What is EEG made of?

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Abstract

A model for EEG as a communication tool of magnetic body is developed. The basic assumption is that communications from cell membrane occur by Josephson radiation inducing the analogs of cyclotron transitions: this leads to resonance conditions forcing the Josephson frequencies to be equal to cyclotron frequencies in the simplest situation. Music metaphor- in particular

the metaphor "right brain sings, left brain" talks allows to further develop the earlier model. One must generalize the original assumption concerning the allowed values of magnetic field B_{end} at flux tubes of the magnetic body: this generalization was forced already by the quantum model of hearing.

The model leads to a detailed identification of sub-bands of EEG in terms of cyclotron frequencies assignable to bosonic ions. One can understand the basic features of various EEG bands, why conscious experiences possible occurring during sleep are not remembered and the four stages of sleep, why beta amplitudes are low and tend to be chaotic, the origin of resonance frequencies of EEG. Also a model for how Schumann resonances could affect consciousness emerges.

Music metaphor allows to develop in more detail the earlier proposal that nerve pulse patterns defined a languages with "phonemes" having duration of .1 seconds and obeying genetic code with 6 bits. Also the right brain signs metaphor can be given a detailed quantitative content in terms of the analog of music scale associated with the resting potential.

1 Introduction

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 evoked potentials, noise, and possible other contributions are subtracted.

In the following TGD inspired model for EEG as a communication and control tool of magnetic body is developed.

1. Sensory data are communicated from cell membrane to magnetic body as Josephson radiation and induced transitions at harmonics of cyclotron frequencies determined by the mass number A and charge Z of ion in question (also electron and proton are included) plus the local strength of the magnetic field B_{end} having nominal value $B_{end} = .2$ Gauss in the simplest situation.

   Communications take place at resonance so that one has $f_J = ZeV/h_{eff} = f_c = ZeB_{end}/2_p$, $h_{eff} = 2^k \times A \times h$, where A is the atomic weight of the ion for the fundamental frequencies a more general resonance condition for harmonics reads as $mf_J = nf_c$. This condition is a new ingredient to the earlier model and is extremely restrictive - especially so if one assumes only bosonic ions forming Bose-Einstein condensates. Also electron and proton are needed to represent frequencies which are of order kHz or higher: this is true for hearing for which frequency range to be represented varies up 20 kHz.

2. Information is coded in frequency modulations of Josephson frequency induced by neural activity and feedback from the magnetic body coming via DNA at harmonics of cyclotron frequencies. Frequency modulations have emotional content in music, which suggests that the "sensory experiences" of magnetic body defined by the Josephson radiation have emotional content dictated by the frequency modulation.

   Also the variations of resting potential induces frequency modulations and the quantum model for hearing suggests that the variations of the voltage could define analog of music scale consisting of discrete spectrum of resting potentials corresponding to cyclotron frequencies of ions belonging to the octave 10-20 Hz and having frequencies $f_c \sim 10$ Hz in alpha band as basic frequency.

3. Basic facts about EEG at various stages of sleep and the fact that octaves of 10 Hz frequency appear as resonance frequencies together with music metaphor suggests that EEG can be regarded as superposition of frequencies spectra very much analogous to frequency spectra associated with music scale. In particular, octaves of $h_{eff} = 2^k m$ and B_{end} suggested also by p-adic length scale hypothesis appear. In the simplest situation the EEGs associated with various ions would be time scaled versions of each other making possible "stories" as representations of same events in various time scales: this is believed to be a basic ingredient of intelligence.

4. The model leads to a detailed identification of sub-bands of EEG in terms of cyclotron frequencies assignable to bosonic ions. One can understand the basic features of various EEG bands, why conscious experiences possible occurring during sleep are not remembered and the four stages of

sleep, why beta amplitudes are low and tend to be chaotic, the origin of resonance frequencies of EEG. Also a model for how Schumann resonances could affect consciousness emerges.

Music metaphor allows to develop in more detail the earlier proposal that nerve pulse patterns defined a language with "phonemes" having duration of .1 seconds and obeying genetic code with 6 bits. Also the right brain sings metaphor can be given a detailed quantitative content in terms of the analog of music scale associated with the resting potential.

To sum up, the model gives quantitative support for the notion of magnetic body and makes several testable predictions.

2 Basic ingredients for dark hierarchy of EEGs

The dark hierarchy of Josephson junctions with fixed size characterized by a p-adic length scale most naturally assignable to a member of twin prime pair defining a fractal hierarchy of EEG like spectra assignable to various parts of organism is the basic element of the model of generalized EEG. In the following only ordinary EEG is considered.

2.1 The path to recent view

The most obvious guess is that Josephson radiation is used for communications from cell membrane to magnetic body, its absorption induces cyclotron transitions, and the feedback to genome induces cyclotron transitions at the level of DNA inducing DNA expressions. This is of course only the simplest guess: one must start somewhere.

There are indeed objections against this view but the notions of magnetic body, dark matter has hierarchy of phases with non-standard value of Planck constant, and zero energy ontology solve these problems as the construction of a model for the findings of Pollack demonstrated [**?**].

1. If one assumes that bio-photons are outcome from transformations of dark EEG photons to visible photons, one encounters a problem since the energies of bio-photons are in visible and UV range unlikes the Josephson photons from cell membrane with energy $E_J = ZeV$ in the range .1-.16 eV for $Z = 2$.

   The earlier proposal for the solution of this problem was that cell membranes can be near vacuum extremal so that classical Z^0 force gives dominating contribution to the membrane potential and increases it so that Coulombic energy has correct order of magnitude. This proposal emerged from a model for color qualia. The problem was that one had to assume for Weinberg angle a value about 1/10 from the standard model value.

2. The nominal value of metabolic quantum is about .5 eV and much larger than the Josephson energy $E_J = .1 - .16$ eV so that one cannot assume that mitochondrial membrane is battery unless there is large chemical potential or some additional contribution to single particle energy.

   In the case of proton Z^0 potential is negligible so that near vacuum extremal property does not solve the problem.

3. In the thermodynamical model of cell membrane and metabolism chemical potentials dominate over Coulomb energy.

   Zero energy ontology means that quantum theory in TGD sense is square root of thermodynamics. This leads to a modification of the thermodynamical model of cell membrane but chemical potential replaced with cyclotron energy of dark matter particle at magnetic flux tube. Also in the thermodynamical model the chemical potential would be replaced by cyclotron energy.

   This model gives hopes of resolving the listed problems. The model has as physical parameters bio-photon energy E_{bio} equal to energy of dark photon, $E_J = ZeV$ or equivalently membrane voltage V, and masses m_i and charges Z_i of charged particles involved, and magnetic field strengths at the portions of the magnetic flux tube at opposite sides of the cell membrane. The octaves of the endogenous magnetic field with value $B_{end} = .2$ Gauss are a good first guess for the values of B. Membrane potential is coded to the generalized Josephson frequency $f = f_{c,I} + f_{J,1}/n$ and the variations of membrane potential give rise to frequency modulation with $\Delta f/f \sim .1$ which would characterize the width of EEG bands. EEG bands correspond to cyclotron frequencies.

2.2 Josephson current

Each junction has a background voltage over it. The basic hierarchy involves the p-adic length scales $L(k)$, $k = 151, 157, 163, 167$ corresponding to Gaussian Mersennes - or to be more precise - the scaled up variants of electron Compton scale for this p-adic scales, which seem to be biologically highly relevant. This suggests the importance of p-adic and dark scales coming in powers of 2. One could consider the possibility that not only $k = 151$ but all these length scales and also twin primes define their own Josephson junctions with their own values of Josephson potential.

Thee model for Josephson current relies on the model of cell membrane inspired by the findings of Pollack.

1. The generalized Josephson current for ion labelled by i can be written as

$$\begin{aligned} J_i &\propto R_{1,i}R_{2,i}sin[\omega_i t + \frac{Z_i e\int V_1 dt)}{\hbar_{eff}}] \ , \\ \omega_i &= \omega_{c,i,1} - \omega_{c,i,2} + \omega_{J,1} - \omega_{J,2} \ , \\ \omega_{J,i,k} = \frac{Z_i e V_k}{\hbar_k}, & \quad k = 1,2 \ , \\ \omega_{c,i} &= \frac{Z_i e B_{end,i}}{m_i} \\ , R_{i,k} &= exp(\frac{nE_{c,i,k} + Z_i eV_k)}{2T}) \ , \quad E_{c,i,k} = h_{eff,i}\omega_{c,i,k} \ , \quad n_{i,k} = \frac{h_{eff,i,k}}{h} \end{aligned} \tag{2.1}$$

Here V_k, $k = 1,2$ denotes electromagnetic potential at the two sides of the membrane and $V = V_1 - V_2$ defines the resting potential. Gauge invariance demands that one can choose $V_2 = 0$ so that one has $V_1 = V$. $R_{i,k}$ denotes the square root of Boltzmann weight defined by cyclotron energy and Josephson energy. T is the physiological temperature.

2. If $n_{i,1} \neq n_{i,2}$ is allowed, the frequency of Josephson radiation is not unique: $\omega_{J,1}/n_{i,1}$ or $\omega_{J,1}/n_{i,2}$. Gauge invariance requires unique Josephson frequency and thus $n_{i,1} = n_{i,2}$ In this case the values of magnetic field B_{end} must differ at the two sides of the cell membrane in order to get radiation with energy scale in that for biophotons. Octave hypothesis for the strength of B_{end} is attractive so that difference of two octaves of $B_{end} = .2$ Gauss would determine E_{bio}.

3. If $E = \hbar_1\omega_1 - \hbar_2\omega_2$ corresponds to bio-photon energy E_{bio} in (possibly IR,) visible or UV range, then the proportionality $h_{eff,i}/h = n \propto A_i$ of h_{eff} to the mass number A_i characterizing the cyclotron frequency of the ion is natural first guess. It implies that

$$E_{bio,i} = h_{eff,i,1}f_1 - h_{eff,i,2}f_2 = h_{eff,i,1}(f_1 - f_2)$$

depends only weakly on ion (through the additive contribution coming from Josephson energy which is smaller by factor 1/50 roughly).

4. The first guess suggested by octave structure of EEG is that $B_{end,i}$ and cyclotron frequency spectrum becomes in octaves so that spectrum to the cyclotron part of bio-photon energy would come as differences of octaves in the general case. These discrete energy values would be widened to bands with width $\Delta f/f$. The basic prediction is that bio-photon spectrum should reflect rather directly EEG spectrum.

5. There are additional complicacies due to the fact that also the harmonics of ω_i are allowed and the membrane potential is time dependent. EEG spectrum becomes effectively continuous and this reflects itself also in bio-photon spectrum. The membrane potential receives also feedback contribution from magnetic body coming through DNA in the simplest model assuming that magnetic flux tubes in the interior of cell connect it with DNA nucleotides [K2].

Some general comments are in order.

1. Generalized Josephson frequency ω_i would define a kind of drum beat whereas the frequencies associated with V_1 would represent modulation of this drum beat frequency so that the outcome would be like Chopin's piano piece with tempo rubato. ω_i also defines a candidate for the time unit in which the time scale of memories and intentional action of the living system are measured.

2. The phase transitions leading to swelling or contraction of cell can be identified as phase transitions changing the value possible at both sides of the cell and implying that equilibrium concentrations of ions are changed in the manner implied by the generalization of the Boltzmann weight formulas. The modulations of Josephson frequency implied by nerve pulses occur in time scale of few milliseconds and are fast in the time scale defined by cyclotron frequencies and it is quite possible that they modulate electron cyclotron frequency rather than ionic or protonic cyclotron frequencies.

The model for nerve pulse [K7] supports strongly the view that in resting state V corresponds to a propagating soliton sequence associated with Sine-Gordon equation. As described in the section about EEG, the situation is mathematically equivalent to a linear array of gravitational penduli coupling with each other and soliton sequence corresponds to a rotation of penduli with constant phase difference between neighbors so that a propagating wave would result. The analog of EEG would be associated also with ordinary cell membranes but the smaller value of $\hbar$ would imply that the frequencies involved are higher. Non-propagating EEG would accompany neuronal soma and possible propagating EEG waves with axons.

2.3 Thermodynamical considerations

The replacement of thermodynamics by its square root required by ZEO has been already explained. The key idea is that the density matrix is replaced with its hermitian square root multiplied by unitary S-matrix. The model of cell membrane would be the first real world application of ZEO.

If cyclotron energies at the two sides of membrane are different and their energy scale is in the range of bio-photons energies or if the membrane is almost vacuum extremal, generalized Josephson energy for ions corresponds to that for a visible or UV photon so that the Josephson photons are well above the thermal energy. The identification of EEG and bio-photons as decay products of large $\hbar$ Josephson photons is possible. If the cyclotron energies are different then the generalized Josephson energy is above thermal energy always and Josephson frequency represents only 10 per cent modulation.

Josephson energy should be above thermal energy at physiological temperatures if one allows also the situation in which cyclotron energies are same at the two sides of the cell membrane. The conservative option is that the cell membrane is far from vacuum extremal phase with very small Z^0 field. From the resting potential whose nominal value is often taken to be for .08 V, f_J corresponds roughly to the energy .16 eV whereas the energies allowed by thermal stability must be larger than the energy corresponding to the maximum of black-body radiation intensity distribution as function of frequency and given by $E \simeq 3T_{phys} \simeq .93$ eV at $T_{phys} = 37$ C.

Nerve pulse is generated when the potential drops to about .055 eV: the corresponding Josephson energy for far from vacuum extremal Josephson junction is .11 eV, which is slightly above thermal energy .093 eV so that it seems that metabolic costs are minimized. The energy $E = .1$ eV is the universal transition energy of Cooper pairs of high T_c electronic super conductor [K1].

The generation of nerve pulse should involve h_{eff} changing transitions at either or both sides of the membrane forcing the equilibrium concentrations to change. They might also accompany the transition of the cell from a resting state to active state, which involves folding of the parts of straight unfolded parts of proteins and partial melting of globular proteins due to the melting of ordered water surrounding them.

For organisms possessing no nervous systems, in particular bacteria, this constraint is not relevant.

ZEO thermodynamics should explain why the temperature of brain must be in the narrow range 36-37 C to guarantee optimal functionality of the organism- one of the fundamental mysteries related to living matter.

1. Quantum criticality in some form is expected to be involved. Phase transitions changing the value of Planck constant at the flux tube portions at two sides of cell membrane must be possible. This would induce flows of ions through membrane and swelling and contraction of the cell which are basic phenomena at cell length scale. Phase transitions changing the length of flux tubes would be also involved with bio-catalysis. The possibility of wide spectrum of length scales is indeed key property of critical system. Temperature appears as a parameter in single particle wave functions in ZEO so that there are good changes to understand the thermodynamical aspects of the criticality at the level of first principles.

2. That the ordinary Josephson frequency is very just above the thermal energy should relate to the quantum criticality. If the temperature has too low, the value of h_{eff} is fixed to single value and bio-control - for instance that needed in basic bio-reactions - does not work. Hence h_{eff} changing phase transitions must be possible, and this requires high enough temperature. The temperature cannot be however too high since Josephson energy should be above thermal energy even in the case that cyclotron energies at two sides of the cell membrane are same. Thus biolocical activity and communications to magnetic body are competing factors and lead to a critical range of temperatures.

3. One could say that above critical temperature magnetic body becomes partially blind because communications with ordinary Josephson frequency are not present. Below the critical temperature the biological body becomes lame.

2.4 Classification of cyclotron frequencies

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

1. Cyclotron frequencies can be classified according to whether they are associated with atomic or 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 rather near 1 Hz irrespective of the length of DNA because the charge is 2 negative charge units per nucleotide.

   Thermal stability condition suggest a lower bound of ~ 1 Hz for significant frequencies of this kind. Thus one can ask whether delta band dominating during deep sleep could correspond to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions. For $B_{end} = .2$ Gauss this would require that DNA strands are at magnetic flux tubes and by previous argument at rather large distance from Earth. Interestingly, the large negative charge of DNA makes possible for it to levitate in the Earth's electric field of $E_2 \sim 100$ V/m at the surface of Earth up to heights about 30-50 km and $r \simeq 1.3R_E$. At higher heights this field becomes small or reverses sign.

   O^{2-} is bosonic ion and of special interest because cyclotron frequency is about 37 Hz and near to the thalamo-cortical resonance frequency. O^{2-} also associated with bio-photon emissions so that a connection with EEG is suggestive.

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 (see Appendix). Situation is essentially the same for biologically interesting ions. $^7Li^+$ is exception and corresponds to 42.9 Hz. Thus the frequency range $7.5 - 15$ Hz is very strongly represented and expected to be fundamental.

3. The integer n characterizing the harmonics of the cyclotron frequency is an additional classificational criterion and n could correlate with the character of neural processing. The harmonics of Josephson frequency are present in Josephson radiation and and induce resonant cyclotron transitions with arbitrary high values of n if the ratio of Josephson frequency and cyclotron frequency is rational number. Note that the sensory representations at magnetic body are generated only at at critical values of the membrane potential. In case of hearing the values of n would characterize the harmonics of the fundamental and determine the character of the pitch.

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

What about electron? The mass ratio m_p/m_e is roughly 2^{-11} so that the cyclotron frequency is by factor about 2^{11}higher. Thus proton and various ions correspond to $h_{eff} = 2^{k+11}A$ and electron to $h_{eff} = 2^k$. This would give some motivation for the original quite too strong hypothesis that the values of h_{eff} come as powers of 2^{11}.

2.5 Basic contributions to EEG

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

There are three contributions to EEG besides the contributions due to the neural noise and evoked potentials. These contributions correspond to Schumann frequencies, cyclotron frequencies f_c of biologically important ions and Josephson frequencies f_J.

1. Schumann resonances do not depend on magnetic field strengths assignable with the magnetic flux sheets and would characterize Earth's magnetic field and collective aspects of consciousness. According to the model for sensory receptor and magnetic body [K3, K6] the inner rotating part of the Earth's magnetosphere could correspond to the third person aspect of sensory perception whereas the personal magnetic body would be anchored to body and move with it. Both inner and outer magnetosphere (which does not rotate with Earth) could receive sensory input from biosphere.

2. Cyclotron frequencies correspond to magnetic field $B_{end} = .2$ Gauss for the ordinary value of Planck constant and its $1/\hbar$ scaled down counterparts. The extremals are assumed to be far from vacuum extremals carrying very small classical Z^0 fields but non-vanishing classical W fields and color fields (with $U(1)$ holonomy). The corresponding flux quanta would naturally correspond to flux sheets traversing through DNA strands.

3. Josephson frequencies f_J are associated with Josephson junctions assigned with transmembrane proteins. Far from vacuum extremals are assumed. Generalized Josephson frequency is given by $f_i = \Delta f_c + f_{J,1}/n$.

   (a) Bio-photons and EEG can be seen as manifestations of one and same thing: generalized Josephson radiation with a large value of Planck constant with energies of bio-photons and frequencies of EEG. Ordinary EEG photons result when dark visible photon decays into a bunch of ordinary ELF photons and bio-photons result when dark photon transforms to ordinary visible photon. Generalized Josephson radiation would propagate along flux tubes parallel to the cell membrane.

   (b) Generalized Josephson frequencies can be said to code for qualia if the generalized Josephson radiation is guided along magnetic flux tubes to a part of magnetic body specific to a given sensory receptor (or even neuron or cell in the case of cell level qualia). According to the model of sensory receptor [K3, K6] they do not however directly induce the sensory quale, which would be characterized by the net quantum numbers of quark pair (or two of them depending on the model).

   Generalized Josephson radiation can also regenerate the sensory quale along neural pathway. Therefore the original vision about spectroscopy of consciousness is realized in a limited sense. This implies that the precise value of the membrane resting potential could characterize both the parts of the organism and state of consciousness in the case of cortical neurons (say alertness) since depending on the value of membrane potential the neuron is in wake-up state or "sleeps". The value of the membrane potential would also directly correlate with the analog of EEG assignable to the body part. The fact that neuron types correspond to different membrane potentials conforms with this picture and suggest that they also correspond to different magnetic bodies with different field strengths.

4. Far from biological body one expects both kinds of flux quanta to fuse to form larger quanta so that one has parallel space-time sheets carrying cyclotron *resp.* generalized Josephson radiation, whose frequencies are rather near to each other so that flux tube with varying value of B can serve as receiver of the entire spectrum of Josephson radiation for a given ion. Wormhole contacts between Josephson and cyclotron flux sheets would induce a non-linear interaction giving rise to a superposition of harmonics of Josephson and cyclotron frequencies.

How these two kinds of radiations relate to the communication between magnetic and biological body and to the control of biological body by magnetic body is not quite clear.

1. One of the basic functions of the cell membrane is to monitor 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. Josephson frequencies would code various fundamental qualia assignable to DNA nucleotide-lipid pairs so that a sensory map defined by the cell membrane would be communicated to the magnetic body.

2. A good guess is that cyclotron frequencies are assignable to the magnetic flux sheets going through DNA strands responsible for quantum control via gene expression. This guess might be too naive. Josephson radiation would induce transitions between cyclotron states and generate in this manner sensory representations at magnetic body so that both frequencies would be involved with sensory representations. Furthermore, the identification of motor action as a time reversal of sensory perception allowed by zero energy ontology would mean that the mechanisms of sensory perception are at work for negative energies (phase conjugate radiation). Resonance is achieved if the condition $mf_J = nf_c$ is satisfied. For small values of integers m and n the condition is quite restrictive. Schumann frequencies can be assigned with the magnetic body of Earth and would correlate with the collective aspects of consciousness.

3. The model of hearing forces to assume quite a wide spectrum of Planck constants- at least the values coming as powers of two and the safest assumption is that at least integer multiples of the ordinary Planck constant are possible. Josephson radiation and cyclotron radiation have same scale if $B_{end} \propto 1/\hbar$ proportionality holds true. Note that for 10 Hz cyclotron frequency the estimate for $\hbar$ in the case of 2 eV dark photon is $r \simeq 3 \times 2^{46}$.

Far from critical vacuum extremals allow also classical W fields and gluon fields and they might be relevant for the quantum control via DNA flux sheets.

1. In the length scales below the weak length scale L_w also charged dark weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a non-local charge transfer. For instance, for $\hbar \sim 2^{89}$ W bosons behave like massless particles below the length scale 10^{-4} m and classical W fields and the exchange of W bosons might make possible charge entanglement. The hypothesis that Mersenne primes and Gaussian Mersennes correspond to a hierarchy of exotic weak physics leads to a highly unique vision for how life has evolved. In this model weak interactions play a key role in even macroscopic length scales.

2. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei could 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 non-local quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control. Long range charge entanglement could be understood also in terms of classical W fields. Same applies to color entanglement which could be crucial element of topological quantum computation.

3. Massless extremals (MEs, topological light rays)- or actually pairs of them- serve as classical correlates for bosons which are identified as wormhole contacts connecting MEs. 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 non-local 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.

3 The simplest model for the correspondence between generalized Josephson frequencies and cyclotron frequencies

The vision is that generalized Josephson radiation is received resonantly at the magnetic flux tubes of the magnetic body and induces a phase transition like emission of cyclotron radiation defining the response of the magnetic body communicated to DNA and possibly activating DNA expression and topological quantum computation like activities in DNA-membrane system [K2, K8]. A natural requirement is that membrane potential coding for the neural events and coded to generalized Josephson frequency is in turn coded to a position coordinate at flux tube by the resonance condition. The thickness and thus the local magnetic field at the flux tube must be varying in order that position coding is obtained.

3.1 Resonance condition equates generalized Josephson frequency with cyclotron frequency

The challenge is to understand the correspondence between Josephson and cyclotron frequencies and the what happens in the absorption of generalized Josephson radiation and how the response of magnetic body is generated. The following discussion represents a dramatic simplification of the earlier model.

1. The simplest coding would correlate $h_{eff}/h = n$ and the mass number A of ion: $n \propto A$ so that carrier frequency for Josephson radiation would correspond to cyclotron frequency. One could have $n = 2^k A$ and generalized Josephson frequency would correspond to cyclotron frequency through resonance condition at magnetic flux tube carrying particular ion and corresponding to a particular value of $h_{eff} \propto A$. Since Josephson contribution is small the two frequencies are near to each other with difference being of order 10 per cent.

2. The sub-band structure of EEG would naturally correlate with the cyclotron frequencies assignable to the biologically important ions. Bands with width about $\Delta f/f \sim .1$ would itself could correspond to the variation from the nominal value $B_{end} \simeq .2$ Gauss along flux tube. Proton would define the frequency scale with $f_c(p) = 300$ Hz and ion with charge Z and mass number A would have cyclotron frequency $f_c = Zf_c(p)/A$.

3. The atomic weight A has rather small number of values for biologically important ions if only bosonic ions are assumed (Bose-Einstein condensate). If also Cooper pairs are allowed, or if one accepts the suggestion of TGD inspired nuclear physics that exotic bosonic nuclei with mass of fermionic nuclei exist [K5], the situation changes. Many nucleon states in large h_{eff} phase can also allow pseudo Bose-Einstein condensates since anti-symmetrization in discrete degrees of freedom corresponding to sheets of multi-sheeted covering allows Bose-Einstein condensation like process in translational degrees of freedom. The anti-symmetrization gives also rise to negentropic entanglement [K4].

4. The magnetic field along flux tube could vary in range which is 10 percent of its mean value. The nominal values are $B_{end} = .2$ Gauss and its octaves. The variation along flux tube length would gives rise to a map of Josephson frequency - and thus membrane potential - to the flux tube coordinate. The variation of V would correspond to back and forth motion of "sensation" along the flux tube. Evoked potentials and neural noise would modulate the frequency and would be coded to this motion.

5. Resonance loop magnetic body-biological body requires that the motor response of the magnetic flux tube communicated to DNA has the same frequency spectrum as sensory input and thus correspond to a radiation at frequencies which correspond to differences of octaves of B_{end}. This can be achieved in several manners.

(a) The change of B by octave at flux tube traversing cell membrane could be translated to phase transition changing the thickness of flux tube and thus the value of B. Generalized Josephson radiation could induce phase transitions reducing h_{eff} by a power of 2. If p-adic prime increases by the same power, do not change the length of flux tube but changes the value of B_{end} temporarily by flux conservation since the thickness of the flux tube changes. This would induce coherent emission of radiation at frequency very near to a multiple of cyclotron frequency and induce a response at DNA level if flux sheets traverse DNA strands. This response would induce genetic expression and possibly further transfer of cyclotron transition to Josephson junction so that a resonant feedback would result. Also topological quantum computation like activities might be induced.

(b) The magnetic field at the receiving portion of the magnetic flux tube receiving generalized Josephson radiation could have a value that corresponds to the difference of magnetic fields at the flux tube traversing cell membrane.

At the level of magnetic body the generalized Josephson radiation induces cyclotron phase transitions and in this manner communicate generalized sensory input to the magnetic body.

1. Chopin's piano pieces are highly emotional and half-jokingly one can ask whether tempo rubato due to the frequency modulation could code for the emotional content of the neural input. As a matter of fact, I have proposed that emotions correspond to the sensory experiences of the magnetic body. Frequency coding would provide the representation the information carried by nerve pulses and possible perturbations at cyclotron frequencies arriving from the magnetic body adding to the basic frequency.

2. The coherent photon state generated by J defines representation of evoked potentials V_1 as a generalized EEG interacting resonantly with magnetic body and providing feed back at harmonics of cyclotron frequency. This would create resonant feedback loops via DNA giving rise to biological representations as dark cyclotron photons interact with the living matter.

3. The scaling $h_{eff} \to n$ scales the time dependences of the Josephson current and Josephson radiation: $t \to t/n$. One obtains scaled variants of representations of the neural dynamics communicated to magnetic body. Different "stories" in various time scales is regarded as an essential element of intelligence and I have indeed proposed that they correspond to different values of h_{eff}. Different dark ions would correspond to these scaled variants of the representation.

To sum up, the model would realize the original idea about spectroscopy of consciousness rather concretely. The assumption that B_{end} has only the bands around preferred values differening by octaves is of course vulnerable to criticism. The model for hearing indeed suggests that instead of only octaves something analogous to music scale is needed. This well be discussed in more detail below. The role of fermionic ions remains open but there are slight indications that Na^+ might be importance for beta band.

3.2 Satellites

The input from cell membrane to the magnetic body can have two effects.

1. It can induce ordinary cyclotron transitions generating cyclotron radiation propagating from the magnetic body to genome to cell membrane as a small perturbation. This feedback could be called perturbative.

2. The input can also induce phase transitions by scaling the value of B_{end} by power of 2 (the simplest assumption) for the entire flux tube from the magnetic body to genome to cell membrane. This would give rise to a biological response as the ionic equilibrium concentrations change in accordance with the model based on "square root of thermodynamics" suggested by ZEO. Nerve pulse might be one such a response.

The perturbative feedback from the magnetic body to the DNA and from DNA to cell membrane would be present in two manners.

1. The feedback could affect the magnetic fields at flux tubes. Besides small oscillations also phase transitions This feedback could serve as basic control mechanism.

2. Feedback could affect also $V_1(t)$ besides the neural input such as evoked frequencies and give rise to additional frequencies satisfying the resonance condition. Nerve pulses generating motor actions could be one form of this feedback.

The general form of the perturbative feedback is easy to deduce.

1. Generalized Josephson current generating generalized Josephson radiation is trigonometric function of its argument of form $\int \omega(t)dt = \omega_0 t + \int \Delta\omega(t)dt$. $\Delta omega(t)$ contains a contribution coming from the modification of magnetic fields at both sides of the cell membrane and from $V_1(t)$.

2. If the amplitude of the feedback is small, it makes sense to develop the generalized Josephson current - essentially sine of its argument $\int \omega_0 t + \int \Delta\omega(t)dt$ - by using trigonometric formulas first and then expressing the trigonometric functions of $\int \Delta\omega(t)dt$ as Taylor series.

3. If $\Delta\omega(t)$ is superposition of trigonometric functions, this gives rise to series of higher harmonics involving integer combinations of generalized Josephson frequencies associated with various charged particles.

4. The simplest - perhaps un-necessary restrictive - possibility is that the feedback uses same frequencies as sensory input to magnetic flux tubes: this poses conditions on the allowed phase transitions inducing a change of B at the magnetic body. In this case only linear combinations of the basic frequencies ω_i with integer coefficients appear.

5. A sinusoidally varying perturbation would contribute to the generalized Josephson radiation frequencies of form

$$\sum_i n_i f_i \ ,$$

   and give rise to what might be called satellites in EEG. These can contribute to conscious experience at magnetic body if the linear combination of the frequencies is cyclotron frequency. For instance, 5 Hz theta frequency could result as $f_c(Ca^{++}) - f_c(Co^{2+})$.

6. Simplest satellites are of form $f_i \pm f_j$ and thus appear as mirror pairs. In 10 per cent accuracy these frequencies are cyclotron frequencies and the first guess is that only bosonic ions contribute. 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 [J4] . 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 [J4] . All these frequencies are expressible in the form $f_c \pm f$, $f = 5$ Hz. $f = 5$ Hz would correspond to cyclotron frequency in alpha band during first stage sleep if the transition $B_{end} \rightarrow B_{end}/2$ occurs during this stage of sleep. Of course, several octavess of B_{end} are in principle possible during wake-up state too.

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 f_J and B_{end} 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 and emerging as the basic prediction of the zero energy ontology appears. It should be also noticed that $f_J = 5$ Hz frequency corresponds to cognitive theta appearing during tasks requiring mathematical skills. Note that the scaling of ordinary value of h_{eff} by a factor of 2 scales 10 Hz frequency to 5 Hz.

3.3 Harmonics

As a special case about satellites one obtains harmonics $f = nf_i$ and these can induce both ordinary cyclotron transitions.

1. 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.

2. Fifth harmonics of alpha band would are 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.

3. The fourth harmonic of 40 Hz thalamo-cortical 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) respectively.

   As will be discussed, a more natural interpretation for thalamo-cortical resonance frequency and also the observed 20 Hz and 80 Hz resonance frequencies is in terms of p-adically scaled values of both h_{eff} and B_{end}.

4 Music metaphor

I have proposed music metaphor as a useful heuristic guideline in attempts to understand brain functioning and music metaphor can be also used in attempts to understand EEG.

4.1 Right brain sings, left brain talks

I have proposed that right brain sings and left brain talks metaphor could apply quite generally to the frequency modulated communications to the magnetic body. That it could distinguish between hemispheres is also an interesting hypothesis to study.

4.1.1 Right brain sings

Right brain sings would in the first approximation (forgetting glissandos!) mean that Josephson frequency and thus membrane potential is a piecewise constant function of time.

1. "Singing" would represent a special case of frequency modulation for Josephson radiation and would require that various perturbations from neural activity and from feedback from magnetic body are small corrections possibly contributing to the emotional content of the signal (vibrato).

2. The metaphor would suggest that generalized Josephson frequencies have a set of discrete values analogous to the notes of the music scale which naturally spans one octave. This would reflect in the spectrum of bio-photons.

3. The variation range for the resting potential V is not a full octave so that the model involving only resting potential does not allow to realize the scale. The addition of the dominating cyclotron contribution saves the situation, and - just as in the case of hearing [K6] - the realization of scale in terms of the values of B_{end} becomes possible.

4. The resonance condition for cell membrane-magnetic body system requires that B_{end} has a spectrum of discrete values analogous to notes of the scale. If one takes 10 percent rule seriously and requires that the "note bands" do not overlap, one obtains $f_{n+1} = f_n + k_f n$, $k = .1$, giving $f_n = (1+k)^{n-1} f_0$. $f_{n_{max}}/f_0 = 2$ gives that the number of "notes" is 7.3 suggesting that 8-note scale could relate directly to the spectrum of generalized cyclotron frequencies.

5. If this picture is correct, the existence of minor and major scales means that emotional content of major and minor scales could reduce to that for the membrane potential scales so that the spectrum of B_{end} would code for the emotional content of the scale.

4.1.2 Left brain talks

Left brain talks metaphor suggests that there is in some sense discrete carrier frequency which is frequency modulated in such a manner that the outcome is analogs for the phonemes of language.

1. Binary code for phonemes is suggestive and I have considered the possibility that genetic code might define the six bits of code words represented as phonemes with duration of about .1 seconds corresponding to the fundamental time scale identifiable as secondary p-adic time scale of electron in zero energy ontology. The occurrence/non-occurrence of nerve pulse having duration somewhat longer than millisecond is an obvious candidate for defining the values of the bit.

2. The coding of nerve pulse patterns to cyclotron frequencies suggest that the carrier frequency f_J is higher than kHz. This requires reduction of h_{eff} by a suitable power 2^{-k} and scaling of B_{end} by 2^k. Also flux tubes contain cyclotron condensate of electric Cooper pairs with cyclotron frequency of order 5.6×10^5 Hz suggest themselves.

3. "No nerve pulse" situation would correspond to a situation in which generalized Josephson radiation with frequency f is generated and magnetic flux tube detects it: continual "beee...p" would characterize the "sensation" at the flux tube would definite bit "0". As the nerve pulse passes by the frequency of beep changes about .1 for a time of order millisecond and returns to a value differing slightly from the original value due to hyperpolarization increasing the value of the resting potential. Thus bit "1" would have just the obvious representation.

4. This form of proposal does not assume any time discretization as the earlier proposals and the code would thus be very flexible. The duration of phoneme would be however about .1 seconds. The capacity to code six bits would require allow 1.5 ms minimal duration for nerve pulse. If the duration of "beep" does not matter at all then only the number of pulses during .1 second interval matters, and one obtains the familiar rate coding and 6 bit reduce to 7 possible values for the number of nerve pulses. This cannot represent all phonemes of spoken language.

   The situation changes if there is background oscillation of the f with period of order nerve pulse duration of order .1/64 seconds $\simeq$ 1.6 ms. In this case it is possible to tell whether given period contains beep or nerve pulse. This would give rise to 6 binary digits able to code for 64 analogs of phonemes and one can consider also the analog of genetic code giving rise to redundancy. This kind of redundancy might be necessary since it can happe that given nerve pulse is present during two subsequent periods.

If this picture is on correct track, language would appear already at the level of communications to magnetic body and spoken and written languages would represent only its "externalizations". The first basic difference between speech and singing (and left and right brain) could be due to the fact that speech uses electronic Cooper pair condensates whereas singing uses ionic B-E condensates. Speech would also involve nerve pulse time scale in an essential manner an carry information about phase transitions changing the value of B_{end}.

4.2 Could the analogs of music scales appear in the communications to the magnetic body

The basic questions concern the allowed values of magnetic field B_{end} and the values of membrane voltage defining the scale of generalized Josephson frequencies.

Consider first hints concerning the spectrum of B_{end}.

1. Position coding suggests a band of about $\Delta B_{end}/B_{end} \simeq 10$ percent related to the position coding. This range would correspond to the frequency variation coming from the additive contributions to the resting potential from neural activity and magnetic body.

2. The model for the various stages of sleep relying on p-adic length scale hypothesis suggest that the scale of B_{end} comes as at least three powers 2^{-k}, $k = 1, 2, 3$ corresponding to alpha, theta, and delta bands. $h_{eff}/h = 2^k n$ would come as three powers in the same manner. It is also known that the frequencies 20, 40, and 80 Hz are resonance frequencies of EEG. 80 Hz is also resonance frequency in ERG.

3. This suggests that at least 6 octaves are involved. The next two powers of two correspond to 160 Hz and 320 Hz quite near to proton's cyclotron frequency 300 Hz for the nominal value of B_{end}.

These observations suggest that music metaphor is realized in rather concrete form. EEG would decompose to octaves just as music scale does. Each ion would define with its own scale scale and thus serve as an analog of instrument (note that the energy spectra of dark photons could be nearly identical for ions) corresponding a spectrum of values of B_{end}. The fundamental octave would correspond to scale with fundamental defined by $B_{end} = .2$ Gauss. In particular, 10-20 Hz interval would be associated with alpha band as the basic octave.

The attempt to identify different notes of the scale in terms of different bosonic ions does not look like an attractive idea. The region 10-20 Hz contains only 4 bosonic cyclotron frequencies: that of corresponding to Co, Fe, Mn in alpha band and Ca at 15 Hz and they need not correspond to notes of the same scale but fundamental frequencies of different keys. EEG could represents same piece in different keys labelled by bosonic ions. If this is the case, one could disentangle information from EEG by separating these contributions from each other by using the fact that they correspond to same function of time but with differently scaled argument.

5 An attempt to understand EEG in terms of the resonance model

In the following an attempt to understand the basic structure of EEG (`http://en.wikipedia.org/wiki/EEG`) and its relationship to state of consciousness is made.

5.1 Basic tests

The identification of EEG bands in terms of cyclotron frequencies identified as generalized Josephson frequencies is quite powerful prediction and deserves sensibility check.

1. The value of the endogenous magnetic field is $B_{end} = .2$ Gauss is 2/5:th of the nominal value of the Earth's magnetic field. B_{end} could be assigned to the magnetic field at flux tubes going through cell membrane (note however that also other values perhaps realizing the analogy of music scale with octaves is suggested by above considerations). The value of B at magnetic body, whose flux tubes would presumably be transversal to those connecting cell DNA and cell membrane, would be slightly different since Josephson frequency does not contribute to cyclotron frequency and have relative variation $\Delta B/B \simeq .1$.

   (a) If the variation $\Delta B/B$ corresponds to the variation of the Earth's magnetic field B_E scaling roughly like $(R_E/r)^3$ with the distance from the Earth's center, one would have $\Delta R/R_E \simeq .033$. This corresponds to $\Delta R \simeq 210.5$ km. Note that the F-layer of ionosphere - its densest layer - begins at about 200 km.

   (b) It could also be that B corresponds to the magnetic field of Earth. For Earth's magnetic field the distance at which its magnitude is about $2/5B_E$, $B_E = .5$ Gauss, would be roughly $r = 1.4R_E$. B_E defines the cyclotron frequencies of various ions and resonance condition must hold true for the resonant absorption of generalized Josephson radiation. The value of B_E should vary in some limits at flux tubes in order to achieve coding of generalized Josephson frequency by distance along flux tube: this gives rise to the EEG band.

2. If one assumes that only bosonic ions are relevant then for $B_{end} = .2$ Gauss, the values of relevant ionic cyclotron frequencies would be $f_c/Hz \in \{50, 27.4, 37.4, 25.0, 15.0, 11.4, 10.8, 9.5, 7.6\}$ Hz corresponding to $^6Li^+, Mg^{++}$,Ca^{++}, Mn^{2+}, $Fe^{2+}, Co^{2+}, Xn^{2+}, Se2-$ and 37.4 Hz near 40 Hz

thalamo-cortical resonance frequency for molecular ion O^{2-} related to the bio-photon emissions in turn having interpretation as transformation of dark EEG photons to ordinary ones [K9]. There are three cyclotron frequencies in alpha band which makes it rather special.

3. The model could explain why wake-up consciousness is effectively lost when EEG frequencies are below 7.6 Hz: there would be no cyclotron condensates receiving input as generalized Josephson radiation and no consciousness assignable to the magnetic body.

   An alternative possibility is that consciousness changes its character during sleep. If magnetic flux tubes with B_{end} scaled down most naturally by factor 1/2 or 1/4 suggested earlier to explain the stages of sleep and h_{eff} is scaled up by factor 2 or 4 respectively, cyclotron frequencies are reduced by factor 1/2 or 1/4, and can be low enough for cyclotron resonance conditions to be satisfied. This scales various frequency bands down by factor 1/2 or 1/4. This consciousness would differ from wake-up consciousness, and this might explain why we do not have memories about sleeping period and conclude that sleeping period is non-conscious.

   If B correspond to the Earth's magnetic field at large enough distance so that the distance of the receiving flux tubes would increase roughly by a factor $2^{k/3}$, $k = 1, 2$, for theta and delta bands. The value of B_{end} could also change in a phase transition increasing p-adic prime approximately by a factor 2^k. This phase transition is proposed to be fundamental for metabolism [K8].

5.2 Theta and delta bands

Wikipedia article about EEG (`http://en.wikipedia.org/wiki/EEG`) summarizes the basic features of EEG bands.

1. Delta band is below 4 Hz and appears frontally in adults and posteriorly in children with high amplitude waves. It appears during adult slow wave sleep, in babies and during continuous attention tasks.

   Cyclotron frequency hypothesis and $h_{eff} \rightarrow 4h_{eff}$ hypothesis are consistent with these features. In particular, the model of slow wave sleep conforms with this picture. The satellite associated with Schumann resonance would be in alpha band and an interesting question is whether it appears in EEG during slow wave sleep.

2. Theta waves (4-7 Hz) appear in locations not related to task at hand, is higher in young children, correlates with drowsiness in adults and teens, is associated with "idling", and with inhibition of elicited responses.

   These features conform with the cyclotron frequency hypothesis and $h_{eff} \rightarrow 2h_{eff}$ hypothesis scaling alpha band to theta band corresponding to idling and also with the explanation of sensorimotor band 12-16 Hz in terms of satellites produced by input from magnetic body parts corresponding to alpha band. Also sleeping spindles can be understood. There would be no cyclotron frequency response at magnetic flux tubes responsible for wake-up sensory consciousness and motor activity. The performance of tasks would induce the transition $h_{eff} \rightarrow h_{eff}/2$ activating alpha band.

5.3 Alpha and Mu bands

Mu band is associated with sensorimotor motor cortex and is identified frequency range $8-12$ Hz and can be associated with rest-state motor neurons. Often one calls this band also alpha band.

Wikipedia definition identifies alpha band as $8-15$ Hz range. Alpha band appears in posterior regions of at both sides and has higher amplitude on non-dominant sides. In a relaxed state beta band disappears and the spectral power in alpha band increases. Alpha dominance correlates with relaxed/reflecting state of consciousness, appears when eyes are closed, and is also associated with inhibition control, seemingly with the purpose of timing inhibitory activity in different locations across the brain. Alpha band appears also in coma.

A possible identification for Mu band is in terms of sub-bands associated with $f_J = f_c$ where f_c is cyclotron frequency for bosonic ions Se^{-2} (7.6 Hz), Zn^{2+} (9.4 Hz), Co^{2+} (10 Hz), Fe^{2+} (10.8 Hz), and Mn^{2+} (11.4 Hz). Depending on definition of alpha band it includes also Ca^{2+} (15 Hz). Also the sensorimotor rhythms belong to this band but in TGD framework it can be distinguished from genuine alpha band.

In a relaxed state beta band disappears and the spectral power in alpha band increases. The simplest explanation is that the value of h_{eff} corresponds to alpha band. An interesting question is whether the 10 Hz resonance frequency associated with the excitations of electric field in ionospheric cavity behaving like 2-dimensional waves on sphere is involved. Also the 10 Hz frequency assignable to electron's CD could be involved.

5.4 Sensorimotor rhythms in range 12-16 Hz

Sensorimotor rhythm corresponds the range 12-16 Hz and associated with physical stillness and body presence is a challenge for the model. For bosonic ions (Mn^{2+} and Ca^{2+} only the cyclotron frequencies 11.4 Hz and 15 Hz belong to this band. These are not enough if one is ready to losen the hypothesis $\Delta f_c/f_c \simeq 10$ per cent.

Two basis options can be considered.

1. If B_{end} indeed has spectrum of values analogous to music scale one could explain sensory motor rhythms in terms this spectrum for some ion. Alpha band extended to a scale is the simplest possibility. The notes C,E_b, E, F G A_b, and A would correspond to $f/Hz \in \{10, 11.8, 12.6, 13.3, 14.9, 15.8, 16.8\}$. D would correspond 1.12 Hz still in alpha band.

2. The increase of h_{eff} by factor of two and satellite phenomenon provide an alternative identification of beta band. Alpha band would be scaled down to about 5 Hz and would be fed by cyclotron frequencies in alpha band from magnetic body. Stillness would mean that order sensory input to the part of the magnetic body responsible for wake-up consciousness is absent since since 5 Hz does not correspond to any cyclotron frequency for the nominal value of B_{end}. The satellite frequencies for alpha band would be in the range 12.6-16.4 Hz. So called sleeping spindle during first stage of sleep for which also TGD model increase of h_{eff} by a factor of two, are also in this range. The interpretation would be as cyclotron communications from alpha part of magnetic body received by scaled down alpha part of neuronal membranes.

5.5 Beta band

Beta band ranges from 16 to 31 Hz, appears in both sides, has symmetrical distribution, is most evident frontally, and waves have low amplitude. Beta band is associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous.

Again one can consider several explanations.

1. The simplest explanation of beta band is in terms of octave wide scale associated with Ca^{++} ion with $f_c = 15$ Hz for $B_{end} = .2$ Gauss.

2. Second possibility is beta band involves in an essential manner the feedback from magnetic body and satellite frequencies which however need not induce cyclotron transitions unless one is willing to losen the basic criterion. If higher order effect is in question, the low beta amplitudes can be understood. Harmonics induce cyclotron transitions without further assumptions and one obtains a rich spectrum of sub-bands.

Besdes Ca^{++} octave beta band can contain resonances.

1. Mg^{++} is the only bosonic ion having cyclotron frequency in beta range at $f_c(Mg^{++})$= 25 Hz and could appear as resonance frequency in beta band. Alternatively it could correspond fundamental frequency assignable to gamma band.

2. If one accepts the hypothesis about octaves of B_{end} then gamma band should contain also resonance frequencies around 15.2 Hz, 20 Hz and 30 Hz corresponding to Se^{2^+}, alpha band and Ca^{2+}. The resonance at 20 Hz is known to exist.

3. As already noticed, in slow wave sleep Schumann resonance at $f_S = 27.3$ Hz could generate this frequency by satellite mechanism but the amplitude would be smaller than for direct generation. Also 10 Hz alpha frequency and Ca^{2+} frequency can add up via satellite mechanism rise to $f_c(Mg^{++}) = 25$ Hz.

5.6 Gamma band

Gamma band is associated with somatosensory cortex and displays during cross-modal sensory processing and also during short memory matching of recognized objects, sounds or tactile sensations. Clearly gamma band relates associative regions of cortex. Thalamo-cortical resonance frequency with nominal value of 40 Hz belongs to gamma band.

The simplest option is that gamma band contaings several octave scales associated with $f_c(Mg^{++}) =$ 25 Hz, $f_c(O^{2-}) = 37.4$ Hz and $f_c(6Li^+) = 50.1$. One can criticize this assumption: 25 Hz is roughly 15 per cent lower than 31 Hz. One the other hand, the identification of the various frequency is far from unique.

Ten percent rule for $\Delta f/f$ suggests that thalamo-cortical resonance of 40 Hz could correspond to 37.4 Hz. This would predict a large amplitude in accordance with resonance interpretation. Note that fourth harmonics of alpha frequencies are around the thalamo-cortical resonance frequency.

An alternative explanation of 40 Hz resonance is that it corresponds to the p-adic scaling of h_{eff} and B_{end}. Ca^{2+} would give rise to 60 Hz resonance frequency and also other bosonic ions would give rise to resonances in gamma band. The octave of $f_J(Mg^{2+})$ would give 50 Hz resonance in gamma band.

The strong amplitude of the feedback contribution in the argument of generalized Josephson current $J = J_0 sin(\omega_0 t + X)$ also means that the higher terms in Taylor expansion with respect to X are important and large number of satellites $\omega_0 + nf_c)$ is important so that the amplitude becomes chaotic. The harmonics of bosonic cyclotron frequencies predict quite rich spectrum of sub-bands in beta and gamma banda and it would be highly interesting to test the prediction.

To sum up, according to the proposed picture the basic contribution to alpha, beta, and gamma bands correspond to octave scales associated with bosonic ions in alpha band around 10 Hz, Ca^{++} around 15 Hz, and Mg^{++} around 25 Hz. There are also resonance contributions and contributions from the octaves of the fundamental octaves. Besides the proposed picture many other options can be imagined. One must make working hypothesis and the basic challenge is to avoid too strong assumptions.

6 EEG during sleep

The EEG during sleep [J3, J1] 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.

The scalings of h_{eff} by factor 2 and 4 accompanied by corresponding compensating scalings of B_{end} so that generalized Josephson energies are almost invariant seem to explain the basic characteristics of these states but it is not completely clear whether the phase transitions occur for both cell membrane space-time sheets and flux quanta or only for the first ones.

6.1 EEG during stage 1

The stage 1 sleep is between wake-up state and full sleep involving sometimes hypnagogic hallucinations. During stage 1 of deep sleep [J3] theta waves in frequency range 4-8 Hz beging to dominate and amplitudes increase as frequency is reduced. The transitiosn $h_{eff} \to 2h_{eff}$ and $B_{end} \to B_{end}/2$ should take place and would take place also in relaxed state and generates sensorimotor rhythms.

1. If $h_{eff} \to 2h_{eff}$ transition takes place alpha band is scaled down to the range 3.8-5.7 Hz. Ca^{++} frequency scales down to 7.5 Hz so that one indeed obtains theta band. The amplitudes associated with these frequencies are expected to be high. These amplitudes should dominate and EEG should look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/f_c$ and thus increase with decreasing f_c. The fact that the amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

2. The secondary amplitudes generated by satellite mechanism for alpha band give rise to sensorimotor rhythms appearing also in sleeping spindles. The mirror frequencies are in theta band below 5 Hz.

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.

One must consider two options.

1. If both cyclotron frequencies at magnetic body and generalized Josephson frequencies are scaled down, the communication-control loop between magnetic and biological body remains intact. This might be necessary for the survival. This raises the question whether sleep actually means a loss of consciousness. Could it be that only the character of consciousness is changed? Since the magnetic body moves to a different page of the "Big Book" having as pages various singular coverings of the imbedding space, one could argue that consciousness is not lost but that it is difficult to remember anything about this period during wake-up period since the negative energy signals responsible for memory recall should leak to another page of Big Book and this process could take place with a low rate. The mental images appearing just at the border of falling asleep could give a glimpse about the character of conscious experience in this.

2. The phase transition changing Planck constant could take place for cell membrane space-time sheets only so that only generalized Josephson frequencies would be scaled down. For flux sheets traversing through DNA the value of Planck constant would not be changed. In this case resonance conditions satisfied in wake-up state would be satisfied for the even harmonics of Josephson frequencies during stage 1 of sleep. Therefore the sensory-motor loop involving magnetic body would not be so active in the relaxed state and in the first stage of sleep.

6.2 EEG during stage 2

The appearance of sleep spindles distinguishes stage 2 from stage 1. Sleeping spindles are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [J2]. The spindles last .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.

The natural interpretation of sleep spindles is in terms of input from magnetic body in alpha band which generates by satellite mechanism sensorimotor rhythms assignable to a relaxed state. 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 but inducing no response. It might be that these sudden responses reflect the fact that the left brain is not fully asleep yet.

6.3 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 [J3] . The most straightforward interpretation is in terms of the scaling $\hbar \rightarrow 4\hbar$ so that alpha band would correspond to 2.5 Hz and beta frequency 15 Hz to 3.75 Hz.

Again one has two options corresponding to the scaling of $\hbar$ for all flux quanta and only for the cell membrane space-time sheets.

1. For the first option consciousness need not be lost during these phases of sleep if the above argument makes sense. The experiences just at the border of wake-up could give an idea about what this kind of consciousness is.

2. For the second option DNA cyclotron transitions could be important during deep sleep and it might be even possible to speak about DNA consciousness. For phosphorylated DNA sequences with charge of 2 units per single base-pair one would have $A \geq 300$. More precisely, the atomic weights for base pairs plus phosphate group and deoxyribose sugar are $327, 321, 291, 344$ corresponding to A, T, C, G. From the fact that proton's cyclotron frequency for $B_{end} = .2$ Gauss is 300 Hz one obtains that DNA cyclotron frequency is 1 Hz in good approximation.

This would suggest that during deep sleep DNA cyclotron transitions are induced by Josephson frequencies and that DNA defines the sensory perceiver.

7 Open questions

7.1 Schumann resonance and consciousness

The lowest Schumann resonance frequency $f_S = 7.8$ Hz is conjectured to be important for consciousness.

1. One might imagine that the magnetic body of Earth as a conscious entity communicates to and controls brain using Schumann resonance. A possible mechanism is communication of Schumann radiation to DNA where it arrives along magnetic flux tubes to cell membrane as external perturbation superposing to membrane voltage as sinusoidal perturbation in the first approximation. One can decompose Josephson current as

$$J = J_0 sin(\omega_J t + X) = J_0[sin(\omega_J t)cos(X) + cos(\omega_J t)sin(X)] \ , \ X = \omega_0 t + \frac{Ze}{\hbar_{eff}} \int V dt \ ,$$

and expand $sin(X)$, and $cos(X)$ in powers series of X. If X is sinusoidal, a perturbation with frequency f the series gives rise to the spectrum $f = f_0 + nf$ which should be equal to f_c for some ion at magnetic body. In the case of Schumann frequency this would give lowest frequency $f_0 \pm f_S$. If there is cyclotron frequency satisfying the resonance condition $f_c = f_0 + f_S$, Schumann frequency is perceived at magnetic body.

2. If sleep means formation of a kind of collective consciousness, then one expects that during first and second state of sleep when the scale f_J is reduced by 1/2 *resp.* 1/4 the resulting frequency might correspond to cyclotron frequency. During second state of sleep alpha band is shifted to 2.5 Hz and $f_J + f_S = 10.3$ Hz is in alpha band so that Schumann resonance could contribute to alpha consciousness. For the first phase of sleep alpha band is at 5 Hz (theta band) and for $f_J = 10$ Hz one has $f_J + f_S = 12.8$ Hz in beta band - this is near to the scaled down cyclotron frequency of $f_c(Mg^{2+}) = 12.5$ Hz.

What about the interaction of higher Schumann resonances with consciousness? Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and could give rise to satellites, which for $f_J = 2.5$ Hz correspond to cyclotron frequencies. $f_c(Mg^{2+}) = 25.0$ Hz is not too far from $f_S = 27.3$ Hz Schumann resonance. During slow wave sleep the satellite $f_S - f_J = 27.3 - 2.5$ Hz equal to 24.8 Hz. For $f_S = 14.3$ Hz the satellite would be 11.8 Hz rather near $f_c(Mn^{2+}) = 11.4$ Hz.

7.2 What about proton and electron?

The model discussed has not said anything about proton and electron. with cyclotron frequencies of 300 Hz and 5.6×10^5 Hz for $B_{end} = .2$ Gauss. There are two hints about the role of these frequencies.

1. The spectrum of audible frequencies spans 10 octaves extending from 20 Hz to about 2×10^4 Hz. For bats the spectrum extends to MHz region. The frequency modulation of EEG frequencies by frequencies above 100 Hz produces a vanishing average effect analogous to small ripples much smaller than the wave-length of wave in water.

2. The durations associated with the nerve pulses are few milliseconds.

A natural manner to represent auditory information would be by using electron's cyclotron frequency as a carrier frequency. The proton cyclotron time 3.3 ms could be short enough to allow a representation of nerve pulse patterns as frequency modulation. This would require $f_J = f_c(p) = 300$ Hz for the neuronal membranes involved. Also electronic cyclotron frequency would allow the representation of neuronal events as slow frequency modulations. The effects of VLF radiation at these cyclotron frequencies on living matter could serve as a test for this proposal.

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