit of information is attractive. The idea that nerve pulse is generated, when the sum of inputs (in some sense) exceeds some threshold value seems to be well established. The details related to the generation of the threshold potential and the relationship of the nerve pulse generation to the general state of awareness and memory content of the brain is however unclear. Also the relationship between nerve pulses and EEG waves is unclear.

2.4 Miniature postsynaptic potentials

Miniature postsynaptic potentials have quantized amplitude of order .5 mV to be compared with the value of the rest potential, which is roughly 100 times larger [38]. Miniature potentials are generated in the postsynaptic neuron, when it has received nerve pulse. The quantized packets of neurotransmitters such as ACh give rise to the emission of miniature potentials. According to [38]

miniature potentials might consist of superpositions of much smaller micro-potentials of amplitude of order .3 μV generated by single neurotransmitter molecule. One could however consider also the possibility that the minimum size for the quantized packet of neurotransmitter is dictated by the requirement that the packet is able to generate the mini-potential.

3 Summary about TGD based view about qualia

The goal is to relate EEG to conscious experienced and in order to provide the needed perspective the basic TGD based vision about qualia is needed.

3.1 Non-geometric 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 non-geometric qualia allow a 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.

1. There are geometric qualia corresponding to zero modes expressing the result of quantum measurement in each quantum jump. All geometric information about space-time surface should reduce to geometric qualia. For instance, geometric data given by visual, auditory, and tactile senses should reduce to conscious information about zero modes or about increments of zero modes in quantum jump.

2. 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 $dE = TdS - PdV + \mu dN + B \cdot dM...$ generalizes to TGD context: note however that in the case of ME selves energy is replaced with the Super Virasoro generator L_0 associated with the light-cone 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. Super-canonical thermodynamics should obviously map ordinary thermodynamics to the level of conscious experience.

3. Since subjective experience corresponds to quantum jumps, it is tempting to assume that only the increments of zero modes and quantum numbers

are experienced consciously. This approximation might be at least a good starting point. Statistical interpretation also suggests that an averaging over increments occurs. The possibility of sub-selves makes possible to have mental images of finite time duration and this makes possible structured subjective memories (for instance, it becomes possible to remember the digits of phone number). A further working hypothesis is universality: qualia associated with quantum phase transitions depend only on the quantum number increments. In particular, the increments of Poincare and color and electro-weak quantum numbers define what might be called universal kinesthetic qualia.

The thermodynamical expression for dE suggests a general classification of qualia consistent with the 'holy trinity' of existences implied by TGD.

3.1.1 What kind of qualia could emotions correspond?

The identification of emotions as qualia is far from obvious. What looks clear is that emotions seem to relate closely to information (peptides are information molecules and their distributions also correlates strongly with the emotional state).

1. Do emotional qualia reduce to gradients of entropy or negentropy?

The first brave guess was that emotions reduce to the changes of a negentropy type variable. A more cautious assumption would be that these changes determine only a 2-valued emotional quale having values positive/negative.

1. The first candidate for the entropy type variable is the entropy for the ensemble determined by the quantum jumps of sub-self. More concretely, $T - S$ pair correspond subjective existence and generalizes to disorder-order type, information theoretic qualia qualia about the state of self: hot-cold and pain-pleasure type sensations and also more abstract experiences associated with various sub-selves of self. These qualia are strongly emotional single-pixel holistic qualia measuring whether some kind of an entropy variable is increasing or decreasing.

   The total entropy for the statistical ensemble defined by sub-self determines how sharp the the mental image is. Low entropy content means alertness and attentiveness. High entropy content means fuzzy mental image. Getting tired means inability to keep mental images in low entropy state. Macro-temporal quantum coherence due to quantum spin glass degeneracy and dark matter hierarchy implying a hierarchy of increasing values of Planck constant is absolutely essential in guaranteing that the mental images stay non-entropic: otherwise 10^4 Planck times would be natural de-coherence time and define the duration of sharp mental images.

   The objection is that the entropy of sub-self is expected to increase as sub-self ages so that this kind of emotions would be always negatively colored.

The notion of number theoretic negentropy based on p-adic variants of Shannon entropy is however non-negative in general and could increase of decrease as the size of the ensemble determined by quantum jumps increases. It is however not obvious whether it is sensible to assign this kind of entropy to ordinary statistical ensemble.

2. The color of emotion (positive/negative) could correlate with the increase/decrease of the number theoretic entanglement negentropy of the mental image, which characterizes the rational (or even algebraic) entanglement assignable to sub-self as a quantum mechanical bound state. The positive negentropy could be argued to be due to a conscious information due to the possibility to compare different states present in the multiverse state. Certainly the assignment of a non-negative quantum information to algebraically entangled bound state number theoretic entanglement entropy (!) is natural since this entropy does not describe lack of information about classical state. This makes possible the huge information processing capacity of quantum computers. Number theoretic negetropy can also increase in quantum jump and Negentropy Maximization Principle [H2] indeed postulates this increase as the fundamental variational principle of the dynamics of conscious experience.

2. Are emotions and cognition sensory qualia at higher levels of dark matter hierarchy?

Emotions and cognition could be higher level sensory qualia assignable to higher levels of dark matter hierarchy and cyclotron phase transitions at the magnetic bodies induced by EEG and its fractal generalizations would define this kind of qualia. Emotions and cognition represent in this picture two different kinds of communications of information from biological body to the magnetic body. This option is perhaps the most promising one but allows also the identification of the positive/negative attribute of emotion in terms of the sign of the negentropy gradient.

3.1.2 Kinesthetic qualia defined by generalized forces

p-V pair corresponds to the geometric existence and is replaced with generalized force-generalized coordinate pairs in quantum fluctuating degrees of freedom. The increments of maximum number of mutually commuting Poincare, color and electro-weak quantum numbers define this kind of qualia. The increments of four-momentum code for the sensation of force whereas the increments of orbital angular momentum code for the sensation of torque. Spin flip could code for something else. Tactile senses such as pressure sense and their generalizations involve kinesthetic qualia. The increment of energy or equivalently, increment of frequency, can be identified as correlate for hearing in generalized sense responsible for the dynamical nature of auditory experience (hearing is time-like version of force sense). In TGD based model of auditory experience

hearing relates to Z^0 magnetic spin flip phase transitions for cognitive neutrino pairs.

The rate for the increase of the two diagonal color quantum numbers should code intensity type variables associated with color sensation. The rate for the increase of electric charge of sub-self should code for electric sense possessed by, say, fishes. Also $B - M$, $\phi\rho$ and $E - P$ pairs correspond to generalized forces since electromagnetic fields are reduced to space-time geometry in TGD framework.

3.1.3 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 flow of particle number in the direction of the subjective time, that is Bose-Einstein condensation type process for, say Cooper pairs. Quite generally, super-canonical and quaternion conformal super algebras should define these qualia and the number of these qualia is very large.

i) One can assign particle numbers to phases with various magnetic quantum numbers and these could define generalized chemical qualia which could perhaps be regarded as qualia and sub-qualia of chemical qualia defined by a particular ion and chemical qualia could actually reduce to magnetic qualia. Since the changes of magnetic field induce these quantum phase transitions, it would seem that magnetic and Z^0 magnetic quantum phase transitions at super-conducting magnetic flux tubes could correspond to this kind of qualia. In principle, endogenous 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. Chemical qualia would very naturally correspond to the Bose-Einstein condensation of ions to the super-conducting magnetic flux tubes: these ions could be even the ions of tastant or odorant. Also secondary representations at the level of cortex in terms of super-conducting light ions are possible and would give rise to classification of tastes and odors.

ii) One must distinguish between magnetic and chemical qualia. Magnetic qualia do not involve changes of net particle numbers and they are characterized by definite transition frequencies. This makes possible place-/time coding by magnetic transition frequencies if magnetic or Z^0 magnetic field varies along magnetic flux tube/is a function of time. The activation of a point of the living map would generate some quale at that point. Perhaps 'feeling of existence' is the correct identification of the magnetic quale. This universal quale would be ideal for the projection of the sensory input to the sensory canvas, place coding of the features inside brain, and induction a motor action from the sensory canvas at a definite region of brain using MEs making possible high precision communication.

iii) 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. The condensation rates for the

numbers of the configuration space photons with non-vanishing color quantum numbers could be interpreted as correlates of color qualia whereas the condensation rates for color singlet configuration space photons could relate to the intensity of color sensation. The capacitor model of sensory receptors however allows any colored particles as realizers of color vision. TGD indeed predicts a wide variety colored quanta: in particular, the center mass color-rotational degrees of freedom are associated with any space-time sheet and analogous to rigid body rotational degrees of freedom. If the rates for the transfer of color quantum numbers define intensity type variables associated with color experience then BE condensation to color singlet states does not give rise to experienced quale so that only non-diagonal color generators correspond to visual colors. Also the BE condensation of the ordinary coherent light should give rise to some kind of quale: perhaps vibratory sense which can be developed to effective vision, could correspond to non-colored vision. Configuration space Hamiltonians are also labelled by 2-dimensional orbital spin quantum number and longitudinal momentum. Polarization sense and sensation about motion of the object of visual field would naturally relate to spin and longitudinal momentum.

iv) Tactile senses involve topological phase transitions involving the creation of join along boundaries contacts between object and skin whose number would thus be the relevant variable. The purely sensory aspect of physical pain could correspond to a topological phase transition involving the splitting of join-along boundaries bonds between space-time sheets (MEs could even define these bonds) so that N would be now the number of join along boundaries bonds. The simplest picture requires that the MEs associated with sensory organs are connected to the MEs responsible for our experience. Of course, splitting and generation of join along boundaries contacts could occur also at the level of sensory representations.

3.1.4 Boolean qualia

The transitions associated with the fermionic generators of super-canonical algebra can be identified as Boolean consciousness with intrinsic meaning ('This is true'). Boolean cognition without intrinsic meaning and/or conscious feeling of quantity can be understood as associated with the temporal sequences of Z^0 magnetization directions of cognitive antineutrinos at cell membrane space-time sheet.

A general model for abstraction process, not only explains the basic numbers of the genetic code, but also suggests an entire hierarchy of codes [L1] in accordance with fractality of TGD Universe. 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). Memetic codewords corresponds to sequences of 126 bits with duration of one millisecond: this time scale is somewhat shorter than the time scale of nerve pulse and it is quite possible that membrane oscillations induced by Z^0 MES are responsible for the representation of the memetic codewords. Sounds are indeed transformed to membrane

oscillations in the auditory receptors. Real and p-adic variants of anti-neutrinos might realize symbolic and cognitive representations [M2].

Memetic code could be realized at the cellular level through the whole body in terms of em and Z^0 MEs and would obey much faster dynamics than the chemical realization of the genetic code. Sequences of 21 DNA triplets could represent memetic codons in the intronic portion of DNA making 99 per cent of human genome. The transcription of memes to em and Z^0 MEs, the latter in turn acting as control commands at the level of cell membrane, could be the key element of biological control. Hence the language conscious-to-us would be only a tip of an iceberg.

3.2 Geometric qualia and zero modes

The zero modes of the configuration space are special in the sense that in each quantum jump localization occurs in this space. Zero modes characterize the size and shape of 3-surface and are excellent candidate to represent information about the state of organism (3-surface itself) geometrically. Zero modes can be parameterized as an infinite-dimensional flag-manifold associated with the algebra of the infinitesimal canonical transformations of $E^2 \times CP_2$, where S^2 is sphere at the light-cone boundary extended by Virasoro algebra acting in radial direction of light cone boundary. Physically this space corresponds to all possible choices of the quantization axes for generators of Super Canonical Algebra and, in accordance with the basic assumptions of quantum measurement theory, each quantum jump involves this kind of choice. Infinite-dimensional flag manifold contains as sub-flag-manifold $S^2 \times F_3$ parameterizing choices of quantization axes of spin and color ($F_3 = SU(3)/U(1) \times U(1)$). Lorentz invariance suggests the extension of S^2 to 2+2 dimensional flag-manifold $F = SO(3,1)/SO(2) \times R$ parameterizing various choices of the quantization axes for Lorentz quantum numbers.

There are continuous, geometric and kinesthetic (both geometric in four-dimensional sense) qualia like position and velocity; orientation and angular velocity, and also geometric time and experienced rate of time flow. All these pairs correspond to mutually in-compatible observables quantum mechanically. The hypothesis motivated by the work of Barbara Shipman [18] is that some coordinates of F_3 parameterize positions. The generalization of this hypothesis is that the infinite-dimensional flag-manifold associated with the zero mode part super-canonical algebra somehow gives rise to a conscious representation of continuous, classical qualia basically assignable to the choice of quantization axes. The hypothesis indeed makes sense: the entire isometry group of the configuration space, in particular the sub-group defined by zero modes, leaves induced Kähler form invariant but affects magnetic and Z^0 magnetic fields and hence magnetic transition frequencies. Also color rotations act in F_3 nontrivially and, although they leave Kähler form invariant, they affect magnetic and Z^0 magnetic fields and thus the corresponding magnetic transition frequencies. This means that a curve of the infinite-dimensional flag-manifold can be mapped to a varying cyclotron frequency.

3.3 Place coding by cyclotron frequency scale

One of the basic aspects of conscious information processing is concrete geometric representation of even very abstract concepts and information as imagined objects of perceptive field. The observations about geometric qualia suggest to magnetic transition frequencies code for positions of sub-selves represented by magnetic or Z^0 magnetic flux tubes. Particular EEG frequency wakes-up particular sub-self in specific position and orientation and gives rise to 'feeling of existence' in some part of the virtual world of brain (or possibly outside brain!). Sensation of motion of object of perceptive field results automatically when sub-self moves inside self. For instance, one could represent coordinate curves as magnetic flux tubes with varying thickness: by magnetic flux conservation thickness codes the coordinate to magnetic field strength to cyclotron frequency.

Conscious comparison of the geometric qualia is also possible. The recent and slightly earlier generalized position can be coded into magnetic (or Z^0 magnetic) field configurations. If these generalized positions are different, cyclotron frequencies are different. If EEG contains superposition of these slightly different EEG frequencies, conscious equivalent of quantum beat phenomenon results and gives rise to experience of comparison. This phenomenon should be also behind the phenomenon of binaural beat making possible to 'hear' otherwise non-audible frequencies.

3.4 Capacitor model for sensory qualia of biological body

The mechanism generating the sensory qualia assignable to the biological boils down to the capacitor model for the sensory receptor. The assumption that sensory qualia are realized at the level of sensory receptors, when combined with the requirement that the average increments are non-vanishing, and perhaps even same from quantum jump to quantum jump, poses strong constraints on the model of the sensory receptor. These constraints suggest what might be called the capacitor model of the sensory receptor.

1. There are two reservoirs of quantum charges having total charges of equal magnitude but of opposite sign. The charges are macroscopic in order to guarantee robustness. These reservoirs are analogous to capacitor plates, and only the second one corresponds to the sensory experienced quale unless both the quale and its conjugate are experienced simultaneously. Capacitors plates can carry several charges.

2. When the sensory quale is generated, there is a flow of charge quanta between the quantum capacitor plates. The charge quanta are more or less constant. This requirement could be relaxed to the condition that only the average increment is constant.

Cell membrane, or rather the pair formed by cell interior and exterior, and synaptic junction are excellent candidates for quantum capacitors.

1. During nerve pulse various ions flow between cell interior and exterior, which suggests that sub-neuronal sensory qualia are generated in a time scale of a millisecond. Also membrane oscillations might give rise to some kind of sensory qualia. In particular, super-conducting Cooper pairs and bosonic ions enter or leave the Bose-Einstein condensates at the magnetic flux tubes and this should give rise to a chemical experience defined by the quantum numbers of the carrier particle. Not only the increment of electric charge but increments of magnetic quantum numbers characterize the qualia in question. Various information molecules transferred through the cell membrane could also give rise to sensory qualia.

2. In the synaptic contact the vesicles containing neurotransmitter are transmitted, and the net quantum numbers for the vesicles should determine the neuronal chemical qualia associated with the process.

It would seem that quantum phase transitions at the magnetic flux quanta and particle flows between the quantum electrodes associated with electret type structures could define two basic types of qualia. Note that electret structures are dual to magnetic flux quanta as solutions of field equations. Vision and hearing would be basic examples of these two types of qualia.

4 EEG and sensory canvas hypothesis

The general qualitative features of EEG seem to conform with sensory canvas hypothesis and it seems possible to make relatively concrete suggestions for EEG correlates of sensory qualia, cognition and long term memories.

4.1 Evolution as emergence of lower EEG frequency scales: dark matter hierarchy

Sensory canvas hypothesis combined with the scaling law suggests an entire hierarchy of sensory canvases. One must however keep mind open for the possibility that the flux tubes of $B_{end} = .2$ Gauss define only single sensory magnetic canvas.

A firm prediction is that evolution should correspond to the emergence of higher level selves characterized by decreasing EEG frequency scales. There are two hierarchies involved. Dark matter hierarchy and p-adic length scale hierarchy and both presumably correspond to evolutionary hierarchies.

Dark matter hierarchy correspond to a hierarchy of values of Planck constant coming as $\hbar = \lambda^k \hbar_0$, $k = 0, 1, 2, ...$ $\lambda \simeq 2^{11}$ is integer and and its harmonics and sub-harmonics cannot be excluded. In fact, the model for the quantization of Planck constant allows all integer scalings of $\hbar$ but number theoretical arguments favor products of arbitrary power of two multiplying product of different Fermat primes characterizing polygons constructible only ruler and compass [C7]. Hence only $\lambda = 2^k$ can define fractal hierarchies for the preferred values of Planck

constant. Furthermore, $\lambda = 2^{11}$ corresponds to a fundamental constant in TGD Universe.

The model for the hierarchy of generalized EEGs assigns to each level of dark matter hierarchy a typical time scale identifiable as typical time span of memories. From this one can conclude that $k = 7$ is the highest level contributing at personal levels of conscious experience. $k = 4$ assignable to ordinary EEG corresponds to the time scale determined by EEG frequency scale. In this case the hypothesis about evolution proceeding as the emergence of higher and higher levels of dark matter hierarchy at the level of personal consciousness is very natural.

4.2 Evolution as emergence of lower EEG frequency scales: p-adic length scale hierarchy

p-Adic length scale hierarchy defines a hierarchy at each level of dark matter hierarchy and one can ask whether also the emergence of increasingly longer p-adic length scales characterizes evolution. The following considerations assume $B_{end} = .2$ Gauss as the value of endogenous magnetic field. This corresponds to $\hbar = 5\hbar_0$ in ground state. Note that $n = 5$ is the smallest value of n allowing universal topological quantum computation and corresponds to a Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [E9].

1. Cerebellar, retinal, and cortical rhythms

The p-adic time scales assignable with the basic rhythms associated with cerebellum, retina, and cortex increase in this order and are consistent with the hypothesis that higher evolutionary levels corresponds to longer p-adic time scales.

1. The fact that the dominating rhythm in cerebellum is about 200 Hz supports the view that it corresponds to shorter p-adic length and time scale than cortex. The fact that cerebellum is responsible for the finer details of motor action is consistent with shorter p-adic time scale.

   If $k_{em} = 4$ dark matter level is assumed to be in question and if one assumes that 200 Hz rhythm is analogous to sensorimotor rhythm of 13 Hz (Na^+ cyclotron frequency) then scaling then the magnetic field at the field quanta involved should be $\simeq 16$ times stronger than B_{end}. Since B_{end} most naturally corresponds to the p-adic length scale $k = 169$ and magnetic flux $2h_5$, this field could correspond to $k = 169-8 = 161 = 7\times 23$ (scaling down of thickness of flux sheets flux sheets) or $k = 169-4 = 165 = 5\times 53$ (scaling down of the radius of the flux tube). The work of Gariaev [64] provides support for the hierarchy of magnetic flux sheets of various thicknesses associated with chromosomes and favors $k = 161$ option.

2. The micro-tremor of retina corresponds to 80 Hz frequency and would relate naturally to 40 Hz thalamocortical resonance frequency if the magnetic field in question corresponds to transversally scaled down magnetic

flux sheets having $k = 167$ instead of $k = 169$. Note that $k = 167$ corresponds to the Gaussian Mersenne $(1 + i)^{167} - 1$.

3. Primary sensory areas are dominated by 40 Hz frequency. Lowest frequencies such as hippocampal theta are in turn associated with long term memory which corresponds to high level mental function distinguishing sharply between humans and other species.

2. Why the interpretation in terms of spin flip frequencies does not work?

The original interpretation of cerebellar rhythm was in terms of some magnetic spin flip frequency. Representative examples of spin flip frequencies near cerebellar 200 Hz are $f_s(Na) = 222$ Hz, $f_s(Al) = 218$ Hz and $f_s(Mn) = 208$ Hz, $f_s(Co) = 199$ Hz and $f_s(Sc) = 204$ Hz. Co is obviously the best candidate.

The spin flip frequencies in EEG range (see the table 4) are $f_s(Cl) = 82$ Hz and $f_s(Rb) = 81$ Hz (80 Hz micro-tremor in retina); $f_s(K) = 39$ Hz and $f_s(Y) = 41$ Hz (both very near to 40 Hz thalamocortical resonance frequency); $f_s(Ag) = 34.2$ Hz, $f_s(Rh) = 26.6$ Hz (27 Hz resonance frequency in dog's cortex); $f_s(Ir) = 17$ Hz (narrow band in EEG [39]), $f_s(Au) = 14$ Hz (the sleeping spindle frequency).

These interpretations are however excluded in the dark matter based view since the ions are assumed to be ordinary ions topologically condensed to dark matter space-time sheets defining λ^k-fold coverings of M^4 so that spin flip photons would be ordinary ones and their energies would be extremely low and much below the thermal threshold.

3. p-Adic length scale hierarchy as abstraction hierarchy

This picture suggest an abstraction hierarchy in which EEG frequency scale of projecting EEG MEs correlates with the abstractness of the feature associated with the point of sensory map. For instance, sensory qualia could correspond to gamma frequencies, in particular frequencies near 40 Hz; cognitive features to beta frequencies whereas alpha and theta and delta frequencies to the generation of the long term memories making possible the historical self. The frequencies involved with long term memory recall are expected to correspond to the time span of the memory characterized by the level of the dark matter hierarchy.

4. Objection against p-adic evolutionary hierarchy

If evolution corresponds to emergence of increasingly longer p-adic time scales in EEG, then the naive application of ontogeny recapitulates phylogeny principle (ORP) suggest that gamma, beta, alpha and theta bands should emerge in this order during the development. This is not the case.

1. According to [40], the wake-up EEG of infants before 3 months age consists of 'fast' background activity. At three months posterior delta rhythm appears at 3-4 Hz and gradually shifts to 6-7 Hz during the first life year. According to [41], binding related 40 Hz oscillations are evident at the age of 8 months. Also the contrast sensitivity of vision improves rapidly

to adult level at this age: this conforms with the hypothesis that EEG is essential for the construction of the sensory representations.

2. According to [42], for infants the counterpart of the alpha band appearing in darkness is the occipital rhythmic activity in the range $5.2 - 9.6$ Hz with peak frequency at about 7 Hz and increases gradually. The frequency band $6.0 - 8.8$ Hz with gradually increasing peak frequency at about 7 Hz is activated during visual attention and seems to be the counterpart of sensory-motor rhythm of about 13 Hz of adults. It would be interesting to know whether the sensorimotor rhythm is eventually established via a continuous shift of this band or not.

A direct correlation between body size and frequency scale of the sensory-motor frequency band suggests itself. This might be understood if magnetic flux tubes in the somatosensory part of the sensory canvas get gradually stretched during the growth so that the increasing distances of the body extremities from head are coded by increasing magnetic transition frequencies.

This picture seems to contradict the idea about p-adic evolutionary hierarchy. In TGD framework one must however seriously consider the possibility that the lowest EEG bands relate with the higher level collective and multi-brained sensory representations. These higher level selves could be especially alert during sleep since the entire information processing capacity used for the sensory and motor activities during wake-up state would be freely available. This suggests also a resolution of the objection against p-adic evolutionary hierarchy.

The work of Jaynes inspires the idea about child as a small bicameral nursed by the higher collective levels of consciousness. The location of the sensory motor and alpha rhythms in theta band could indeed be seen as an indication for a kind of magnetic nursery provided higher level magnetic selves and their presence would not corresponds to the infant's consciousness but to the consciousness of the "magnetic nurse". Rather interestingly, according to Jaynes [43] sitting in mother's lap can induce EEG in infants not possessing stable EEG yet. An interesting question is whether mother's EEG shows a correlation with that of infant and whether it deviates from ordinary EEG in theta band.

The TGD based model of EEG to be discussed in detail later predicts that EEG consists of two copies so that ordinary alpha band has a scaled down copy around 5 Hz. The scaled down copy of EEG is predicted to dominate during sleep. The 7 Hz rhythm in the infant EEG could be interpreted as the scaled down counterpart of the sensorimotor rhythm identifiable in terms Na^+ cyclotron frequency. Infants would be in a state of consciousness analogous to sleep state as far EEG is considered: this of course conforms with the magnetic nursery hypothesis.

4.3 EEG rhythms in contrast to evoked and event related potentials

Evoked and event related potentials are believed to be associated with the neuronal activities generated by the sensory stimuli and it seems that they must be

distinguished from the narrow frequency bands associated with the sensory and cognitive representations. Indeed, both evoked potentials associated with simple stimuli and event related potentials accompanying more complex stimuli have temporal structure which clearly reflects the propagation of nerve pulses along various parts of brain and one can assign to the peaks of the evoked potentials various a anatomical correlates in the neural pathways involved [44].

The time-scale systematics for the evoked and event related potentials conforms with the idea of self hierarchy. For instance, brain stem responds to simple auditory stimuli like clicks in time scale is 10 ms: the corresponding frequency is 100 Hz, which is the dominating EEG frequency in brain stem. For cerebellum the corresponding rhythm is about 200 Hz and cerebellum indeed takes care of macro-temporal regulation of motor actions. For higher regions of brain the time scale of event related potentials is typically about 100 ms: this correspond to the time scale of 10 Hz and time scale of memetic code. For instance, at V4 activity starts 100 ms after the onset of the visual stimulus and is peaked around 135 ms.

A good example of an event related potential (ERP) is P300, which is a large positive amplitude ERP following an improbable target in the sequence of repeated target stimuli: P300 occurs with the latency of 300 ms for young adults and for simple stimuli. P300 is preceded by a negative potential called N2 which presumably corresponds to the conscious detection of the target stimulus whereas P300 probably represents the use of this information to update the model about world. N2 contains also information about novelty of the stimulus and the difference of N2 for standard stimulus and novel stimulus is called mismatch negativity.

4.4 Coherence of EEG and sensory canvas hypothesis

If the EEG measured at skull relates closely to the sensory representations, it must inherit high coherence from the high coherence of the sensory landscape. Also fractal like hierarchy is predicted. At higher frequencies associated with sensory representations in shorter length scales, coherence should be restricted in shorter range. Indeed, according to [39], the coherence length for EEG at skull is present and measured by using 10 cm as a natural unit. This coherence could reflect the correlations between neural activities in various parts of brain but it is not at all obvious whether the timing of neural ionic currents can be so sharp that destructive interference cancelling the correlations EEG level does not occur.

According to [39], very complex structures of coherence in bands around 3, 5 and 7 Hz and 13, 15 and 17 Hz are definitely inconsistent with simple dipole models for the generation of EEG patterns. The findings are however consistent with the view that several distant regions of cortex can project features to the same point of a sensory map and that the coherence reflects the coherence of the sensory map. Coherence regions could naturally correspond to the objects of the perceptive field. The high coherence in the band $4 - 5$ Hz during mental calculations [39], which certainly represent abstract information processing and

involve also long term memory in an essential manner, supports the view that abstract long term memories correspond to lowest EEG bands at 3, 5 and 7 Hz. According to [39], also increase of coherence between prefrontal and posterior cortical association areas have been reported during working memory retention in the range $4 - 7$ Hz.

The coherence lengths for EEG inside cortex are generally much shorter and complex patterns are encountered. Coherence length of order 2 cm is associated with cortical EEG structures which Freeman introduces as basic units of EEG activity [57] and calls mesoscopic level of sensory processing. Note that also retina has same size as the mesoscopic structures. Perhaps it is not accident that this length scale corresponds to the highest ionic cyclotron frequencies in Helium period.

4.5 EEG synchrony

The place-coding hypothesis differs from binding by EEG synchrony hypothesis. The experiment carried out by Revonsuo originally deviced to test the binding hypothesis in fact supports the place-coding hypothesis. The interpretation for 40 Hz EEG frequency inspired by the binding hypothesis is as a synchronizing frequency necessary for the generation of unified percepts. This hypothesis has been studied using auto-stereograms [45]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when auto-stereogram was experienced as a set of random dots as compared to the situation when it was perceived as a coherent, symmetrical gestalt. The situation was same also in 8-13 Hz and 13-20 Hz beta bands. The finding is consistent with the place coding hypothesis.

On the other hand, when the conscious percept was transformed from a random set of points to a coherent gestalt, there was a detectable increase in 40 Hz power in the occipital and right posterior sites for EEG electrodes in a time window 500-300 ms before the unified percept was reported. No increase of power in beta bands was detected: this might be due to the fact that the widths of the measured bands are much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [39]. Note that in the model for a hierarchy of EEGs based on dark matter hierarchy beta band correspond to data communicated to the magnetic body [M3].

That the change in activity is associated with the emergence of a new percept suggests that the temporary increase of the EEG power could be assigned to the reaction of the magnetic body to the symbolic mental image in the cortex representing the new percept.

If the response is realized as a negative energy signal from the magnetic body to the geometric past, the time lapse due to the propagation of the sensory signal to the magnetic body is compensated since the negative energy signal travels to the geometric past. In this case the time lapse of 300-500 ms would correspond to the time it takes for the cyclotron phase transition at the magnetic body to occur so that the time lapse would not provide estimate for the distance to the magnetic body. The frequency scale of 40 Hz would suggest that the length

scale involved is about $.75 \times 10^7$ m whereas 3 ms lapse would imply a length scale of $.5 \times 10^8$ meters if only positive energy signals are involved.

There could be also some time lapse between the unified percept and the report about it but it is not clear whether this can explain the entire lapse. That the change occurred 300-500 ms before the report about the emergence of a unified conscious percept is consistent with the view that the conscious percept is possible only after the new sensory representation at the sensory magnetic canvas has been established. This lapse is not predicted if only brain is involved so that the observing self would be indeed the magnetic self rather than brain.

4.6 Narrow EEG bands and sensory canvas hypothesis

Sensory canvas hypothesis predicts the existence of narrow EEG bands corresponding to the magnetic transition frequencies varying in the range determined by the thickness range for the magnetic flux tubes involved with the sensory representation. The most natural candidates for the magnetic transition frequencies are cyclotron frequencies and their harmonics. There is indeed evidence for this kind of bands [39].

1. The best known band is alpha band around 11 Hz and has width of order 1 Hz. From this one can conclude that the relative variation of the magnetic field along magnetic flux tubes and thus magnetic flux tube area in the radial direction is roughly 10 per cent so that the radius would vary about 3 per cent. The fact that alpha band at 11 Hz becomes active when eyes are closed is consistent with the interpretation that alpha band corresponds to cyclotron frequencies of bosonic ions and to the motor control by rather than sensory communications to the magnetic body. The activation of the alpha band is also associated with the generation of meditative and 'creative' states of mind. Hence one cannot exclude the possibility that alpha band activation corresponds to the projection of some information to the possible multi-brained sensory/cognitive representations associated with higher level collective selves.

2. Besides alpha band Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as sub-bands at 13, 15 and 17 Hz in beta band [39]. That beta disappears when eyes are closed conforms with the interpretation of these bands as being associated with sensory communications to the magnetic body. Hence these bands might be associated with the assignment of cognitive features to the points of the sensory canvas. Indeed, the evolutionary hierarchy sensory representations$\rightarrow$ cognitive representations$\rightarrow$ long term memories involving time like entanglement and making possible historical self, suggests this.

3. 40 Hz band has a width of about 8 Hz, contains several cyclotron frequencies, is associated with the primary sensory areas and disappears during sleep. This suggests that also this band is involved with the projection of the sensory qualia to the sensory canvas. The information about narrow

sub-bands of EEG during hypnagogic states (the state between wake-up and sleep involving sensory hallucinations), during the schizophrenic hallucinations and hallucinations generated by sensory deprivation, and during lucid dreaming could provide interesting constraints on the possible sensory quale-EEG frequency correlations.

4. A well motivated guess is that 3, 5 and 7 Hz bands do not correspond directly to the sensory qualia experienced by our magnetic body. Hippocampal theta band (which actually extends from about 4 to 12 Hz) could contain these narrow bands and be involved with the assignment of abstract features, such as concepts and verbal associations and emotions, to the sensory map crucial for the memories. The fact that alpha and theta waves are important during this period suggests that alpha and theta frequencies are involved with the generation of episodal memories.

Whether the same frequency must be present during memory recall as during the generation of the memory, depends on the model of memory recall. According to the simplest model, memory recall means that an object in the sensory canvas of the geometric past is activated and temporal quantum entanglement mechanism allows us to share the experience. This does not require that the EEG frequency involved with sensory projection is generated in the brain which remembers. Of course, the formation of memory about recalled memory could generate this frequency.

4.7 Propagating and standing EEG waves

There is evidence for propagating EEG waves. At the surface of skull the phase velocities of the alpha waves are of the same order of magnitude as typical nerve pulse conduction velocities: the wave scans over the cortex in time of order 10 ms. At the surface of skull the corresponding time is of order 20 ms. Whether standing EEG waves are really there is to my best knowledge a question which has not yet been resolved.

The standard identification for the function of the propagating EEG wave is as a spotlight of attention scanning the cortex. In TGD framework it is not at all obvious how to define the notions of standing and propagating EEG waves and I have considered several alternative identifications.

The basic observation is that classically ME represents a signal coded by a 2-dimensional pattern propagating with a light velocity and accompanied by a light like vacuum 4-current. The dependence of the CP_2 coordinates on both light-like coordinate and some transversal coordinate gives also rise to a propagation of constant phase surfaces in transverse directions with sub-luminal velocity.

1. It is very natural to assume EEG MEs connecting brain to the magnetic body are transversal to the cortex. If this is the case the effective propagation of EEG wave could be a purely kinematical effect due to the transverse propagation of constant phase surfaces along cortex. The mechanism

would be same as in the case of transversal W MEs inducing propagating physiological waves. For instance, Ca^{+2} have extremely wide velocity spectrum and they play a key role in the bio-control. They could also have a key role in the realization of non-episodal long term memories as classical communications from the geometric past. This mechanism is the my recent favorite.

2. The transversal EEG MEs and W could also have small transversal size but drift in the transversal direction. Also in this case the velocity of drift would be naturally small using light velocity as a standard and would naturally correlate with the nerve pulse velocity.

3. The least plausible option is the original hypothesis that MEs are parallel to the cortex and drift in a direction parallel to the direction of the wave propagating inside ME. If ME is partially attached along its boundaries to, say cell exterior and cell membrane space-time sheets, its effective phase velocity can be reduced, to say nerve pulse conduction velocity. What would happen that ME hops to the direction of the geometric future in each quantum jump and background space-time sheet remains stationary. The effective phase velocity could even reduce to zero in this manner and one would have a standing wave as an outcome.

Standing or effectively standing EEG waves would be naturally associated with the ME projections to the magnetic body, and correspond to EEG MEs at narrow bands of EEG frequencies (place coding by the frequency scale). Neuronal bodies could generate these EEG MEs. If the magnetic flux tubes of the personal magnetic body emanate radially from the surface of cortex, they amplify the EEG MEs in the radial direction by Alfven wave resonance so that EEG projectors would emanate radially.

5 Generalized EEG as a basic control and communication tool of the magnetic body

The idea about p-adic fractal hierarchy of Josephson junctions is not new in TGD framework. The development of quantitative models based on this notion has been however plagued by the absence of concrete idea about what these Josephson junctions look like. The dark matter hierarchy based on hierarchy of scaled up values of Planck constant when combined with the p-adic length scale hierarchy allows to circumvent the problem.

An essential boost for the development of ideas have been the effects of ELF em fields in living matter explainable in terms of quantum cyclotron transitions in Earth's magnetic field. Especially the fact that these effects appear only in narrow temperature and amplitude windows has provided the key hints concerning the model for the hierarchy of Josephson junctions and EEGs. The discussion of these effects is left to a separate section.

5.1 Fractal hierarchy of Josephson junctions

The hierarchy of Josephson junctions involves actually two hierarchies, dark matter hierarchy and p-adic hierarchy, which can be said to be in resonance for living matter systems.

5.1.1 Fractal hierarchy of dark copies of cell nucleus as a fundamental structure in living matter

There are actually two hierarchies. The first hierarchy correspond to the p-adic length scales for given value of $\hbar$. Second hierarchy corresponds to dark matter hierarchy for which length scales come in powers $\lambda^{k_{em}} L(k))$ the basic p-adic length scales, $\lambda \simeq 2^{11}$. In fact there are arguments supporting the exactness of this value. Since 11 p-adic length scales combine naturally to form single block in this hierarchy, there is strong temptation to assume that (at least) the p-adic length scales $k = 151, 147, 163, 167, 169$ form the fundamental block. Same length scale can have interpretation as several different p-adic length scales belonging to different levels of dark hierarchy. This is expected to induce an interaction between various levels of dark matter hierarchy.

The size of cell nucleus varies in the range ($L(169) = 5\ \mu m, 2L(169) = 10\ \mu m$). This is consistent with the assumption that cell nucleus provides the fundamental representation for this block. This would mean that at least the multiply coiled magnetic flux quantum structures associated with DNA appear as fractally scaled up copies.

Each dark matter level corresponds to a block of p-adic length scales $L(k)$, $k = 151, ..., 169$. Also new length scales emerge at given level k_{em} and correspond to $L(k)$, $k > 169$. The dark copies of all these length scales are also present. Hence something genuinely new emerges at each level.

The emergence of a genuinely new structure or function in evolution would correspond to the emergence of new level in this fractal hierarchy. Quantum criticality would be essential: phases corresponding k_{em} and $k_{em}+1$ levels would compete at quantum criticality. A good guess is that for all levels flux sheets traverse partially the DNA of possibly several cell nuclei and that they are part of Josephson junctions.

1. $k_D = 0$ would correspond to cell nucleus since electronic and neutrino superconductivity correspond to ordinary $\hbar = 5\hbar_0$.

2. $k_{em} = 1$ would correspond to emergence of organs with sizes below 4 cm and bounded by epithelial sheets (double cell layers) of thickness about 10+10 μm.

3. $k_{em} = 2$ would correspond to layers of thickness 2+2 cm and structures with size smaller than 80 m. Obviously genuinely dark level is in question now. The layers of this Josephson junction could be assignable to left and right halves of central nervous system. The interpretation in terms of dark matter around the magnetic body of organs suggests also itself. $k_{em} = 3$

corresponds to the emergence of double layered dark matter structures of thickness 40+40 m and size scale below 160 km. Now dark matter condensed around magnetic bodies of magnetic bodies of organs could be in question.

4. $k_{em} = 4$ could correspond to the emergence of EEG assignable to flux sheets of personal magnetic body. The bilayered structure has thickness of 80+80 km and the analog of cell nucleus has minimum $512 \times 160 = 8$ Mm and corresponds to Earth size scale (Earth radius is 6.96 Mm).

5.1.2 Fractal hierarchy of Josephson junctions and EEGs

The fractal hierarchy of Josephson junctions defining a fractal hierarchy of EEGs is the basic element of the model.

1. Josephson junctions provide representation of electric field as biological action induced by generalized EEG

Each junction has a background voltage over it and this voltage is independent of the p-adic length scale $L(k)$, $k = 151, ..., 169$ inside block. Josephson current can be written as

$$J \propto sin(2eVt + 2e \int V_1 dt) \ ,$$

where V corresponds to the background voltage analogous to resting potential of cell membrane and varies in rather narrow limits. $V_1(t)$ represents external perturbation.

The frequency of V_1 is represented as a period of periodic multiplicative modulation of the V_0. J itself is not periodic. There is however a periodicity with a period $T = n/f$, where f is frequency of V_1 for $f_J = mf/n$. There are two interesting limits. For $f_J^1 = 2eV_1/2\pi\hbar \gg f_J$ amplitude V_1 is represented as frequency since in reasonable approximation frequencies $f_\pm = f_J \pm f_J^1$ dominate. Second limit corresponds to $f_J^1 \ll f_J$. In this case the dominating frequencies are $f_\pm = f_J \pm f$

Josephson frequency would define a kind of drum beat whereas the frequencies associated with V_1 would represent the rest of the music. Josephson frequency $f_J = eV/2\pi\hbar$ indeed turns out to belong to the scaled up variant of delta band of EEG and thus defines the analog of drum beat and corresponds to a resonance frequency in delta band for the scaled up variants of EEG. Josephson frequency defines a candidate for the time unit in which the time scale of memories and intentional action of the living system are measured.

The coherent photon state generated by J defines representation of V_1 as a generalized EEG and biological representations result when the photons interact with the living matter.

The reactions of the Josephson junctions corresponding to different p-adic length scales $k = 151, ..., 169$ (if really present!) to external electric field are

different due to $V_1 \propto L(k) \propto 2^{(k-151)/2}$ proportionality and independence of V on k.

2. Thermodynamical considerations

Josephson energy does not depend on the level of dark matter hierarchy and is thus above thermal energy since this holds true in the case of cell membrane. From the resting potential whose nominal value is often taken to be for .08 V, f_J corresponds roughly to the energy 1.6 eV roughly twice the energy allowed by thermal stability. Thermal stability of drum beat would allow 140 °C temperature. The growth temperatures of thermophilic bacteria can be even higher than 100 °C.

Nerve pulse is generated when the potential drops to .05 eV: the corresponding Josephson energy is .01 eV which is above thermal threshold for $T \leq 70$ C. For organisms possessing no nervous systems, in particular bacteria, this constraint is not relevant. The energy $E = 1$ eV is twice the energy $E = .05$ eV, which is a universal transition energy of Cooper pairs of high T_c electronic super conductor [J1]. The generation of nerve pulse might involve these transitions.

3. Josephson frequencies

Resting potential corresponds to the Josephson frequency $f_J = 5.95 \times 10^{13}$ Hz. Infrared radiation with intensity spectrum having characteristics of coherent state of photons would be a signature of this current. The Josephson frequency corresponding to threshold potential is $f_J = 3.36 \times 10^{13}$ Hz.

f_J scales like $f_J \simeq \lambda^{-k_{em}}$ as a function of the level of the dark matter hierarchy. For $k_{em} = 4$ one obtains $f_J = 3.38$ Hz using $\lambda = 2^{11}$. This frequency belongs to delta band (defined as the the frequency range .25-5 Hz). For $\lambda = 2.17 \times 10^3$ deducible from the model for planetary orbits as Bohr orbits the prediction is $f_J = 2.68$ Hz.

5.1.3 Levels of dark matter hierarchy as a physical counterpart of chakras

The model identifying generalized EEG as coherent photons emitted by Josephson junction suggest that $k_{em} = 7$ corresponds to the highest level of dark matter hierarchy for humans. This brings in mind the seven chakras central for Eastern mystic traditions. The magnetic flux quanta would enter the body through organs which are assignable to a particular value of k_{em} and chakras could be identified as groups of organs with a given value of k_{em}. An alternative possibility is that the space-time sheets at level k_{em} are joined to the level $k_{em} + 1$ by Josephson junctions. In this case it is not necessary to have connections directly from the level of DNA.

The magnetic bodies involved include the magnetic body associated with biological body, presumably that associated with $k_{em} = 2$, magnetic body of Earth for $k_{em} = 4$, magnetic body associated with plasma sheet at night side of Earth's magnetosphere, the magnetic body of Sun for $k_{em} = 6$ and that of solar system for $k_{em} = 7$. Note however that the endogenous magnetic field is

$B_{end} = .2$ Gauss and relates to $B_E = .5$ Gauss by a scaling factor. This suggests that personal magnetic bodies in the hierarchy interact with the astrophysical magnetic bodies but are not identical with them.

Josephson period associated with the largest chakra would would correlate with the time scales of intentional action and memories and would give a criterion making possible to estimate which levels are present for a given kind of organism or part of organism.

Of course, detailed one-to-one map between chakra picture and dark matter hierarchy is not possible. There are however common elements, most importantly the hierarchical structure of conscious experience leading from animal consciousness (root chakra) to cosmic consciousness (crown chakra). Chakra hierarchy should also have direct counterpart at the level of evolution of living organisms.

Hence it seems that two ideas, chakras and the idea about delicate interaction between astrophysical objects and human consciousness, hated bitterly by skeptics, find a natural place in dark matter hierarchy.

5.1.4 What is the precise value of λ?

The precise value of λ is important if one wants to assign the amplitude windows to resonance bands of EEG.

1. By the general model for quantization of Planck constant already discussed λ can correspond to a power of 2 and hence $\lambda = 2^{11}$ is strongly favored.

2. $\lambda = 2^{11}$ implies a precise resonance between dark length scales and ordinary p-adic length scales. If λ is integer and if it equals to 2^{11} then also lower powers of 2 can in principle appear in the dark matter hierarchy as sub-harmonics $\lambda/2^k$ (this is indeed predicted by integer quantization of Planck constant).

3. The interpretation of the Josephson period associated with the highest level of dark matter as the time scale for intentional action and memory allows to estimate the value of largest k relevant for humans and it turns out that the scaled up Josephson frequency corresponds to a period of 80 years for this option meaning that $k_d = 7$ naturally corresponds to the highest level in the dark matter hierarchy associated with humans.

4. $\lambda = 2^{11}$ option predicts for the length scale associated with $k_d = 4$ Josephson junctions a value having direct physical interpretation.

5. $\lambda = 2^{11}$ option provides a plausible interpretation for amplitude windows in terms of EEG resonance bands.

5.1.5 Josephson frequencies for various levels of dark matter hierarchy

The following tables list the Josephson frequencies for doubly charged current carriers for the levels of dark matter hierarchy corresponding to $k_d = 0, ..., 7$

using the value .08 V/m for the resting potential for $\lambda = 2^{11}$.

The powers of $\lambda = 2^{11}$ are allowed by the requirement that the scaling $\hbar = n\hbar_0$ of Planck constant corresponds to a quantum phase $q = exp(i\pi/n)$ assignable to an n-polygon constructible using only ruler and compass. In this case one has $n = n_F = 2^k \times \prod_k F_{n_k}$, where each Fermat prime $F_n = 2^{2^n} + 1$, $n = 0, 1..., 4$ can appear only once. The quantum phase $exp(i\pi/n_F)$ is expressible using only iterated square root operation [C6] so that only this kind of extensions of p-adic numbers are needed for $p \; mod \; 4 = 3$. This is not true for $\lambda = 2176$ so that $v_0 = 2^{-11}$ remains the only candidate.

For $\lambda = 2^{11}$ the Josephson period for $k_d = 7$ is $\simeq 80$ years, which roughly corresponds to the duration of human life cycle. $k_d = 6$ corresponds to $\simeq 14.3$ days and $k_d = 5$ to $\simeq 10.1$ minutes.

Note that there is no dependence on the p-adic length scale $k = 151, ..., 169$. Also the frequencies corresponding to the .05 V corresponding to the potential at which nerve pulse is generated are listed. For singly charged bosonic ions the frequency would be $f_J/2$. For fermionic ions Josephson currents are not of course possible.

k_d	0	1	2	3
$f_J(80\ mV)/Hz$	5.95e+13	2.91e+10	1.42e+07	6.93e+03
$f_J(50\ mV)/Hz$	3.72e+13	1.82e+10	8.87e+06	4.33e+03
k_d	4	5	6	7
$f_J(80\ mV)/Hz$	3.38	6.18e-4	2.85e-7	1.31e-10
$f_J(50\ mV)/Hz$	2.11	1.0e-3	5.04e-07	2.46e-10

Table 3. The Josephson frequencies $f_J = 2eV/2\pi\hbar$ of doubly charged particles for $\lambda = 2^{11}$ corresponding to the resting potential .08 V and threshold potential .05 V for nerve pulse generation for $\lambda = 2^{11}$.

5.2 What is EEG made of?

The usual classification of EEG frequencies by EEG bands is more or less a convention and the definitions of various bands vary in frustratingly wide ranges. In a more ambitious approach bands should be replaced with some substructures identified on basis of their physical origin and function. In the proposed framework this is possible. This identification of substructures of course applies only to that part of EEG from which noise is subtracted. The contribution of neural activity is one such source of noise, often regarded as the only contribution.

5.2.1 Basic contributions to EEG and ZEG

There are three fundamental contributions to EEG (or hierarchy of EEGs) besides the neuronal noise. This picture applies more or less as such also to ZEG.

1. Schumann resonances whose interpretation should be clear. These frequencies do not depend on magnetic field strengths assignable with mag-

netic flux sheets and characterize Earth's magnetic field and collective aspects of consciousness.

2. Cyclotron frequencies generated in cyclotron transitions of ions in field $B_{end} = 0.2$ Gauss. An attractive guess is that cyclotron frequencies correspond to the control signals from magnetic body so that Josephson junctions and magnetic body would form a closed feedback loop. These frequencies can be classified to those associated with bosonic and fermionic ions respectively. The transitions of Bose-Einstein condensates of bosonic ions are of special interest. The scale of these frequencies could be be subject to homeostatic regulation which is local and can vary even inside genes of a given nucleus.

3. The frequencies generated by Josephson currents as coherent photons. Harmonics of cyclotron frequencies shifted upwards and downwards by Josephson frequency $f_J = 5$ Hz. If the amplitude of the perturbation at cyclotron frequency is strong the EEG looks locally like it would consists of amplitudes with frequencies $f_\pm = f_J^1 \pm f_J$ during most of the cyclotron period so that the visual inspection of time evolution of EEG can be rather misleading. Since these frequencies are involved with communications to the magnetic body of Earth, the natural guess would be that they correlate with the neural processing.

The following general overview about quantum communication and control emerges in this framework.

1. Cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control.

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter ionolito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere.

3. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

4. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a nonlocal charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy. This provides a nonlocal quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control.

5. Massless extremals (MEs, topological light rays) serve as correlates for dark bosons. Besides neutral massless extremals (em and Z^0 MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The interpretation of the charged MEs has remained open hitherto. Charged W MEs (hierarchy of WEGs!) could induce long length scale charge entanglement of Bose-Einstein condensates by inducing exotic ionization of ionic nuclei. State function reduction could lead to a state containing a Bose-Einstein condensate in exotically ionized state.

   In this manner the dark charge inside neuron and thus by Faraday's law also membrane potential could be affected by magnetic body. The generation of nerve pulse could rely on the reduction of the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. The mechanism might apply even in the scale of magnetic body and make possible the control of central nervous system. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

To sum up, charged massless extremals could be seen as correlates for nonlocal quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K3].

5.2.2 Classification of cyclotron frequencies

Consider now the classification of cyclotron frequencies ($B_{end} = .2$ Gauss will be assumed).

1. Cyclotron frequencies can be classified those associated with atomic and molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band. Thermal stability condition suggest a lower bound of ~ 1 Hz for significant frequencies of this kind.

Thus it would seem that delta band dominating during deep sleep corresponds to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions.

2. Atomic ions can be classified into bosonic and fermionic ions. Practically all biologically important bosonic ions have $Z = 2$ and in alpha band: $f(^6Li^+) = 50$ Hz and $f(Mg^{2+}) = 25$ Hz are the only frequencies above alpha band. Situation is essentially the same for biologically interesting ions too. $^7Li^+$ is exception and corresponds to 42.9 Hz: as a fermionic ion it does not possess satellites and does not contribute to Josephson part of EEG. Thus the frequency range $7.5 - 15$ Hz is very strongly represented and expected to be fundamental.

3. Also the position in the periodic table of elements provides a classificational criterion but this criterion does not seem to be so useful as thought originally.

4. The integer n characterizing the harmonic of the cyclotron frequency in question is an additional classificational criterion and n could correlate with the character of neural processing.

5.2.3 Wake-up EEG

The question is whether this classification is consistent with the conventional decomposition into various bands and whether it allows to gain some real insights EEG. Consider first wake-up EEG [30].

1. The first implication is that each cyclotron frequency f_c is accompanied by by two satellites $f_c \pm f_J$. For alpha band these satellites correspond to theta band and beta band identifiable as responses to control signals from magnetic body in alpha band. One can ask whether these bands as a whole correspond to the satellites of alpha band. This identification implies that both bands are present and makes sense for wake-up EEG but not as such for the EEG during first and second period of deep sleep during which theta band is present but higher bands are absent.

2. Sensorimotor rhythm in range (12-16) Hz is associated with physical stillness and body presence. The interpretation is as a low amplitude satellite of alpha rhythm with low amplitude control signals from the magnetic body so that rhythmicity is not lost and frequencies are clearly $f_c + f_J$.

3. Beta band is above 12 Hz and associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous. The natural interpretation is as large amplitude satellite of alpha band involving the activation of communications to the magnetic body and large control signals with $f_J^1 \gg f_c$. Hence the spectra would for a considerable part of period $1/f_c$ effectively consist of frequencies $f_\pm = f_J \pm f_J^1$, where f_J^1 varies in frequency range characterized by the amplitude of perturbation.

There is no definite resonance frequency since ω_1^J can vary continuously. Globally the situation is different since the spectrum can in principle be decomposed to frequencies $f_J \pm nf_c$. These two descriptions correspond to time domain and genuine frequency domain.

For sufficiently high harmonics of f_c the chaoticity disappears and frequencies $f_J \pm nf_c$ become more manifest. The Josephson amplitudes of higher harmonics decrease as $1/nf_c$.

Beta band is predicted to have a mirror image in theta band during cognitive activity. The frequencies in theta band are assigned with cognitive activities and memory recall. Note that also alpha band due to cyclotron frequencies should be present as well as the basic "drum beat" defined by f_J for $f_J^1 \gg fc$.

4. Odd higher harmonics of cyclotron frequency are expected to be the most important ones and would have interpretation as control signals from magnetic body. Satellites would correspond to responses to magnetic body involving entire 160 km thick Josephson junction but certainly correlating strongly with what happens in brain (recall the analog of biological body with a receptor at cell membrane).

   For alpha band the third harmonics of most bosonic ions are in the range 28.2-34.2 Hz and roughly in gamma band above 30 Hz assignable with the control of cognitive activities from a flux quantum of Earth's magnetic field.

   Fifth harmonics would be be in the range 37.5-57 Hz. The fermionic ion Na^+ would correspond to 65 Hz. During REM sleep EEG very similar to awake but 65 Hz resonance is present. One can ask whether fifth harmonics are present during REM sleep and serve as correlates for conscious visual imagery.

5. 40 Hz thalamocortical resonance band is very important EEG band. The upper satellite of the third harmonic of Mn^{2+} is 37.9 Hz. The third harmonics of fermionic ions $^7Li^+$ and Na^+ correspond to 42.9 Hz and 39 Hz (Schumann resonance) and have no satellites as fermionic ions.

5.2.4 Satellites exist as mirror pairs

The existence of the mirror satellites might be regarded as a killer prediction. Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [39]. Besides alpha band at 11 Hz, Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as the bands at 13, 15 and 17 Hz in beta band [39]. All these frequencies are expressible in the form $f_c \pm f_J$, $f_J = 5$ Hz, which is one half of the frequency 10 Hz of the memetic code and by 14 per cent higher than 3.7 Hz predicted assuming $\lambda = 2^{11}$. The value of λ deduced from these frequencies would be $\lambda = 1902$ and about 7 per cent smaller than $\lambda = 2^{11}$. This discrepancy

cannot be taken too seriously since it is quite possible that the thickness of Josephson junction is not scaled up completely exactly.

The cyclotron frequencies associated with the bands are 8, 10, and 12 Hz. The cyclotron frequencies of bosonic ions $^{80}Se^{2-}$, $^{64}Zn^{2+}$, and $^{55}Mn^{2+}$ for a magnetic field strength $B_{end} = .2$ Gauss are 8.00, 9.90, and 12.00 Hz. The cyclotron frequencies of bosonic ions $^{59}Co^{2+}$ and $^{56}Fe^{2+}$ would be 10.52 Hz and 11.36 Hz and the satellites are at frequencies 5.52 Hz and 6.36 Hz and 15.52 and 16.36 Hz. All these frequencies belong to the bands reported by Nunez since their widths are 1-2 Hz. Thus the frequencies of all bosonic ions in alpha band and in their satellites belong to the bands reported by Nunez for values of λ and B very near to their nominal values used in calculations!

With these assumptions the frequencies $3f_c(Mn^{2+}) \pm f_J$ are 40.97 Hz and 30.97 Hz corresponding to 40 Hz band and the threshold of gamma band. That $f_c(O^{2-}) = 39.6$ Hz is also in this band suggests additional reason for why oxygen is so important for consciousness. $f_c(Mg^{2+}) = 26.3$ Hz is very near to Schumann resonance 26 Hz and its upper satellite corresponds to the threshold of gamma band.

What is also very remarkable that the 10 Hz magic frequency of the memetic code corresponding to the secondary p-adic length scale $L(2, 127)$ associated with Mersenne prime M_{127} characterizing electron appears. It should be also noticed that $f_J = 5$ Hz frequency corresponds to cognitive theta appearing during tasks requiring mathematical skills.

5.2.5 Alpha band dominance during relaxed state

In a relaxed state beta band disappears and the spectral power in alpha band increases. This seems to be in conflict with the idea that beta band is a mere satellite. There are two mutually non-inclusive manners to understand this.

1. The first possibility is that cyclotron frequencies in alpha band are not actually present and only Schumann frequency 7.8 Hz and 10 Hz resonance frequency associated with the excitations of electric field in ionospheric cavity behaving like 2-dimensional waves on sphere.

2. Second possibility is that ionospheric Josephson junction is somehow closed so that only the cyclotron contribution of various ions is present. This might be caused by DNA level mechanism which simply prevents the flow of the Josephson currents flowing along magnetic flux sheets through DNA strands. This mechanism would be completely analogous to the closing of ionic channel associated with cell membrane protein.

5.2.6 EEG during sleep

The EEG during sleep [59] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM

sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question. This turns out to be a correct guess.

1. EEG during stage 1

During stage 1 theta of deep sleep [59] waves in frequency range 4-8 Hz dominate and amplitudes increase when frequency is reduced. The control signals from magnetic body are expected to be weak so that $f_J^1 < f_J$ approximation should hold true implying that frequencies $f_J \pm f_c$ should dominate and EEG would look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/\omega_c$ and thus increase with decreasing ω_c. The fact that amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

These facts does not conform with the general picture as such. If theta and beta bands are mere satellites of alpha band, both of them should be present during stage 1 sleep but this is not the case. The idea that cyclotron frequencies of heavier ions in $B_E = .5$ Gauss could replace those appearing during wake-up does not work. Theta band simply does not contain the cyclotron frequencies of biologically important ions for $B_E = .5$ Gauss. One can imagine two manners to resolve the difficulty.

a) Two manners to quantize magnetic flux

One way out of difficulty seems to be that the value of the magnetic field associated with active flux sheets is reduced by a factor of 1/2. This would mean that the most important range 7.5-15 Hz of cyclotron frequencies would be scaled down to 3.75-7.5 Hz which indeed corresponds to the theta band. If one excludes Ca^{2+}, the range for bosonic ion reduces from $7.5-11.4$ to $3.75-5.7$ Hz. The satellites correspond to the range $.05 - 8.7$ Hz and $7.45 - 9.4$ Hz plus Ca^{2+} satellites at 3.8 Hz and 11.2 Hz. With Ca^{2+} forming a possible exception, the resulting frequency ranges are consistent with empirical facts. Of course, it is quite possible that magnetic body does not generate cyclotron transitions at Ca^{++} cyclotron frequency.

The resolution of the puzzle might relate to the character of ions at the flux sheets in left and right hemisphere.

1. The quantization of magnetic flux reads as $Ze \int BdS = n\hbar$ and for Cooper pairs and bosonic ions with $Z = 2$ (Z refers to the absolute value of charge) it gives magnetic field strength which is one half from that for fermionic singly charged ions. Both fermionic ions with $Z = 1$ and bosonic ions and Cooper pairs with $Z = 2$ are allowed in this case by the single valuedness of wave functions. For $Z = 2$ the quantization condition allows single valued wave functions for $Z = 2$ ions or Cooper pairs only.

2. Assume the quantization condition corresponds to $Z = 1$ for the right hemisphere and $Z = 1$ for the right hemisphere. The presence of fermionic ions implies additional cyclotron frequencies on left hemisphere and the

presence of fermionic ions conforms with the old proposal that fermionic Fock states provide a realization of quantal version of Boolean algebra. This conforms with the view that left brain is more reductionistic and performs linear logic operations whereas right brain is more holistic.

3. As a consequence the cyclotron frequency scale in right hemisphere is reduced by a factor of 1/2 and during right hemisphere dominated NREM sleep alpha band would be scaled down to theta band.

4. The prediction is that, apart from the Schumann frequencies and neural noise, left hemisphere EEG spectrum consists of right hemisphere EEG specrum scaled up by a factor of 2 plus the contribution of fermionic ions and the Josephson satellites of these frequencies.

The assumption that the two quantization conditions correspond to just left and right hemispheres rather some other pair is of course un-necessarily strong and one can imagine also other correspondences.

b) Exotic ions as a resolution of the problem?

Second manner to achieve the scaling down of alpha band by a factor of 1/2 relies on the notion of exotic atomic nuclei. Z^0 ions coupling to $k = 113$ exotic weak bosons with $k_{em} = 2$ result if some color flux tubes bonding the nucleons of nuclei to nuclear string become weakly charged. This means that a color bond having quark and antiquark at its ends becomes $u\overline{d}$ type bond or its charge conjugate so that color bond becomes also em charged. There is evidence for this process. For instance, TGD explains the properties of tetraneuron assuming that alpha particle with two negatively charged color bonds is in question [F8].

Exotic ion is not chemically equivalent with an ion of same em charge since the valence of the system is anomalous. For instance, as far as electronic shell is considered, the ion could behave like noble gas atom. Electronic ionization could also compensate exotic ionization so that an electromagnetically neutral but weakly charged ion would result. For instance, doubly charged bosonic ions could have em neutral counterparts with two units of weak charge (unit defined as the weak charge of $u\overline{d}$ type color bond).

Since fermion number is not affected, singly charged exotic ion is boson for all nuclei with even neutron number, that is for the most stable nuclei. All biologically relevant ions might thus exist in bosonic states and form Bose-Einstein condensates. One can even wonder whether ions such as Na^+, K^+, and Cl^- associated with cell are actually exotic ions and appear as Bose-Einstein condensates. For doubly charged bosonic ions, most of which are in alpha band, cyclotron frequencies of singly charged exotic counterparts would be halved. Also the Josephson frequency would be halved. For the first option this is not the case.

2. EEG during stage 2

Sleep spindles appearing in the state 2 of deep sleep are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [49]. The spindles

.5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

One interpretation is that sleep spindles correspond to the occasional wake-ups of the left hemisphere. Sleep spindles would thus correspond to the satellites of alpha band identifiable as responses of the corresponding Josephson junctions to occasional strong control signals at cyclotron frequencies in alpha band. K complexes could be interpreted as signals from magnetic body to left hemisphere but inducing no response. It might be that these sudden responses reflect the fact that the left brain is not fully asleep yet.

3. EEG during stages 3 and 4

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [59]. This implies that control signals at cyclotron transition frequencies of ions from the magnetic body cannot be appreciably present and the control signals at cyclotron frequencies of molecular ions, such as DNA with cyclotron frequencies below 1 Hz, should be responsible for the EEG. The small amplitude of control signal implies $1/f_c$ behavior and large amplitude as compared to the corresponding amplitudes at higher bands at weak amplitude limit.

Taking into account the fact that magnetic field strength is scaled down by factor of 1/2 this means that mass numbers of the ions in question must satisfied $A/Z \geq 150$ for $f_c \leq 1$ Hz. For DNA sequences with charge of 2 units per single base-pair one would have $A \geq 300$. The atomic weights for base pairs plus phosphate group and deoxyribose sugar are $327, 321, 291, 344$ corresponding to A, T, C, G. Harmonics would be present also now but their contributions are small if the amplitudes of the control signals are small.

5. EEG during sleep and sensory canvas hypothesis?

The amplitudes associated with the higher EEG frequencies get much weaker during sleep. This is what sensory canvas hypothesis allows to expect since both sensory representations and the associated symbolic and cognitive representations are absent. Since no sensory and cognitive representations are present, no EEG MEs projecting the data to the sensory canvas need to be activated. This suggests that EEG frequencies associated with our sensory representations must be in alpha, beta and gamma bands. This first principle explanation for the reduction of EEG intensity in alpha, beta and gamma bands is actually highly nontrivial outcome of the sensory canvas hypothesis.

One can also deduce from the sensory canvas hypothesis which sub-selves can remain in wake-up state during sleep and possibly have sensory representations. It is known that 80 Hz range of EEG is not affected during sleep so that lower level selves could remain in wake-up state and wake-up also higher level cortical selves during dreams. For instance, the EEG frequencies associated with brain stem are of order 100 Hz whereas reticular formation corresponds to dominating rhythm of 200 Hz. It is natural to assume that these sub-selves remain in wake-up state and take care of the basic functioning of the body.

The process known as the consolidation of long term memories represent

an example of a generalized motor activity of performed by the magnetic body during sleep. The gene expression required by the consolidation of long term memories in terms of conformational patterns of micro-tubuli would be simplest explanation for the presence of DNA cyclotron frequencies.

There could be also a transmission of abstract information from brain during sleep. For instance, the mirror mechanism of long term memories might be based on preferential entanglement of the wake-up brain with the sleeping brain so that maximal capacity would be available for memory function. One could consider the possibility that EEG MEs at these frequencies project some features to magnetic selves which correspond to higher collective, multi-brained levels consciousness which wake-up during night time when the composite brains are not using their information processing capacity to the processing of sensory input and generation of motor output. The fact that neuronal activity continues also during sleep is consistent with this kind of shared use of brain. This hypothesis would assign the long sought fundamental function to sleep.

6 Emotions, cognition, and EEG

TGD has led to a model for sensory qualia and provide general ideas about emotions but a concrete model for emotions is lacking. In case of cognition the models are more concrete and a hierarchy of p-adic cognitive codes has been proposed.

In the following the view that emotions and cognition can be regarded as somatosensory experiences of the magnetic bodies generated by cyclotron transition patterns induced by dark EEG photons, will be developed. Place coding assigning ELF frequencies to positions at the magnetic body is an essential element of this map. The interpretation of music as a language of emotions and "right brain signs-left brain talks" metaphor allow to develop the model in a considerable detail.

6.1 Some aspects of emotions

Emotions look the most mysterious aspect of consciousness and there are only hints about their character.

6.1.1 Emotions and information

Emotions and information are closely related. For instance, peptides are information molecules and could be closely correlated with the generation of emotions or emotional expression.

Rational (or even algebraic) bound state entanglement gives rise to a positive entanglement negentropy (defined as a number theoretic entropy). The change of entropy of sub-self (mental image) in quantum jump could characterize the corresponding emotion. The sign of the negentropy change could correspond to the positive/negative dichotomy for emotions. One can of course argue that the

color of emotion is only a response to the change of the information content of the mental image.

6.1.2 Emotions as higher level qualia?

Emotions have metaphoral resemblance to qualia (white/black, cold-warm,...) but intuitively correspond somehow to a higher level than sensory qualia. For instance, insects presumably possess sensory qualia but do not look emotional. Pain-pleasure dichotomy is especially interesting since physical pain can be regarded as a sensory quale and psychological pain as an emotion. This suggests that emotions might be qualia of some kind, perhaps sensory qualia of the magnetic bodies at higher levels of the dark matter hierarchy. This correspondence might however be illusory: the association of certain kind of emotions with certain kind of qualia could explain these metaphors.

It is not at all clear whether this identification is consistent with the assignment of emotions to the negentropy change. One can of course ask whether the "sign" of the emotion as a higher level sensory quale is determined by the sign of the negentropy change. One could also argue that the sign of the negentropy change for sub-self defines one particular higher level sensory quale.

6.1.3 Emotions are whole body feelings

Emotions are holistic and not localizable in any part of the biological body. The time scale for the change of emotions is long as compared to that for the sensory qualia. Emotions possess time scale hierarchy and vary from temporary irritation as you find that you email box is full of junk mail to moods and emotional states like love and hatred lasting for decades. To love some-one for decades one must be able to remember this person. If one assumes that the time scale associated with the level of dark matter hierarchy fixes the geometric duration of the moment of conscious and the characteristic time span of long term memories at that particular level of hierarchy, the conclusion would be that emotions are associated with the higher levels of dark matter hierarchy and are indeed assignable to the magnetic bodies.

6.1.4 Could Josephson radiation to the magnetic body generate emotions?

The simplest hypothesis is that magnetic bodies share the sensory mental images localizable at the sensory organs. The same would hold true for the mental images generated by brain as symbolic representations of the sensory input. The sharing of mental images would correspond to quantum entanglement between sub-selves of the magnetic body and biological body. Charge entanglement induced by W MEs is a good candidate in this respect and would be also in a key role in the motor control. The selection involved in the state function reduction process would correspond to a selection of percepts known to occur (binocular rivalry provides a standard example).

This leaves open the interpretation of the communications to the magnetic body based on Josephson radiation at frequencies $nf_c \pm f_J$, where f_c is ionic cyclotron frequency and f_J Josephson frequency determined by membrane resting voltage. Also more general frequencies are possible. In particular, communications based on slow (in cyclotron time scale) modulations of Josephson frequency induced by modulation of membrane voltage are of special interest.

The Josephson radiation consisting of dark photons induces cyclotron transitions at the magnetic body and in the absence of any other identification, the natural interpretation would be that these transitions define emotions as somatosensory experiences of the magnetic body. The intentionally generated generalized motor actions involving charge entanglement by W MEs would induce the emotional expression just like other motor interactions.

If magnetic body experiences emotions as somatosensory input, it is difficult to avoid the question whether magnetic body is also able to move and change its shape. The model for various kind of OBE experiences [H10] indeed relies on the assumption motor control is induced by motor actions deforming the magnetic body: biological body would be like a puppet hanging from strings.

There is quite recent finding that the sensation of movement is generated by the intention to move rather than by the real motion of body part itself [51]. The explanation would be that the sensation of movement is a somatosensory of magnetic body about its own motion (the interference patterns for Josephson radiation from the body are changed and therefore also cyclotron transition patterns). The communication-control loop between magnetic body and biological body would guarantee that the two movements correspond to each other. This interpretation would provide also a new view about dreams and hallucinations.

6.2 The coding of pulse patterns to Josephson current

Suppose that one takes the statement "right brain sings-left brain talks" as a guideline. A more formal statement would be that right brain hemisphere is more involved with the motor control of singing and left hemisphere with that of speech. There is support for this statement. For instance, people who have lost their ability to communicate via speech can still communicate by singing.

"Right brain signs, left brain talks" metaphor suggests the existence of two basic types of sensory representations at magnetic body identifiable as emotional and cognitive representations. Josephson currents code slow variations of membrane voltage into this kind of representations in a very natural manner.

6.2.1 Right brain sings, left brain talks

The small modulations of the membrane voltage which are slow in the time scale of Josephson and cyclotron frequencies induce corresponding modulations of the Josephson frequency f_J and can represent information. The higher levels of dark matter hierarchy could induce this modulation and also become conscious about this information.

Singing and speech serve as models for two different kinds of modulations for f_J. For song representation f_J is piecewise constant and for speech representations the standardized temporal patterns of f_J define analogs of phonemes. "Right brain signs-left brain talks" metaphor inspires the hypothesis that left brain neural processing tends to produce phoneme like postsynaptic voltages whereas notes with varying pitch are produced at the right side.

1. Right brain sings

A small constant shift of the membrane voltage shifts the Josephson frequency by a constant amount. If the duration of the pulse is long as compared to Josephson frequency and if the cyclotron time scale is short as compared to the duration of the period of perturbation, Josephson junction codes series of voltages to a series of frequencies defining a melody as a somatosensory map to the magnetic body. Of course, also glissandos realized as regularly rising or lowering notes are possible. The combined contributions from various parts of brain define kind of music piece.

Also a change of the phase of Josephson current proportional to the duration of the pulse is induced. This could have relevance for the representation of information since it would change the phase relationships for the Josephson radiations coming from different parts of the biological body. The resulting representation would be very much like music.

The neural input to the neuron induces miniature- and micro-potentials in the postsynaptic neuron and could determine the pitch of the voice of single neuron. The neurotransmitters of the frequency representation should be able to induce several values of voltage difference. This kind of graded response at the level of single neuron might be achieved by a co-operation of excitatory and inhibitory transmitters. One can also imagine a situation in which each neuron has its characteristic pitch and the music of brain gives a map about neural activity of brain.

The temporal constancy of the postsynaptic voltage in time scales longer than EEG time scale requires that the neural inputs are simultaneous. This would be achieved by the synchronous firing of neurons. Synchronously firing neuron groups might be like choir.

Both pitch and rhythm are important for music representation and as a special case when only rhythm matters codes based on bit sequences become possible. If the magnetic body receiving the Josephson radiation carries a constant magnetic field, only single voltage value induces cyclotron transitions and the experience of the magnetic body is a bit sequence. This is of course true at a given position of magnetic body always. This could provide a realization for various binary codes associated with declarative memories. p-Adic length scale hypothesis $p \simeq 2^k$, k integer, defines a hierarchy of codes with the number of bits equal to a prime power factor of k. Memetic code based on $M_{127} = 2^{127} - 1$ provides a basic example of this kind of code with the duration of codeword equal to .1 seconds or its λ^k-multiple, $\lambda \simeq 2^{11}$.

The basic prediction is that the analysis of rhythm and pitch are not separate brain functions and assignable to left *resp.* right hemisphere as one might think

first. There is indeed evidence that the patterns of pitch and duration are analyzed by same brain regions and that right hemisphere is more involved [50].

2. Left brain talks

For speech like representation the membrane voltage is not piecewise constant but decomposes to a sequence of temporal patterns defining the counterparts for phonemes. In this case average voltage could remain more or less constant like the pitch of speech since information is coded in phonemes. The input to the neuron should be such that this phoneme like pattern results. To my meager knowledge, the assignment of speech processing to the left hemisphere is justified. There are even anatomical differences: the temporal planum in left hemisphere is larger than in right hemisphere and if this asymmetry is absent dyslexia results.

6.2.2 Music and speech representations are local at the level of the magnetic body

Music and speech representations would be local representations at the magnetic body and magnetic body could accommodate several representations of this kind. For instance, in the case of miniature potentials the range of magnetic body would correspond to a variation of cyclotron frequency by about one per cent. Besides this representations harmonics of cyclotron frequencies of various would define large scale representations at the magnetic body. Also the homeostatic variation of the magnetic fields strengths in biological body varies the position at which cyclotron phase transition for given ion happens at the magnetic body. Whether this representation contributes directly to our conscious experience and what the contribution is, remain an open question.

6.2.3 Does left magnetic body understand speech and right magnetic body understand singing?

One can also ask whether the right magnetic body could have specialized to the emotional response induced by song-like Josephson radiation and left magnetic body to speech like Josephson radiation.

If the frequencies are coded to the deviations of the resting voltage of Josephson junction from the standard value, then heard frequencies would be mapped to the modifications of Josephson voltages in turn mapped to cyclotron frequencies represented at different points of the magnetic body.

This would give rise to a holistic representation of the frequency pattern as a kind of somatosensory experience of the magnetic body. Higher harmonics of a given frequency can be also represented as higher cyclotron transitions. This would give rise to a local representation in particular point of the magnetic body. In the case of music harmonics of the fundamental distinguish between different instruments and also contribute to the emotional content.

The two representations would not correspond to the auditory experience as such but to the emotional and cognitive responses to it. Critical reader can

of course wonder why left and right magnetic bodies could experiences also the sounds directly.

A possible answer would be that Josephson radiation is not specific to any sensory quale and it would be strange to assume that hearing would be a sense of magnetic body whereas other senses would be assigned to the biological body. Now the critical reader would probably ask Why not?: language is after all what distinguishes us from our cousins, and might continue by arguing that perhaps internal speech (cognition) and internal song (emotions) corresponds to the hearing of the magnetic body. This might be indeed the case and be part of the sensory experience of the magnetic body. This would also conform with the general vision that internal speech and song represent all kinds of brain activity in terms of Josephson radiation.

6.2.4 Realization in terms of postsynaptic potentials

Neuro-transmitters induce micro- and miniature potentials. The scales of membrane potential, miniature-,and micro-potentials are 80 mV, .5 mV and .3 μV. The relative variations of f_J are thus of order 10^{-2} and 10^{-5}. Thus the time scales corresponding to Δf_J could correspond to the $k_{em} = 5$ and $k_{em} = 6$ levels of the dark matter hierarchy. $k_{em} = 5$ corresponds to the time scale of short term memories.

Quantized micro- and miniature potentials of post-synaptic cell are a good candidate for defining the small variations of f_J. If f_J were directly experienced, the variation would be very small and about one percent of a full octave. Only during nerve pulse the situation would change and the the variation of Josephson frequency would induce a cyclotron transition scanning of the magnetic body in question and waking it up.

Music metaphor encourages however to think that it is Δf_J which is experienced as a tone rather than f_J. If this is the case, then the fundamental frequency would correspond to some minimum deviation Δf_0 and the notes in the octave to rational multiples of Δf_0. During music experience the tonic of the scale is remembered all the time even in the case that the scale is modulated temporarily. This suggests that fundamental is represented all the time in some sense. This situation is achieved if the reference value $f_{J,0}$ of f_J corresponding to $\Delta f = 0$ is also communicated to the magnetic body. Music metaphor encourages to think that $f_{J,0}$ is not experienced consciously since it corresponds to infinitely low pitch.

Reference beam would be the hologrammic counterpart for this frequency. The Josephson radiation serving as the reference note could be radiated by neurons which do not receive neural input or by those parts of neuronal membrane which are not affected by neuronal input.

6.2.5 Concrete models for the place coding

Consider now a concrete models for the place coding. Let x define a longitudinal coordinate of the magnetic flux sheet. Suppose that f_J is mapped to a point

$x = x_0$ with magnetic field B_0. The simplest assumption is that the magnetic field depends on Δx via a power law: $\Delta B = -B_1 y$, $y = \Delta x/\Delta x_0$. This implies that Δf_J and y relate as $\Delta f_J \propto y$. This implies that scaling of Δf_J by a factor 2 implies corresponding scaling of y. The scaling by 2^{-n}, $n \to \infty$ corresponds to $y = 0, \Delta f_J = 0$.

In the case of music experience this would reduce the harmonic equivalence of octaves to 2-adic fractality of the magnetic body provided that Δx_0 corresponds to a 2^n-multiple of the dark variant $L_2(k) = \lambda^k L_2$, $\lambda \simeq 2^{11}$ of the fundamental 2-adic length scale: $\Delta x_0 = 2^n \lambda^k L_2$. This poses a strong quantitative constraint on the model.

Titius-Bode for planetary orbits states that the radii of planetary orbits obey the law $r(k)/AU = .4 + 0.3 \times 2^k$, $k = -\infty, 0, 1, ...,$. AU denotes the distance of Earth from Sun. Obviously the law corresponds to the proposed place coding and the expressions for the radii are consistent with the assumption that the scale starts from Mercury's orbit and the distances between subsequent planets correspond to full octaves.

The interpretation is inspired by the model for the Bohr orbit like character of planetary orbits based on dark matter as a template controlling the patterns of ordinary matter. The interpretation would be in terms of a large $\hbar$ representation for which 2-adic length scale L_2 or by 2-adic fractality $2^n L_2$ for some value of n is scaled up to .3 AU. $n = 4$ and $k = 12$ level of dark matter hierarchy (corresponding to $\hbar = \lambda^k \times \hbar_0$ gives .3 AU in a good approximation for $\lambda = 2068 = 4 \times 11 \times 47$ slightly larger than $\lambda = 2^{11} = 2048$. L_2 itself would be mapped to $L_2(k = 12) = 2.8$ Mkm to be compared with the Earth radius $R = 6.4$ Mkm and the depth 2.9 Mkm of the upper boundary of the outer core in the Earth's interior. Perhaps Kepler's vision about planetary harmony might have some meaning after all.

6.2.6 Why the magnetic field strength at left and right brain magnetic bodies differ by a factor two

The model for EEG forced the assumptions that neurons in brain can be divided to two classes as far as EEG is considered. The magnetic field at flux sheets going through DNA would be B_E in the first class and $B_E/2$ in the second class. These two classes might correspond to neurons in left and right hemisphere.

The values of the magnetic field strength correspond to different quantization of magnetic flux using the condition $Z \int BdS = n\hbar k$, $n = 1$, assuming that the minimum charge of super-conducting particle is $Z = 1$ for the left brain hemisphere and $Z = 2$ for the right brain hemisphere so that right magnetic body would presumably contain only bosonic dark ions.

Why these two different scales of EEG frequencies? A possible answer is that one cannot avoid right brain Josephson radiation of inducing cyclotron transitions at left magnetic body and vice versa. Different scales of EEG frequencies would however guarantee that right and left Josephson radiations do not interfere since left and right brain inputs of the local representations are separated by a distance of one octave.

6.3 Music as a language of emotions

Music is a language of emotions and the understanding of the emotional experience created by music experience is a natural challenge for the model.

6.3.1 Music metaphor

The basic philosophy behind the identification of the quantum correlates of the sensory qualia has been provided by music metaphor [H4] which, when understood in a sufficiently general sense, has turned out to be not only a metaphor for brain but for consciousness itself. Of course, metaphors are metaphors because they fail in some respects and also music metaphor has done this several times. Brain as orchestra and axons as strings of a music instrument are two examples of the failures of the metaphor. Brain as writer of the music of the sensory organs to notes is much more plausible form of the metaphor in TGD framework. That music metaphor should be expanded to include also the notes, is rather obvious after all since symbolic representations are a crucial element of conscious intelligence.

The time is now ripe for an attempt to deduce the music metaphor from the basic theory. Or at least to develop a detailed view about emotional representations at magnetic body by requiring that the model allows to understand basic aspects of musical experience such as the notions of pitch and rhythm, resonance, harmony and dissonance, why octaves are harmonically equivalent, why scales appear naturally and why the scales defined by rational frequency ratios are in a special role, etc... This leads to an increased understanding of how multi-p-fractality, and in particular 2-adic fractality, are involved with music experience. It must be emphasized that these features seem to characterize the of all emotional representations based on the modulation of generalized EEG frequencies, and do not to music experience only.

6.3.2 Rhythm and pitch

Both rhythm and harmony are important in music. Rhythm corresponds to the time domain and pitch to frequency domain and these aspects relate to each other like signal and its Fourier transform. Hence one might think that right brain analyzes the pitch and left brain the rhythmic aspects. TGD based model predicts that this is not the case and there is experimental evidence supporting this conclusion [50]. Left brain would use instead of piecewise constant frequencies modulated frequencies with standard modulation patterns to produce sequences of generalized phonemes instead of singing.

6.3.3 Harmonic equivalence of octaves and 2-adic fractality

The scaling of the fundamental frequency by a factor 2 does not change its harmonic character. This encourages to think that p-adic length scale hypothesis ($p \simeq 2^k$, k integer) is involved at a level of dark matter hierarchy corresponding to the typical time scale of music. Multi-p-fractality involving $p = 2$ and

some other primes would be thus involved. 2-adic fractality means approximate 2-adic continuity and smoothness and implies that space-time surface at points x and $x + 2^n$ is very similar. If also the local geometry of the magnetic body besides the cyclotron frequency is relevant for the musical experience besides the frequency alone harmonic equivalence of octaves could be understood. In the model for representations of duration and pitch patterns to be discussed below parallel magnetic flux sheets would correspond to different octaves by 2-adic fractality.

6.3.4 Rational music scales and 2-adic fractality

The experience of music involves also cognitive aspects. Suppose that p-adic space-time sheets indeed serve as space-time correlates for cognition and intentionality. One can say that p-Adic space-time sheets intersecting real space-time sheets at rational points define a mimicry of a real space-time sheet. It is also possibly to regard this mimicry as a discrete coordinatization of the real space-time sheet as a selection a subset of rational valued points of real space-time surface as intersection points.

Musical scale, 8-note scale or perhaps 12-note-scale, could represent a particular kind of discrete coordinatization. Selections of this kind could be a basic element of geometric consciousness and would perhaps allow to understand also the roots for the notion of sacred geometry as well as the basic constructs of elementary geometry (plane polygons for instance).

Rational valued ratios for the pitches are favored and the scales used in old music are indeed based on rational values using fundamental pitch as a unit. The even-spaced standard 12-note-scale is a compromise defined by non-rational frequencies $2^{n/12} f_0$. Brain might map also these frequencies to the points of magnetic flux sheets corresponding to rational cyclotron frequency ratios.

The special role of rational points could be understood in terms of p-adicity if the proposed general view is accepted. There are several rational scales but if one assumes that the ratios to the fundamental are expressible as rationals expressible in terms of primes 2, 3, and 5, 12-note-scale would correspond to the ratios 1/1,135/128,9/8,6/5,5/4,4/3,45/32,3/2,8/5,27/16,9/5,15/8, 2/1 assigned by Kepler to the planetary motion.

The basic scales of western music are given in the following table (in Eastern music also one-fourth steps occur)

major	1/1	9/8	5/4	4/3	3/2	27/16	15/8	2/1 ,
upwards minor	1/1	9/8	6/5	4/3	3/2	27/16	15/8	2/1 ,
downwards minor	1/1	9/8	6/5	4/3	3/2	8/5	9/5	2/1 .

The interpretation in times of multi-p-adicity involving primes 2, 3, and 5 could be considered. The difference between major scale and minor scale is that major scale involves only 2 and 3 in denominators and is in this sense simpler. This and the somewhat naive character of the major scale suggest that

minor scale is in some sense more information rich and expressive. This view is supported by the following information theoretic argument.

The notes of the scale are regarded as a statistical ensemble defined by the probabilities $p_m = f_m / \sum_n f_n$. The number theoretic negentropy associated with the scale can be defined as the maximum of number theoretic negentropies $N_p = -S_p$, p prime. N_p can be defined as the maximum over p-adic Shannon entropies (!) obtained by replacing $log(p_m)$ with $log(|p_m|_p)$ in the defining formula of Shannon entropy and is positive in general unlike the ordinary Shannon negentropy.

The dominant positive contribution to N_p comes from the largest power of prime in $\sum_n f_n = N/2^4 \times 3 \times 5$ for the major scale and $\sum_n f_n = N/2^4 \times 3$ for the minor scale. In the case of minor scale one must use the ensemble formed by the upwards and downwards minor scales. For the major scale the largest prime appearing as a factor of N is 47 and for the minor scale N is equal to prime $p = 5107$ so that minor scale would be much more negentropic. The upwards minor scale would correspond to $p = 83$ and downwards minor scale to $p = 181$ so that also these scales are more negentropic than major scale.

The ratios of frequencies (major/minor scale) are able to code for emotional tones. Why the lowering major third to minor third changes the emotional tone to its opposite looks mysterious. Music is a cultural phenomenon, and one might argue that learned associations are in question. For instance, a simple visual association about a linear growth at discrete constant steps or climbing up step by constant steps might be involved as generating positive, perhaps one might say optimistic, emotions. The first full step in both scales creates expectation about second full step. Step size/linear growth is however suppressed in the replacement of the *second* $\rightarrow$ *major third* with *second*$\rightarrow$ *minor third* so that the optimistic expectation fails. Also the two large downwards steps in the beginning of the downwards minor scale could create analogous emotional associations.

6.3.5 Harmony and dissonance

The phenomena of harmony and dissonance serve as a further guideline. If frequencies are represented by the positions at the magnetic body dissonance would mean that the positions of cyclotron transitions at the magnetic body are too close to each other. This might mean that the nearby frequencies can induce cyclotron transitions at same points of the magnetic body so that a kind of competition would result. Harmony would mean that the distances for points at which cyclotron transitions occur must be maximized modulo octave to avoid dissonance (this something familiar from human human societies).

Slow frequency modulation (vibrato) has also emotional content and makes music livelier. At magnetic body it would correspond to the oscillation of the position of the cyclotron transition. This is indeed possible since in the vertical direction along the flux sheet magnetic field varies continuously.

The scale is experienced by a person not possessing absolute ear as inherently the same independently of the the pitch of the fundamental. Musical persons

are able to remember the basic scale of a classical music composition although complex changes of scale are performed during the composition. This can be understood if the fundamental frequency defining the scale is represented all the time as cyclotron transitions and plays a role very much analogous to the reference beam in the case of hologram. This would require Josephson junctions for which the Josephson voltage is not modified by the auditory input. The alternative option is based on the representation of the fundamental as a geometric memory. The choice of the tonic fixing the scale would correspond to the choice of the origin of a coordinate system with certain rational valued points representing the scale.

6.3.6 Absolute ear

Absolute ear means the existence of a preferred hardwired scale and ability to associate to the heard notes their names. Transposing an instrument is painful for an instrumentalist with perfect pitch since the notes she's playing are not the ones she's hearing.

Musicians with absolute ear can even decompose sounds that are usually regarded as a noise to a collection of notes with well-defined pitches. Obviously absolute ear means a well-developed ability of some part of brain to perform a Fourier analysis for the incoming sounds. It is known that the temporal planum part of the cortex is much more developed on the left side than on the right side for people with absolute ear [52]. The larger size of left temporal planum correlates also with right-handedness so that "absolutists" might be more strongly righthanded than usual. The increased size of the left temporal planum is also involved with reading: people with dyslexia tend to lack temporal planum asymmetry [53].

Perhaps the left temporal planum of the "absolutist" automatically assigns to the heard notes a symbolic representation as written notes. If only right brain hemisphere performs the Fourier analysis, this would require right-left communication which could be also carried out via the magnetic body inducing generalized motor action associating to the pitch pattern heard by right magnetic body their names in left temporal planum.

One can however imagine much simpler mechanism. During the recognition task the left temporal planum could simply send Josephson radiation from the points representing the names of notes to the right magnetic body at the frequency of the note in question. The recognition of the note would be based on resonance with the Josephson signal coming from the signal representing the music percept. This would also allow to detect dissonance. The inability to adapt to a new scale would be due to the fact that the Josephson frequencies in the left temporal planum are hard wired.

6.4 p-Adic cognitive representations at EEG frequencies

The upper levels of dark matter hierarchy could control lower levels by inducing modulations of Josephson frequency slow in the time scale characterizing the

Josephson frequency of the level in question and scaling as $1/\lambda^k$. For a given magnetic fields cyclotron time scale does not depend on the level. Depending on modulations speech or music like Josephson radiation would result.

Miniature- and micro-potentials and possible even smaller long lasting voltage changes affecting neuronal function in long time scales could be seen as modulations of this kind. If also magnetic field strengths are modulated in the same manner, all generalized EEG frequencies are modulated in the same manner. In the following p-adic cognitive codes which correspond to generalized phonemes of a speech like representation resulting via a music like representation involving only rhythm and using only single pitch in time scale $T(n,k)/k$ ($T(n,k)$ is n-ary p-adic time scale associated with $p \simeq 2^k$) are discussed.

6.4.1 p-Adic cognitive codes

Symbolic representations rely on p-adic cognitive codes such that the number of the binary digits is defined by the prime k (or power of prime) associated with the representation ($p \simeq 2^k$, k prime or power of prime). Since also n-ary p-adic length scales defined by powers p^n are allowed, it is convenient to introduce effective value $k_{eff} = nk$.

The maximum number of bits of the cognitive codon is either $k-1$ or k depending on whether $p < 2^k$ or $p > 2^k$ holds true. Primary p-adic time scales define obviously the most information rich codes whereas for n-ary p-adic time scale the number of bits is reduced by $1/n$-factor. Memetic code with the duration of memetic codon about $T(2,127) \simeq .1$ seconds is an especially important representations of this kind although the number of the bits is $1/2$ of the maximal. The values of k_{eff} relevant to the EEG range (.3-80) Hz vary within the interval $[248, 262]$.

6.4.2 p-Adic time scales

Cognitive codes are very flexible. There is no need for the code words to appear with strictly regular intervals and phonemes can also repeat themselves without a loss of meaning. This is indeed the case for ordinary speech and could be the case also for the nerve pulse activity.

What is however needed that codewords possibly defining say phonemes of speech represent standard modulations with standard duration. p-Adic time scales and their dark scaled up variants are unique in this respect by their universality. For these reasons p-adic time scales are more appropriate a characterization for cognitive codes than p-adic frequencies. In the following both characterizations are however used. The signature of the cognitive codes in the case of nerve pulse patterns would be the appearance of sequences of few spikes with precise time intervals.

p-Adic time scales are in principle quite independent of cyclotron frequencies and EEG frequencies are in principle quite independent. It is possible to imagine a resonant coupling with cognitive code with characteristic duration with Josephson radiation at corresponding frequency but in the case of the cognitive

representations this would spoil the representation and one must assume that the duration of bit is longer than the cyclotron time scale involved.

p-Adic cognitive codes should correspond to the Josephson time scales assignable to $k_{em} = 5$ or higher levels of dark matter hierarchy. For $k_{em} = 5$ the duration of the codeword would be scaled up from $T_p(k, EEG)$ to $\lambda \times T_p(k, EEG)$, where $T_p(EEG)$ corresponds to a p-adic time scale in EEG range so that bit duration is $(\lambda/k) \times T_p(k, EEG)$ and longer than corresponding EEG time scale T_{EEG}, which can be taken to have value $T_{EEG} \sim 1$ s from the width ~ 1 Hz of narrow EEG resonances.

Also p-adic time scales $T_p(k) \gg kT_{EEG}$ are acceptable: this requires $k > 276$ ($T(276) \simeq 205$ s). Arbitrary long time scales are expected to be important for conscious experience as is suggested already by the model of long term memories and the restriction to EEG is only an approximation. This would mean that modulations of membrane potentials in time scales up to the duration of life cycle would be important.

p-Adic frequencies $f(k) = 1/T(n, k)$ as such do not define a frequency modulation of the generalized EEG frequencies. The frequencies $nf(k)$, $1 < n \leq k$, in particular the frequency $kf(k)$ defined by the duration of the bit, appear as frequencies in the Fourier expansion of the codeword, and therefore modulate EEG frequencies. Therefore EEG frequencies $f \gg kf(k)$ should split to $f \pm nf(k)$ if only Josephson frequency is modulated. For the dark variant of the memetic code having $T = \lambda T(2, 127) = 200$ s this would predict a splitting in multiples of $\Delta f = 5 \times 10^{-3}$ Hz and a maximal splitting $\pm.63$ Hz. The widths of narrow alpha bands are of order 1 Hz. This splitting is expected to correlate with short term memory representations.

An interesting question is how the time scale of the modulation and change of the Josephson frequency relate. There is a temptation to apply the quantization rule $\Delta f_J = n/(\lambda^k T_p)$. This would quantize the modification of the membrane voltage to

$$\frac{\Delta V}{V} = \frac{\Delta f_J}{f_J} = n\lambda^{-k}\frac{f_p}{f_J} \quad .$$

Micro-potentials are known to be quantized and this prediction could be compared with the amplitudes miniature and micro-potentials.

6.4.3 Table of p-adic time scales in EEG range

In the following the spectrum of p-adic time scales relevant for cognitive codes realized as modulations of Josephson frequency $f_J = 5$ Hz associated with the ordinary EEG is summarized. The time scales appearing in the table must be multiplied by $\lambda \simeq 2^{11}$ or a higher power of λ in order that they apply to the modulation of Josephson frequency associated with EEG.

k_{eff}	k	τ/ms	f/Hz	τ_b/ms	f_b/Hz
248	31(8)	12.5	80.0	.4(1.56)	2480(640)
249	83(3)	17.7	56.7	.2(5.9)	4690(170.1)
250	125	25.0	40.0	5.0	5000
251	251	35.4	28.3	.14	7099
252	9	50.0	20.0	5.6	180
253	23	70.7	14.1	3.1	325
254	127	100	10.0	.79	1270
255	17	141	7.07	8.3	120
256	256	200	5.0	.78	1280
257	257	283	3.54	1.1	909
258	43	400	2.5	9.3	108
259	37	566	1.77	15.3	65.4
260	13	800	1.25	61.5	16.3
261	29	2263	.44	78.0	12.8
262	131	3200	.31	24.4	40.9

Table 1. The table gives the value of prime k defining the number of bits as $N = k$ or $k-1$ for the cognitive representation carrying maximum information, the duration τ of the codon and corresponding frequency f, as well as the duration τ_b of the bit and the corresponding frequency f_b for $N = k$ for these cognitive codes as a function of k_{eff}. The values of k in brackets are the maximal values of k for which duration of bit is above millisecond time scale.

6.4.4 Are phonemes represented by a code?

Phonemes of speech like representation could correspond to a music like representation at the lower level of the hierarchy involving only rhythm and reducing to some binary code.

1. Memetic code?

The average duration of phoneme is around .1 seconds. This raises the question whether phonemes could be coded by memetic code assignable to the p-adic time scale $T_{M_{127}}(2) \simeq .1$ seconds with code word having duration of .1 seconds and consisting of $k = 127$ bits, which is of course quite too much to represent only phonemes. There are several constraints to be satisfied.

1. A precise timing of neural inputs in millisecond time scale seems to be required. One might hope that kHz neural synchrony might make this possible. What looks problematic is that nerve pulse durations are somewhat longer than the bit of the memetic code.

2. The duration of bit should be longer than the time scale of cyclotron frequency. This excludes EEG frequencies from consideration unless one is satisfied with only few signifying bits. At $k_{em} = 3$ level of hierarchy the situation changes. The Josephson frequency would be $f_J(3) = \lambda f_J(4)$ and

from $f_J(4) = 5$ Hz equal to $\simeq 10^4$ Hz. This would allow to regard memetic code as a slow modulation of the scaled up EEG frequencies. Alpha band is scaled up to 2×10^4 Hz if the magnetic field strength on flux sheets in question is $B = \lambda B_E \simeq .1$ Tesla. Note that the upper limit for audible frequencies is 2×10^4 Hz.

Memetic code could be realized without difficulty at $k_{em} = 5$ level of dark matter hierarchy using EEG frequencies. The duration of the code word would be 200 seconds and the duration of bit about 1.6 seconds. Short term memories could rely on this coding.

2. Genetic code?

As noticed, 127-bit memetic codons are much more than is needed to code for phonemes. Genetic code corresponding to $M_7 = 127$ is enough and requires only 6+1=7 bits. Bit would have a duration of 14 ms corresponding to a minimal 70 Hz EEG frequency. 80 Hz frequency associated with the micro tremor of eye might correspond to the alpha band cyclotron frequency associated with the memetic code: the magnetic field would $8B_E$ and correspond to $k = 163$ space-time sheets.

6.4.5 2-adic psychophysics?

Music metaphor has turned out to be of crucial importance for the theory of qualia. The most natural explanation for this is that music metaphor reflects underlying 2-adicity of our sensory experience. Perhaps at least some aspects of our experience result from a mimicry of the lowest level of the p-adic self-hierarchy. Taking 2-adicity seriously, one is forced to ask for the possible consequences of 2-adicity. For instance, could it be that at the level of primary qualia the intensity of sensation as function of stimulus depends on the 2-adic norm of the 2-adic counterpart of the stimulus and is thus a piecewise constant function if sensory input?

The following observation supports this speculation. When over-learning occurs in tasks involving temporal discrimination, the intensity of sensation as a function of stimulus deviates from smooth logarithmic form in small scales by becoming piecewise continuous function [58] such that the plateaus where response remains constant are octaves of each other.

This observation suggests a generalization inspired by 2-adic version of music metaphor. Primary quale has multiple of cyclotron frequency as its correlate and, being integer valued, is essentially 2-based logarithm of the 2-adic norm for the 2-adic counterpart of the intensity of the sensory input. Hence the increase of intensity of the sensory input by octave correspond to a jump-wise replacement of the n:th harmonic by n+1:th one and should be seen in EEG. Our experience usually corresponds to the average over a large number of this kind of primary experiences so that underlying 2-adicity is smoothed out. In the case of over-learning or neurons involved act unisono and the underlying 2-adicity is not masked anymore. At the level of ELF selves this would mean

generation of higher harmonic when the number of nerve pulses per unit of time achieves threshold value allowing the amplification of corresponding frequency by the mechanism discussed already earlier.

p-Adic cognitive codes suggest an alternative interpretation of this phenomenon. Cognitive codes corresponds to p-adic frequencies coming as powers of $\sqrt{2}$ of the basic frequency and appearing also as resonance frequencies of EEG (also higher frequencies could be involved at the level of sensory organs). The jump-wise replacement of the stimulus intensity could correspond to the replacement of the p-adic resonance frequency $f(k)$ by $f(k+1)$. In this process the number of the bits of the memetic code in general changes since both k and $k+1$ cannot represent primes. The decrease would mean a reduction of the information content of the codeword if the full representative capacity of the codes is utilized. This prediction could be testable.

6.5 Biological body as an instrument of cognitive and emotional expression

The intentional actions involving generation of W ME mediated charged entanglement and its reduction leading to the generalization motor action is the natural mechanism of emotional and cognitive expression giving rise to song, speech and emotional and cognitive body languages.

Peptides are in a well-defined sense molecules of emotion. What does this mean in TGD context is however not quite obvious.

1. Could magnetic body express emotions using peptides: in this case basic expression would be at the level of genome and would involve W MEs realizing gene expression producing peptides as a generalized motor command.

2. Could peptides be involved with the modification of the membrane voltage inducing the modification of Josephson frequencies and modifying thus sensory representations at the magnetic body? Peptides act also as neurotransmitters. Neurotransmitters quite generally lead to a local modification of the postsynaptic membrane resting potential by inducing discrete micro- and miniature potentials having interpretation in terms of a discrete scale analogous to music scale. This modification of Josephson frequency would in turn be coded to the change of the position at which Josephson radiation generates cyclotron transition at the magnetic body. The modification of the membrane potential is rather small and could relate to the so called miniature and micro-potentials involved with the nerve pulse generation.

All biological information molecules could induce similar modifications of the membrane potential affecting the sensitivity of nerve pulse generation and assigning to the neuron a position at the magnetic flux sheet so that magnetic bodies would carry somatosensory maps about the state of the multi-neuron system.

For instance, alert-rest dichotomy would directly correspond to the reduction-increase of the membrane voltage from the resting value (depolarization-hyperpolarization).

An interesting question is whether one can also identify molecules of cognitive expression. If they exist, left-right brain asymmetry would characterize corresponding neurotransmitters.

7 Scaling law

Scaling law provides bird's eye view about transitions which can represent conscious-to-us qualia at given level of the p-adic self hierarchy. The law relates two levels of self hierarchy corresponding to mental images associated with magnetic bodies of astrophysical size and with physical bodies, the latter with size not much larger than brain size. Scaling law assumes that self sizes L at given p-adic level k are between the p-adic length scales $L(k)$ and $L(k(next))$. Scaling law is of form $L = v/f$ and relates ELF self size characterized by ELF frequency f to the self size L and to the effective phase velocity v of the EEG wave.

I ended up with the scaling law much before the realization that sensory representations could reside outside the brain and have same sizes as EEG MEs. The hypothesis that scaling law relates the sizes of the magnetic flux tube structures outside the body serving as a magnetic canvas to the sizes of the sensory representations inside brain implies that the view about hierarchy of magnetic body becomes rather quantitative.

With the discovery how non-episodal/declarative long term memories could be realized, came the realization that the scaling law could also relate the sizes of magnetic loops involved with positive frequency MEs propagating with subluminal effective phase velocity v along magnetic flux tubes and negative frequency MEs propagating with light velocity along much larger flux loops. Quite generally, it would seem that it is magnetic structures associated with positive and negative energy MEs, whose sizes are related by the scaling law.

The input from the work of Cyril Smith [62] led to a variant of the scaling law stating the existence of imprinted frequency pairs (f_h, f_l) such that the presence of f_h implicates the presence of f_l and vice versa and satisfying $f_h/f_l \simeq 2 \times 10^{11}$. In chapters [K5] and [K6] the explanation of this scaling law and its relationship to the scaling law considered here is discussed.

7.1 Scaling law for the qualia about brain structure of given size scale

The classical fields associated with MEs are expected to code information about the contents of conscious experience at various levels of self hierarchy. EEG represents one level in this hierarchy. This coding is crucial for the realization of declarative memory as classical communications from the geometric past. p-Adic length scale hypothesis to estimate how wide the range of frequencies

responsible for coding information about conscious experience at given level of self hierarchy is. The model makes a prediction for the number of EEG harmonics representing information about conscious experience at a given level of self hierarchy, and suggests a general law telling what transition frequencies correlate with experiences conscious-to-us.

7.1.1 Relationship between self size and EEG frequency

Scaling law in its basic form reads as

$$\begin{aligned} v &= \lambda f \ , \\ L &= \lambda \ . \end{aligned} \tag{2}$$

Here v denotes the effective phase velocity associated with the EEG wave, λ corresponding wavelength, and f EEG frequency. L denotes the size of the sub-self and is assumed to be multiple of the effective wavelength associated with the EEG wave. The sub-self in question can give rise to a sensory mental image at the level of primary sensory organs or to a symbolic or cognitive representation at the level of brain.

In TGD Universe effective EEG phase velocities correspond basically to the effective phase velocity for MEs drifting along the relevant brain structure or a closed magnetic loop. The sub-luminal phase velocity results because positive energy ME tends to hop towards geometric future in quantum jump with some average rate while the space-time sheet representing environment is stationary. This velocity can be super-luminal for negative energy MEs if they dissipate since dissipation in this case would mean gradual shifting of ME backwards in the geometric time. Whether the dissipation really occurs significantly is not at all clear. If the frequency of the negative energy ME corresponds to an energy above thermal energies, the probability that negative energy can be absorbed is very low. This makes negative energy MEs ideal for generating time-like quantum entanglement, which is the prequisite for the sharing of mental images. This process is the key element of long term memory, and even of the ordinary sensory experience and motor activity.

TGD based model for nerve pulse and EEG relates effective EEG phase velocities to the effective phase velocities of Z^0 MEs moving along axon and generating the nerve pulse and also cell membrane oscillations [M2]. The dropping of ions to the magnetic flux tubes of the Earth's magnetic field during the process generates positive energy EEG MEs propagating along magnetic flux tubes of the personal magnetic body with sub-luminal phase velocity and representing in their modulation pattern information about the contents of sensory experience presumably crucial for declarative long term memories.

It is quite possible that nerve pulse sequences are accompanied also by propagating soliton sequences associated with the cell interior-exterior Josephson junctions. What has however become clear that the soliton sequences very probably do not control the generation of nerve pulse sequences although they

might be otherwise important. The velocity of the soliton sequence can be either $v < c$ or $v = c^2/V > c$, $V < c$ and this suggests that these velocities correspond to two kinds of EEG waves. $v = c^2/V > c$ gives standing solitons at the limit $V \to 0$: in practice even $v = c$ gives effectively standing waves. For $v \gg c$ self sizes $L = v/f$ would be astrophysical and the original idea was that these selves correlate with transpersonal states of consciousness. It seems however that negative energy MEs very probably propagate with light velocity so that this idea does not look promising. Despite the beauty of the solitonic theory and the obvious applications solitons might have in bio-control, one must admit that their role in the neural activity remains open and poorly understood.

1. Ordinary states of consciousness and scaling law

One can argue that for the states of consciousness deriving only from ordinary sensory data by information processing in CNS, L cannot be larger than brain or body size for normal states of consciousness. The reason is that ELF self gains the sensory information from nerve circuits when it scans the relevant brain region and it does not make sense to scan regions much larger than brain size. This obviously implies $v < c$.

A stronger hypothesis making sense for ordinary states of consciousness encouraged by the empirical data [39] is that apparent phase velocity is actually equal to the conduction propagation velocity of the nerve pulses in the neural pathway involved:

$$v = v_{cond} \ . \tag{3}$$

TGD inspired model of EEG and nerve pulse predicts that conduction velocity, and hence also drift velocity for ELF MEs, equals to the effective phase velocity of Z^0 MEs [M2].

2. Transpersonal states of consciousness and scaling law

One could argue that transpersonal levels of consciousness (during sleep perhaps) provide sensory information from several brains simultaneously. Also states of transpersonal consciousness and even cosmic consciousness are difficult unless one allows self sizes much larger than brain size. That this kind of experiences might be possible is suggested by out-of-body experiences in which person sees her own body in eyes of outsider.

1. The first guess was that transpersonal states of consciousness correspond by $L = v/f$ law super-luminal effective phase velocities $v = c^2/V > c$ associated with the Lorentz boosts of time-like soliton sequences. The soliton sequences can be assigned with the possible existing Josephson junction structures connecting parallel super-conducting magnetic flux tubes. The potential differences associated with the junctions are extremely weak and correspond to the EEG frequencies via the formula $\omega = eV$.

2. The second guess is that they correspond to negative energy MEs for which EEG frequencies predict length of the order of the Earth's circumference.

Negative energy MEs are indeed natural correlates for the generation of the bound state entanglement and the generation of macrotemporal quantum coherence accompanied by experiences of "one-ness". Negative energy MEs make also possible telepathic sharing of mental images. Episodal (sensory) long term memories would involve negative energy MEs with ultra low frequency scale. The generation of negative energy MEs could also provide metabolic energy by buy now-let others pay mechanism and might explain the claims about the ability of yogis and meditators to survive with minimum nutrition.

It might be that negative energy MEs associated with semitrance mechanism (semitrance mechanism is described in chapters [N5] and [N6] and possibly also with the initiation of motor actions. Positive energy MEs would in turn be involved with long term declarative memories involving classical communication with a sub-luminal phase velocity along closed magnetic loops of size $L = v/f$. These communications could be more or less automatic and the active memory recall could only mean a decision to receive the signal. Hippocampus and amygdala are good candidates for the parts of brain responsible for generating the positive energy MEs responsible for inducing the non-episodal memories.

Memory circuits could be also indirectly responsible for the generation of long term episodal memories. It is indeed known that removal of these structures leads to a loss of, say, hallucinations induced by say LSD [55]. In [H4] the mechanism of synesthesia is discussed with the cautious conclusion that the activity in the hippocampal region indirectly induces the generation of long term episodal memories. The over-activity in the memory circuits would induce a "starvation" in certain cortical regions. In order to get metabolic energy these starving regions would apply buy now-let others pay mechanism and generate negative energy MEs inducing a time-like entanglement with the geometric past and a sharing of mental images resulting in episodal memories.

7.1.2 Maximal number of harmonics at given level of p-adic hierarchy

The general vision is that we can have experiences mediating information about several levels of the p-adic length scale hierarchy associated with body. Both primary and secondary and even higher p-adic length scales are allowed in this hierarchy. The sharing of mental images made possible by negative energy MEs and classical communications made possible by positive energy MEs are the main mechanisms involved. Classical communications involve some code translating information to the shape of the classical fields and/or vacuum currents associated with positive energy ME propagating with sub-luminal phase velocity.

To build a model one can make more detailed technical assumptions.

1. For a given p-adic length scale $L(k)$ the self sizes between $L(k)$ and $L(k_{next})$ contribute to the experiences about that level. $v = Lf$ law in turn allows to estimate for a given fundamental transition frequency f

how many harmonics contribute to the classical field of ME in question at level k. The number of harmonics determines the maximum information content of the experience generated by the classical signal carried by ME at that level.

2. For a given transition frequency and nerve pulse velocity v_{cond}, which could be for definiteness assumed to be equal to EEG phase velocity, there is some minimal p-adic prime $k(min)$ nearest to the length scale v_{cond}/f:

$$L(k_{min}) \leq \frac{v_{cond}}{f} \quad . \tag{4}$$

The minimal p-adic length scale does not in general allow maximal sensory acuity since v/f is not in general infinitely near to $L(k_{min})$.

The next k:s can however give maximal number of transition frequencies corresponding to $[k_{next} - k]/2$ octaves if the spectrum of self sizes is maximal. The frequency band for a given k is filled by starting from the frequency corresponding to the lowest possible 'bodily self' size $L(k)$, which is the largest possible frequency for that k, and proceeding to smaller frequencies corresponding to larger values of self size. This means that the hierarchy of p-adic length scales coming as octaves of the basic scale very precisely corresponds to the hierarchy of conscious experiences about various length scales. Every p-adic length scale is like music instrument producing $[k_{next} - k]/2$ octaves of musical notes.

Scaling law should apply completely generally and thus for both magnetic and Z^0 magnetic transitions as well as the transitions associated with Super Canonical Algebra. Scaling law leads to rather strong predictions when combined with the formula identifying self size as the apparent wave length associated with EEG waves.

For instance in the case of $k = 199$ characterizing the size of brain, there are 6 octaves of frequencies between $L(199)$ and next primary p-adic length scale $L(211)$. Rather interestingly, the range $1.5 - 90$ Hz of EEG frequencies spans also 6 octaves. ELF self can have also experiences about what it is to be brain hemisphere ($k = 197$): this is possible for suitably tuned drift velocity range of ELF self, in this case the maximal frequency range would be 2 octaves. Amygdala would presumably correspond to $k = 193$ and in this case three octaves of EEG frequencies are possible. One must also consider the possibility that secondary and higher p-adic length scales are involved. In this case $L_3(67) = 32$ cm corresponds the p-adic length scale next to $L(199) = 16$ cm and only

7.1.3 Communication between different levels of the self hierarchy and fractal scalings

Communication between different levels of p-adic hierarchy means mapping of various functions representing sensory information from a given level p to another level p_1. The obvious manner to realize this mapping is simply to scale

by the ratio $p_1/p = 2^{(k_1-k)/2}$. Music piece is transposed to $(k_1 - k)/2$ octaves higher. For instance, actual EEG pattern corresponding to virtual motor activity would be simply its fractally scaled version containing virtual nerve pulse pattern as a repeated command (*'Do this- do this-...'*). It is known that motor neurons indeed serve as low pass filters [25] noticing only low frequencies and this might correspond to this kind of fractality. Unconscious fine structure of motion could result from unconscious-to-us processing by this kind of fractal scaling. This kind of temporal scaling fits nicely with the paradigm of 4-dimensional brain.

Super Virasoro frequency scales $f(n_1, k_1)$ and $f(n_2, k_2)$ discussed in [K3] differ from each other by power of 2 when both n_1 and n_2 are even or odd. This means that for a given prime Super Canonical transition frequency spectrum is fractal and contains the frequency spectra associated with shorter p-adic length scales as sub-spectra and thus can generate resonantly Super Canonical transitions in shorter p-adic length scales. Similar fractality might be realized for magnetic and Z^0 magnetic frequencies. The scaling law $B \propto 1/L^2(k)$ for magnetic field strengths suggested by p-adic fractality would imply that magnetic transition frequency scale scales as $f(k) \propto 1/L^2(k)$.

7.1.4 Is there a correlation between brain size and apparent EEG phase velocity?

A natural assumption is that self sizes at level k are in the range $[L(k), L(k_{next})]$. $L(k_{next})$ can be also secondary or even higher p-adic length scale such that brain size is in the range $[L(k), L(k_{next})]$. This would give

$$\frac{v}{f} \quad \in \quad [L(k), L(k_{next})] \ . \tag{5}$$

An interesting possibility is that there is correlation between brain size and nerve pulse conduction velocity in the neural pathways contributing to consciousness:

$$\frac{v_1}{v_2} = \frac{L(k_1)}{L(k_2)} \ , \tag{6}$$

where $L(k_i)$ are the p-adic length scales associated with the brains of the organisms 1 and 2 and v_i are velocities in corresponding neural pathways. If this assumption holds true then the maximal information content of the field pattern of ME depends only weakly on the size of the brain since the frequency ranges are more or less the same. That velocity of conduction should increase with the size of organism sounds rather natural since axons get thicker.

It is possible to make definite estimates about conscious qualia for given species using information about nerve pulse velocities involved and about brain size. There is indeed some evidence for the correlation between brain size and inverse of the peak frequency of EEG [39]. For instance, it is known that in the case of dog intracranial phase velocities of alpha waves are in the range

$.3 - 1.2$ m/s [39]. These data suggests that the sizes of alpha wave selves for dog are in the range $3 - 12$ cm so that dog's alpha consciousness would correspond to $L(197) = 8$ cm, which is the length scale associated with single brain hemisphere for humans. The result supports the view that the sizes of self correlate with brain size. Large animals like whales could have in ordinary wake-up state sensory input from p-adic length scales above $L(199)$ [$L_3(67) = 32$ cm, $L_2(101) = 45$ cm, $L_2(103) = 180$ cm].

If the phase velocity of the alpha waves is same along the entire magnetic flux loops associated with the magnetic body, the values $.3 - 1.2$ m/s *resp.* 14 m/s for the phase velocities of dog *resp.* human would mean that the time span for the long term non-episodal memories would be at least by a factor 1.2/14 shorter for dogs than for humans. This would roughly conform with the dog/human life time ratio.

Consider some examples illustrating what this hypothesis predicts assuming that the velocity range $(v_l, v_u) = (3, 7)$ m/s applies to EEG waves associated with the entire brain and that the doubled velocity range $6 - 14$ m/s applies to single brain hemisphere. Table 1. helps to get overall view about the important p-adic lengths scales.

1. For $k = 199$ corresponding to entire brain the maximal self size L_m, when identified as the next p-adic scale, is $L_3(67) = 32$ cm if tertiary p-adic length scales are allowed. Otherwise L_m is $L_2(101) \simeq .45$ meters. By $v = L/f$ law the ratio $L_m/L(199)$ should be smaller than the ratio $v_u/v_d = 7/3 \simeq 2.3$. $L_2(101)/L(199) = 2\sqrt{2} \simeq 2.8$ is larger than the ratio $7/3 \simeq 2.3$ whereas $L_3(67)/L(199) = 2$ satisfies the constraint so that $k = 67$, which corresponds to rather closely to the length scale of head, is favored.

2. The EEG frequency ranges correlating with qualia conscious-to-us are predicted to be $9.4 - 21.9$ Hz for $k = 67$ and $6.7 - 15.6$ Hz for $k = 101$. The frequency range associated with $L(199)$ is $19.0 - 43.8$ Hz.

3. For $k = 197$ corresponding to brain hemisphere one has $L(k_{next}) = L(199)$ and frequency range corresponding to the velocity range $7 - 14$ m/s is $43.8 - 102$ Hz and for $L(197)$ the range is $87.6 - 204$ Hz.

k	191	193	97_2	197	199	67_3	101_2	103_2
L_p/m	.01	.02	2.8	.08	.16	.32	.45	1.8

Table 1. p-Adic length scales $L(k, n)$ possibly relevant to consciousness and life at length scales relevant to human brain and body. k characterizes p-adic prime via $p \simeq 2^k$ and $n = 1, 2, 3$ tells whether primary, secondary, or higher p-adic length scale is in question. $n > 3$ n-ary scales are assumed to be unimportant.

7.1.5 Lower bounds for "bodily" self sizes from the range of nerve pulse conduction velocities

The range for nerve pulse conduction velocities associated with EEG waves does not correspond to the entire range of nerve pulse velocities in somatosensory system ranging from .5 m/s to 120 m/s [25]. Thus our brain anatomy could allow much wider spectrum of sizes for mental images than allowed by the rather narrow range $3-14$ m/s of propagation velocities for alpha waves.

Nerve pulse conduction velocity as a function of the axon thickness obeys the approximate law [25]

$$v = kv_0 \times \frac{d}{d_0} \ , \quad v_0 = 1 \ \ m/s \ , \quad d_0 = 1 \ \ \mu m \ .$$

The value of k is about 6 for thickly myelinated axons and between 1.5 and 5 for thinly myelinated axons. The variation ranges of conduction velocities in somatosensory (!) system are in ranges $80-120$ m/s, $35-75$ m/s, $5-30$ m/s and $.5-2$ m/s for unmyelinated axons. Conduction velocity varies in rather wide range $(.5-120)\ m/s$: 'quale key' can vary in a range of almost 8 octaves. The lowering the conduction velocity of nerve pulses by reducing myelinization or thickness could make it possible for us to have qualia about length scales of brain nuclei.

It is interesting to look for the lower bound $L(min)$ of self sizes assuming that 90 Hz is upper bound for transition frequencies representing experiences possibly conscious to us. The values of L_{min} are .89 m for $80-120$ m/s range; .39 cm for $35-75$ m/s range; 5 cm for the range $5-30$ m/s and .5 mm for the range $.5-2$ m/s associated with the unmyelinated axons.

The following table gives the length scales below which electron, proton and ionic cyclotron consciousness is possible assuming that the nerve pulse velocities vary in the range described above. These ranges of nerve pulse conduction velocities are associated with somatosensory system and actual 'phase velocities' of EEG waves seem to vary in much narrower ranges.

$v/(m/s)$	$.5-2$	$5-30$	$35-75$	$80-120$
$L(1,e)/\mu m$	.8-3.2	8-48	58-125	133-200
$L(1,p)/mm$	$.27-1.0$	$2.7-5.9$	$19-41$	$44-66$
$L(1,Li_+)/cm$	$.1-.5$	$1.2-7.1$	$8.3-17.9$	$19.0-28.6$
$L(1,Ca^{++})/dm$	$.3-1.2$	$2.9-17.1$	$20-43$	$46-69$
$L(1,Co_+)/m$	$.1-5$	$1.2-7.0$	$8-17$	$18-28$

Table 2. The table gives the length scales below which electron, proton and ionic consciousness is possible assuming that the nerve pulse velocities vary in the ranges associated with somatosensory system.

From the table one finds that electronic cyclotron consciousness is possible in p-adic length scales $L(173) = 20\ \mu m$ and $L(179) = 160\ \mu m$ but not above this length scale. Also the length scale $L(169)$ might be possible. Protonic cyclotron consciousness is possible at all length scale above $k = 169$ up to $k = 193$.

7.2 Scaling law and evolution

Scaling law, when combined with general ideas about consciousness, allows to build speculative models for the evolution of consciousness at both biological and cultural level. What would be new and nontrivial would be the strong correlation between cultural and electromagnetic evolution (strictly speaking, also the evolution of Z^0 field bodies is involved). Cultural evolution could be perhaps seen as evolution of memes with memetic code playing the role of genetic code. There are good reasons to believe that the intronic portion of DNA codes for memes represented dynamically as field patterns associated with MEs [L1]. The portion of the introns in genome is indeed large for humans (99 per cent).

7.2.1 Scaling law contra biological, cultural, and spiritual evolution

One can distinguish between two kinds of developments of individual: the neural development of child in the p-adic length scales relevant to body and the electromagnetic and Z^0 development in ELF frequency range. Besides the personal magnetic bodies also the magnetic body of Earth, magnetosphere, is expected to carry sensory, cognitive and symbolic representations resulting through entanglement with various organisms. Negative energy MEs in EEG range are natural in this respect. These representations would give rise to multi-brained magnetospheric selves [N1]. The development at ELF frequency range corresponds by *ontogeny recapitulates phylogeny principle* to the evolution of civilization.

There are good reasons to believe that brain anatomy has remained more or less the same in time scales much longer than the evolution of civilization from bicamerality to modern man. This would mean that the evolution of our consciousness and civilization is basically electromagnetic rather than genetic evolution and corresponds to the evolution of EEG and ZEG during ontogeny. The evolution of magnetospheric consciousness might be a crucial factor in this development. These evolutions are not completely independent since $L = v/f$ ($v < c$) relationship correlates these developments to each other.

1. Scaling law and the relationship between cultural and biological evolution

A fascinating challenge would be to understand the detailed relationship between cultural evolution and the evolution of field body. In particular, there are many interesting questions related to the relationship between self-hierarchy and Freud's ideas. Is super ego above EEG length scales or above the body length scale? Could one regard the counterpart of Id as a species consciousness, some kind of biological superego, in length scales larger than body size but considerably below ELF length scales representing cultural aspects of consciousness? Can one speak of cultural superego? Is the time scale of the phenomenon direct measure for the p-adic length scale of the corresponding self?

It is important to notice that $v = Lf$ relationship defines mapping $k \to f(k)$ between the biological and electromagnetic length scale hierarchies such that ELF self at particular p-adic level has sensory experiences about experiences of particular self at bodily level? Very roughly this mapping would correspond to

the scaling

$$L(k) \rightarrow [\frac{c}{v} L(k)] \equiv L(f(k)) \ ,$$

where $[L]$ is shorthand for the nearest p-adic length scale below length scale L. More explicit manner to define this mapping would be as

$$k \rightarrow [k + log_2(c/v)] \ ,$$

where $[k]$ now denotes the nearest power of prime below k. If this kind of mapping is involved then the evolutions at these two widely different length scales might correspond to each other rather closely.

7.2.2 Evolution at the level central nervous system

The natural implication of the proposed picture is that the biological (as also electromagnetic) evolution of the central nervous system (CNS) proceeds from shorter to longer p-adic scales. Jump in the evolution correspond to emergence of new p-adic length scale when the size of self becomes equal to next p-adic length scale.

This vision about evolution of central nervous system can be tested immediately. Magnetic spectroscopy of consciousness predicts that there are seven levels between $k = 169$ level of neuron and brain and they correspond to the primary p-adic length scales associated with $k = 173, 179, 181, 191, 193, 197, 199$. Central nervous system indeed has 7-levelled hierarchy corresponding to spinal chord, medulla, pons, midbrain, diencephalon, brain hemisphere, brain and higher levels of this hierarchy have indeed emerged one-by-one during evolution. The eight levels of the hierarchy (perhaps it is worth to notice the amusing connection with the eight-fold way of Buddhism and the idea of Lily about eight levels of consciousness) would correspond to the next level of bio-consciousness $k = 211$ which might be already present at delta and theta frequencies.

Geometric consciousness at the level of spinal chord geometric consciousness should at least correspond to multiples of electron cyclotron frequencies. Electronic consciousness is not possible at higher levels. This picture explains why the activities of autonomous nervous system is more or less unconscious to us. Hypothalamus and thalamus and presumably also many other brain nuclei would correspond to the level $k = 193$ in the hierarchy. Their sizes are indeed above 2 cm and below 8 centimeters. Thus autonomous nervous system should correspond to lower level of the p-adic hierarchy of selves so that the contribution to our consciousness would involve several averageings. Note that protonic cyclotron consciousness is still possible at at this level but not at higher levels for typical conduction velocities of nerve pulses.

7.2.3 Scaling law and ontogeny

During the early development neural pathways myelinize gradually [39] and this means gradual increase of the conduction velocities $v = Lf$. This suggest that

various versions of quale about given p-adic length scale $L(k)$ labelled by the harmonics of the fundamental frequency emerge gradually one by one as nerve pulse propagation velocities in neural pathway increase. First pops up $n = 1$ version of quale, then $n = 3$ version, etc.. One could visualize this as drift of various versions of quale from shorter to longer p-adic length scales.

This predicts that the sensory acuity of infant increases in stepwise manner at critical values of the nerve pulse propagation velocity making possible new harmonic of EEG pattern representing particular quale. The critical values of the nerve pulse propagation velocity for secondary experiences about events at level k are given by

$$v(n) \quad = \quad nf \times L(k) \quad . \tag{7}$$

This applies also to motor expression which in TGD framework is very much like virtual sensory experiencing amplified to macroscopic motor activity by puppet-in-string mechanism. For instance, coordination and control of motor activities improves and emotional expression in speech becomes more refined.

This option is not the only one that one can imagine. Also EEG develops during the development of individual. The fact that the peak frequency of EEG moves gradually from delta band to alpha during the first ten years allows to consider the possibility that the sizes L of mental images, stay more or less constant during maturation. This requires that both that nerve pulse velocity and the harmonic of the fundamental frequency giving the dominating contribution to the quale gradually increase. An interesting possibility is that the sizes of selves correlate with body size or with the size of relevant body part during development of individual.

$$L = \frac{v}{f} = k \times L(\textit{body part}) \quad .$$

This would mean that all ions correspond to the same self size for given value of nerve pulse conduction velocity.

7.2.4 Transition from bicamerality to modern consciousness

TGD based vision about the evolution of civilization relies on *ontogeny recapitulates phylogeny principle* stating that the development of child's electromagnetic body is fractally scaled version of the development from bicamerality to modern consciousness. In particular, the hypothesis has been that this development meant the emergence of higher level emotion and cognition and of the semitrance mechanism in which collective self gave commands and advices to the bicameral.

The proposed model for the evolution of qualia concretizes this general vision considerably. The picture about what might have happened in the transition might perhaps look like follows.

1. *Semitrance mechanism*

Semitrance mechanism made possible for the collective higher level ELF self to communicate commands and advices to the bicamerals. This higher level ELF self presumably had also higher level sensory experiences about entire social group in some p-adic length scale larger than body size. $L(211) = 10$ meters and $L(223) = 640$ meters are the most obvious length scales involved. The emergence of new ELF frequencies to EEG meant also that the sensory and emotional acuity of bicameral man improved. It is not absolutely clear whether semitrance is communication of higher level selves to us or sensory experiencing of transpersonal levels of consciousness or both. The predicted lifetimes of transpersonal selves are however measured in years which suggests that they are closely involved with long term memories.

2. Development of speech

The emergence of modern man involved the development of speech faculty. This evolution must have been proceeding in two directions. We have self-narrative in rather long time scales and someone must tell it to us: this implies that ELF MEs corresponding to $k = 127_2, 2^8$, $257, 131_2, 263$, $89_3, 269, 271$, $137_2, 277, 139_2, ...$ should have emerged gradually. This could have also meant development of amplitude modulation hierarchy and increasingly complicated linguistic structures. Note that the time scale starting from .1 seconds ($k = 127_2$) and ending up to 6.1 seconds ($k = 139_2$) contains especially many primary, secondary and tertiary p-adic time scales. This also meant development of increasingly refined linguistic structures in short time scales: words decomposed to syllables and syllables to phonemes presumably identifiable as memetic codewords at $k = 127_2$ level and this made possible development of written language.

In conflict with the standard beliefs about our position in the hierarchy of consciousness, this picture suggests that to some extend both speech and internal speech are speech of higher level self. It is indeed well-known that it is almost impossible to speak fluently if one tries to control what one is saying: one must simply let it go. Also body unconscious-to-us language can be interpreted as talk of higher level self using limbic brain as instrument of expression: this would explain why we express emotional reaction before becoming conscious about the emotion.

3. Emergence of long term memory

What Jaynes believes could be translated to the statement that the transition from bicamerality to modernity involved the emergence of the long term memory and its evolution from a direct sensory memory to declarative memory [43]. Sensory memory means direct re-experiencing by the sharing of mental images made possible by time-like entanglement. Declarative memory would be based on a symbolic representation of the data, and would be communicated classically (communication would be ultra-slow!) from the geometric past as a response to the shared mental image representing the desire to remember.

A possible model for long term declarative memories is based on the generalization of the frequency representation of the memetic code. What is presumably

coded, are perhaps not details of particular experience but sequence for names of 'program modules' realizing particular kind of experience. Thus very high level coding would be in question. In this model long term memories could perhaps be represented as a modulation of the carrier frequency of 'hippocampal theta frequency' varying in the range $4 - 12$ Hz [54] by multiples of some lower ELF frequency representing higher level of self hierarchy.

The large range of variation for hippocampal frequencies suggest that they could correspond to magnetic (or Z^0 magnetic) transition frequencies of various ions (atoms) subject to homeostatic regulation. It is indeed known that the state of arousal correlates with the hippocampal frequency. The modulating level would correspond naturally to the ELF self associated with multimodal association regions which project via entorhinal cortex to hippocampus. If the tertiary time scale associated with $k = 251$ (28 Hz) corresponds to primary sensory areas, this region must correspond to $k = 131$ and frequency of .63 Hz and cycle of 1.6 seconds which sounds sensible. If this is the case, long term memories should have natural time unit of 1.6 seconds.

The motion of the peak frequency of child's EEG from delta band to alpha band during the first ten years looks paradoxal against the idea that lower frequencies correspond to higher levels of consciousness. One interpretation for the presence of low frequencies is that the child is in a semitrance state and that the presence of the low frequencies reflects control from the higher levels of self hierarchy. A second interpretation allowing to get rid of the paradox is that the carrier frequency evolves gradually from delta to alpha band while fundamental modulation frequencies stay constant. This would mean that the number of multiples fundamental frequency which can appear in the modulation increases and information storage capacity increases.

This kind of coding is not the only possibility and it is quite possible that entire fractal hierarchy of codings are involved such that single codeword at higher level corresponds to an equivalence class of codewords at lower level. For instance, hippocampal theta period could define the duration for the codeword of a lower level code realized by modulation using gamma frequencies. There is evidence for temporal coding in the sense that the relative temporal shift of the spike sequence with respect to the 'hippocampal theta frequency' codes for the position of moving rat [56]. This would mean the coding of rat's position to the overall phase of the complex Fourier components representing $n > 1$ harmonics of the memetic codeword ($n = 1$ would correspond to 'hippocampal theta frequency') and can be understood if the motion of rat is coded to periodically occurring nerve pulse patterns inducing reset of theta oscillator.

4. Schizophrenic as a modern bicameral?

Schizophrenic is regarded by Jaynes as a modern bicameral. According to Jaynes, schizophrenics seem to have amazing ability to tolerate pain and to work hardly for long times without experiencing fatigue. For instance, catatonics can stay in same bodily posture for hours. Perhaps this is due to the fact that they do not experience pain in same sense as normal persons do. Jaynes also explains by this the architectural feats of ancient civilizations impossible for modern man

using the primitive tools available for bicamerals.

Our emotions are partially generated by the feedback loop in which the lower level emotions expressed by the limbic brain are perceived by the cortical levels and amplified and in turn affect limbic brain. If this loop is not working properly (say due to the inhibited emotional expression), nociception is not accompanied by the experience of pain. If the transition to modernity meant also evolution of emotions and their expression, the emotional expression of bicamerals must have been primitive so that this loop cannot have been so effective as it is in the case of modern man. One can also consider the possibility that bicamerals spent a considerable fraction of time in semitrance in which regions of the emotional right brain were entangled with higher level selves or with large selves and were thus unconscious and unable to feel pain. The myth about exile from paradise would reflect that the newly developed ability to experience strong emotional pain.

Schizophrenics have often also unusually high sensory acuity: this is probably due to the weakened sensory censorship eliminating from sensory landscape unessential features. The fact that the attention of schizophrenic is more easily distractable is also consistent with this.

5. Child as a small bicameral?

Scaling law suggests that child is during the first years of her life more or less the modern counterpart of the bicameral man of Jaynes [43] receiving commands and advices of the higher level selves as sensory, in particular auditory hallucinations which should seen preferably in ZEG (Z^0 magnetic transitions are responsible for hearing) as suggested in the chapters [N5] and [N6]. Semitrance hypothesis is consistent with the fact that REM occur during wakefulness and sleep. REM is also found to occur few moments after an infant begins to engage in nutritional sucking. Even modern man has day dreams with the same 90-120 minute period as he has REM period during sleep. That small children comment their activities from third person view (*'Now John is going to do this'*) is consistent with semitrance hypothesis.

Delta wave dominance of EEG (see below) is indeed consistent with the hypothesis that child spends long times at transpersonal levels of consciousness seeing her body with eyes of outsider. The fact that the speech of child however lacks much of the emotional component present in the speech of adult is consistent with the idea that emotional expression develops gradually more refined when also generalized sensory experience about state of body becomes more refined. It has been indeed noticed already by Rousseau that child's speech lacks much of the emotional color involved with the speech of adults.

It is known delta band dominates during childhood and that the EEG intensity in delta band is reduced during ageing. A possible interpretation is that the attention is during childhood more directed to transpersonal levels and gradually shifts to more bodily level (perhaps for the simple reason that the unpleasant side effects of ageing require more and more attention to the state of body!). This would suggest that ageing could but need not mean spiritual degeneration. The shift to higher frequencies could mean that higher harmon-

ics of the cyclotron frequency in delta band begin to dominate. On the other hand, sensory acuity gets poorer when individual gets older. This could have purely anatomical reasons but could also involve gradual increase of the average cyclotron frequency associated with the quale so that also harmonics of low cyclotron frequencies responsible for high sensory acuity tend to disappear from EEG. Also the timing accuracy of the temporal patterns of nerve pulses could become worse during ageing. As a consequence, the frequencies of EEG waves would not be sufficiently near to the harmonics of low cyclotron frequencies anymore.

6. The role of Earth's magnetic field in the evolution of civilization?

The fundamental frequencies associated with exotic super-canonical representations are constants of Nature. As far as the proposed role of these frequencies is considered, this is very satisfying feature. Many basic frequencies associated with exotic super-canonical representations in EEG range are however very near to Schumann frequencies (inversely proportional to the circumference of Earth) and to important cyclotron frequencies proportional to Earth's magnetic field. This suggests the possibility of a resonant interaction so that the value of Earth's magnetic field could have played important role in the evolution.

During last thousand years Earth's magnetic field has reduced by a factor of one half. For instance, the cyclotron frequency of Co^{++} ion (probably closely involved with 10 Hz bio-clock in pineal gland), which is 10 Hz for present value of about $.5 \times 10^{-4}$ Tesla of Earth's magnetic field, has reduced by a factor two during this period. The considerations of the chapter [N1] raise the question whether the reduction of the magnetic field might have something to do with the exponential evolution of the civilization during this period.

7.3 Scaling law and sensory maps

The vision about sensory maps realized using magnetic canvas outside the body inspires the hypothesis about a hierarchy formed by the primary and secondary sensory organs inside brain with levels labelled by the p-adic length scales. The radius of the approximately spherical structures from which the radial magnetic flux tubes serving as magnetic canvas emanate should be roughly given by the relevant p-adic length scale L. ELF MEs define the projection of the sensory image from the (possibly secondary) sensory organ to the magnetic canvas by place-frequency coding. This requires that the thickness of the magnetic flux tube depends weakly on the distance from the projecting sensory organ. A stronger assumption is that the magnetic structure serving as a sensory canvas has the same size as EEG MEs: $L(magn) \sim L(EEG)$. Hence sensory images would be magnetic giants in TGD framework whereas in standard neuroscience they would be miniatures defined by the cortical neural activity patterns.

By scaling law the sizes $L(EEG)$ of ELF selves relate to the sizes L of brain structures: $L(EEG) = (c/v)L$. Here v is the velocity of motion of EEG ME along axon, or equivalently nerve pulse conduction velocity, and f is the EEG frequency. The consistency with the scaling law is achieved if secondary sensory

organs, which could be approximately spherical structures analogous to eyeball, have radii $L \sim v/f$ approximately given by various p-adic length scales $L = L_p$. As will be found later, the resulting sensory hierarchy correlates nicely with the brain anatomy, with the band structure of EEG and with the structure of the periodic table.

It is of interest to apply the scaling law at the level of eye. Amazingly, the sizes of the lense (about $L(191) \simeq 1$ cm) and retina (about $L(193) \simeq 2$ cm) are just at the lower bound of the p-adic length scale range allowing the EEG frequency to be in the range of cyclotron frequencies in Earth's magnetic field. For $v = 3$ m/s, which is the lower bound for the velocities of alpha waves, $f = v/L$ gives proton cyclotron frequency $f_c = 300$ Hz for lense size $L \sim 1$ cm and deuterium cyclotron frequency $f_c = 150$ Hz for retina size $L \sim 2$ cm. Note that higher harmonics cyclotron frequency are possible even if the lowest one is not and could thus allow deuteronic cyclotron consciousness. For retina $v = 6$ m/s gives proton cyclotron frequency for retina. He_4 consciousness would require $v \sim 1.5$ m/s, which is possible only for unmyelinated axons: the axons from retina are myelinated.

Thus it seems that the lowest level or perhaps even two lowest levels of visual consciousness could be possible at the level of lense and retina. The size of the pupil correlates with the state of consciousness. An interesting question is whether these two levels of retinal consciousness could correlate with the size of pupil. For instance, the velocity of nerve pulse conduction in the axons from retina could correlate with the size of the pupil. Contracted pupils might correspond to the most primitive form of retinal consciousness and dilated pupils to deuteron consciousness. The projection to the exterior world would be determined by the input from the next level of the visual hierarchy and would be directed backwards rather than to the visual field of the retina. Retinal visual selves could thus represent the lowest level of the visual self hierarchy above EEG and would be unconscious to us as also 40 Hz visual consciousness at the primary sensory areas seems to be. What is encouraging is that the size of retina fits nicely with the general vision about hierarchy of visual selves starting already at the level of the primary sensory organ.

The lowest level in the hierarchy of the sensory consciousness would correspond to electron with cyclotron frequency $f_c \simeq 6 \times 10^5$ Hz in Earth's magnetic field. The size of the the projecting organ would be about 5 micro–ns for the minimal value of $v = 3$ m/s of alpha wave velocity. This would suggest that even neurons can represent sensory input on the magnetic canvas and have senses just as we do. TGD neurons would be considerably more complex creatures than the fire-doesn't fire neurons of computationalist. This is of course what fractal self hierarchy predicts on completely general grounds. From the scaling law the size of the neuronal sensory image represented by electronic magnetic transitions would be of order 10^4 meters. A possible test for this view is whether radiation at electron's cyclotron frequency or its multiples has direct effects at neuronal level.

7.4 Does the structure of neocortex correlate with the hierarchy of p-adic frequencies?

p-adic frequencies differing by appropriate scalings by a power of square root two would correspond naturally to the brain structures and organizational hierarchy of brain and CNS. The nice aspect of this hypothesis would be universality and prediction of the cognitive codes.

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

$$L(k(bio)) \to L(k(ELF))$$

between biological length scales $L(k(bio))$ and cultural length scales $L(k(ELF))$. The mapping means that ELF self characterized by $k(ELF)$ receives sensory input from corresponding biological length scale $L(k(bio))$ and presumably has corresponding biological selves as sub-selves. This mapping is illustrated in the table below. For instance, the selves 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.

By $L = v/f$ correspondence the structures of neocortex correspond to definite 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 the fundamental frequencies correspond to gamma, beta, alpha, theta and delta bands. The table below provides a concise summary of the proposed correspondences. The length scale $L_3(83)$ corresponds to $f(1,0) = 56$ 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_2^5	251	127_2	$2^8 = 256$	257	131_2
f(k,n)/Hz	40.0	28.2	10.0	5.0	3.5	.63
sensory area	I	I	II	III	IV	V
EEG band	gamma	beta	alpha	theta	delta	delta
period	He	He	Ne	Ar	Kr	Xe

Table 4. 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 the case that it is not primary (one has $p \simeq 2^k$ by p-adic length scale hypothesis).

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