Quantum model of nerve pulse, EEG and ZEG

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Contents

1 Introduction **4**
- 1.1 The role of MEs and magnetic flux tube circuitry 5
- 1.2 The model for the generation of nerve pulse 6
- 1.3 The role of electronic superconductivity 7
- 1.4 What happens at the microtubular level during nerve pulse? . . . 7
- 1.5 General vision about EEG and ZEG 8

2 A general view about the generation of nerve pulse **11**
- 2.1 Could Z^0 MEs control the nerve pulse generation? 11
- 2.2 A possible scenario for the generation of nerve pulse 12
  - 2.2.1 Many-sheeted view about cell membrane 12
  - 2.2.2 Z^0 charge neutralization by neutrinos and antineutrinos at $k = 151$ space-time sheet 12
  - 2.2.3 Z^0 MEs as a mechanism controlling the flow of matter between cell interior and exterior 13
  - 2.2.4 The modification of the Hodkin-Huxley model 15
  - 2.2.5 Anesthetic action and classical Z^0 force 16
  - 2.2.6 The role of Ca^{+2} ions in synaptic contact and Z^0 MEs . . 16

3 Many-sheeted neuron **17**
- 3.1 Neuronal consciousness 17
- 3.2 New view about ionic pumps 17
- 3.3 Functions of nerve pulse 18
  - 3.3.1 What the specialization of sensory pathways to sensory modalities means? 19
  - 3.3.2 Could nerve pulse patterns realize the memetic code? . . 19
  - 3.3.3 Generation of declarative long term memories at microtubular level 20
- 3.4 Functions of transmitters 21

3.4.1 Information molecules as quantum links in quantum web? 21
3.4.2 Excitation and inhibition 22

4 A model for the effective electronic super-conductivity in axons 23
4.1 Many-sheeted space-time and connection between thermal de Broglie wavelength and size of the space-time sheet 23
4.2 Magnetic flux tubes as effective super-conductors and breaking of super-conductivity 24
4.3 Quantitative model for the breaking of super-conductivity 25
4.4 Application at axonal level 26
4.4.1 Understanding the critical temperature 27
4.4.2 Predictions for the critical temperature and resistance . . 27
4.4.3 What happens in saltation? 28

5 Relating the model of nerve pulse with the microtubular level 28
5.1 General ideas 29
5.1.1 Increments of zero point kinetic energies as universal metabolic currencies 29
5.1.2 Liquid crystal phase of water as stabilizer of biopolymers 30
5.1.3 What distinguishes between sol and gel phases? 31
5.1.4 IR MEs inducing sol-gel phase transitions as controllers of the cellular dynamics? 32
5.1.5 Do Ca^{+2} ions induce dropping of protons from atomic to larger space-time sheets? 32
5.2 What happens inside neuron during nerve pulse? 33

6 Quantum model of EEG and ZEG 34
6.1 EEG and ZEG 34
6.1.1 EEG and sensory perception 35
6.1.2 ZEG and motor action 36
6.1.3 Tests for the basic assumptions 37
6.2 Scaling law and EEG 38
6.2.1 Scaling law of homeopathy and the mechanism generating EEG 38
6.2.2 Evolution as emergence of lower frequency scales 39
6.3 Basic facts about EEG in TGD framework 42
6.3.1 EEG rhytms in contrast to evoked and event related potentials 42
6.3.2 Coherence of EEG 43
6.3.3 Propagating and standing EEG waves 43
6.4 Spectroscopy of consciousness 44
6.4.1 p-Adic cognitive representations at EEG frequencies . . . 45
6.4.2 Comparison with experimental data 48
6.4.3 Realization of the resonance frequencies as magnetic transition frequencies 51
6.4.4 How EEG spectrum reflects the change of percept? 53
6.4.5 Sleep, wake-up and the notion of magnetic body 54
6.5 Features as AM modulated non-periodic mesoscopic EEG patterns represented by MEs and the relationship to genetic and memetic codes 56
6.5.1 Features as AM modulated EEG patterns 56
6.5.2 MEs as AM patterns representing features 56
6.5.3 Genetic code and odours 57

6.5.4 Magnetic representation of the genetic codewords 58
6.5.5 Data compression as frequency cutoff and threshold coding 59
6.6 Does neuronal synchronization allow to understand the role of Z^0 MEs and how p-adic cognition is realized? 59
6.6.1 Temporal binding by synchronization 60
6.6.2 Empirical evidence for synchronization 60
6.6.3 Does neuronal synchronization with millisecond precision require Z^0 MEs? 61
6.6.4 What is the dynamics of volition and thought? 63
6.6.5 A general view about the role of synchrony 64

Abstract

The topics of this article is the TGD inspired model of nerve pulse, EEG and ZEG (classical Z^0 fields are a prediction differentiating between TGD and standard model). The basic idea is that Z^0 boundary MEs for which classical fields propagate with effective phase velocity equal to the conduction velocity of nerve pulse induce also electromagnetic membrane oscillations and even nerve pulse if Z^0 electric field is strong enough and of correct sign. The mysterious anesthetic action of noble gases can be seen as a direct evidence for the role of the classical Z^0 force. The model explains elegantly also the strange findings challenging the notions of ionic pumps and channels.

The TGD view about the functions of membrane oscillations, nerve pulse and neural transmitters is summarized. Electromagnetic membrane oscillations induced by Z^0 MEs provide a realization of the memetic code as a fundamental cognitive code. The binding of various information molecules to the corresponding receptors gives rise to neuronal qualia. Neurotransmitters could be also seen as conscious links in quantum web. The view that inhibition actually requires active energy feed and that excitation occurs automatically in the absence of the energy feed and induces entanglement with environment, is defended. This view conforms with Huxley's vision about brain as a filter inhibiting conscious experiences.

A p-adic hierarchy of superconductivities is the basic prediction of TGD inspired model of living matter. The many-sheeted model of the effective electronic superconductivity explains at quantitative level the recent findings of Hafedh Abdelmelek and his group about the reduction of the axonal resistivity in the range of physiological temperatures. The effective superconductivity might play key role in the saltation within myelin sheeted portions of the axon. The view about what happens at the microtubular level during synchronous neuronal firing relies on a many-sheeted model for sol-gel phase transitions as conscious bits and on the seesaw mechanism of remote metabolism according to which sol-gel transitions induces gel-sol transitions elsewhere in the cell and vice versa. Microtubular surfaces can be seen as analogs of cortical sensory and motor areas providing kind of conscious log files about sensory and motor history of the cell in terms of conformational transitions of tubulin dimers representing conscious bits.

In the TGD inspired model of EEG and ZEG EEG-ZEG dichotomy corresponds to sensory-motor dichotomy. EEG rhytms are induced by negative energy MEs whereas evoked and even related potentials are assumed to relate to positive energy EEG MEs responsible for classical communications of symbolic representations to magnetic body and declarative long term memories. The scaling law of homeopathy and p-adic length scale hypothesis allow to see the evolution of consciousness as the emergence of lower EEG and ZEG frequencies.

The hypothesis that EEG and ZEG resonance frequencies correspond to the universal p-adic frequencies and their sums and differences (and

more general superpositions) by mutual modulation, and that each p-adic prime $p \simeq 2^k$, k power of prime, defines a hierarchy of cognitive codons with k bits and duration given by the n-ary p-adic time scale, reduces EEG and ZEG to simple number theory. The outcome is a succesful prediction for the resonance frequencies of EEG and ZEG, and one can understand the informatics of EEG and ZEG and relate them to the brain structure and function.

The findings that cyclotron frequencies in the Earth's magnetic field are in EEG range and ZEG cyclotron frequencies are in alpha band, motivate the hypothesis that p-adic frequencies correspond to cyclotron frequencies. This hypothesis allows to identify the ions responsible for various cognitive representations. The dropping of ions between magnetic flux tubes corresponding to different p-adic primes explaining the findings of Peter Gariaev explains also the modulation of p-adic frequencies by p-adic frequencies. Only the biologically most important ions are needed if one assumes that p-adically scaled versions of the Earth's magnetic field are present, and are quantized as stripe like structures characteristic for a superconductor of type I near criticality. The disappearence and appearence of EEG bands as percepts are changed lead to the view that the magnetic body is subject to intentional control by the generation of wormhole magnetic fields consisting of flux quanta with opposite time orientation and thus having a vanishing net energy.

The notion of feature introduced by Freeman to describe mesoscopic aspects of brain function is related to the memetic code but generalizes to the case of an arbitrary cognitive code. Neuronal synchronization in terms of Z^0 MEs serves as a basic element in the model for how intentional action is realized at neuronal level.

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 biosystems as macroscopic quantum systems. Background for this article containing confessions about evolution of the ideas and summarizing the recent views about EEG and nerve pulse can be found from the four online books about TGD and TGD inspired theory of consciousness [1, 2, 3, 4]. The chapter "Quantum model of nerve pulse and EEG" of [4] provides a more detailed discussion of the model of EEG and nerve pulse and also of ZEG defined by classical Z^0 radiation fields predicted by TGD.

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 biocontrol. 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 phenomenona and evolve from long to short length and time scales just as it indeed occurs when motor

activity is learned.

The generation of nerve pulse and EEG represent only particular cases of many-sheeted control and communication mechanisms in the living matter. The MEs, which are partially attached to the boundaries of two space-time sheets and for which classical signal propagates with the effective phase velocity $v << c$ of EEG, can act as bridges between the two space-time sheets and induce a leakage of (em or Z^0) ions between them. The classical em or Z^0 field associated with the boundary ME forces the leakage to occur in a direction determined by the sign of the charge. The Z^0 field associated with the Z^0 ME can induce both oscillations of the membrane potential and nerve pulse sequences. The cyclotron transitions of ions leaking from smaller space-time sheets to magnetic flux tubes give rise to MEs with frequencies in the range of EEG frequencies.

1.1 The role of MEs and magnetic flux tube circuitry

The developments in the understanding of the role of MEs and magnetic flux tube circuitry have repeatedly forced to rethink the model of nerve pulse and EEG.

a) The notion of conscious hologram means that Universe is an extremely complex fractal Feynmann diagram with lines replaced by 4-dimensional space-time sheets and MEs are particular kinds of lines analogous to photon lines. These lines are like laser beams, which interfere in the vertices of the Feynmann diagram: vertices correspond to material space-time sheets, atoms, molecules, ..., cells, ... Superconducting magnetic flux tubes are also important and act effectively as wave guides along which MEs propagate.

b) Topological field quantization allows to assign to any material system a field (magnetic) body. The view that "me" corresponds to the personal magnetic body of an astrophysical size receiving information from the material body by both classical communications and by sharing of the mental images realized in terms of bound state entanglement having negative energy MEs as a space-time correlate, has become a key hypothesis in the attempts to understand the functions of nerve pulse and EEG. The idea about brain as a seat of consciousness is deeply rooted in scientific thinking, and it took some time before I was able to take really seriously the idea about magnetic body as an intentional agent controlling the material body serving as its sensory and motor organ. In this respect the latest developments occurred while writing this article.

c) MEs, in particular, the topological field quanta of ELF em and Z^0 fields are in a crucial role as far as the understanding of EEG (and the predicted ZEG) is involved. Interior MEs correspond to what might be called ELF MEs but they form only a small portion of the spectrum of MEs characterized by the fundamental frequencies defined by their lengths $f = c/L$ extended to ULF frequencies which correspond to length scales of order light lifetime. In the case of boundary MEs, which are assumed to be positive energy MEs, the effective phase velocity satisfies $v << c$, and from $f = v/L$ the sizes of the structures associated with a given frequency are smaller by a factor v/c. The hypothesis that motor-sensory dichotomy corresponds to Z^0-em dichotomy in a very general sense is a working hypothesis deserving testing.

Negative energy MEs make possible intentional action at the microtubular level, they are crucial for the understanding of the macrotemporal quantum coherence, and have also inspired the notions of remote metabolism and quantum credit card. One of the newest discovery along this line is what might be called seesaw mechanism of energy metabolism (see the article "Time, Space-time, and

consciousness" of this issue of JNLRMI). Phase conjugate laser beams [6, 7] seem to be the standard physics counterpart of negative energy em MEs and negative energy photons accompanying them. Population inversion for a many-sheeted laser allows the possibility that negative energy MEs only stimulate the phase transition like return to the ground state providing positive energy to the sender of negative energy photons. Hence even negative energy biophotons might make possible remote metabolism.

d) Fractality implies that MEs contain MEs within MEs. MEs within MEs is the topological correlate for decoherence of Fourier components of classical field. In the simplest situation MEs appear as pairs of high frequency and low frequency MEs. The scaling law of homeopathy [8] states that low frequencies are accompanied by high frequencies such that the frequency ratio has preferred predictable values identifiable as characteristic velocities in the system (such as EEG phase velocity): $f_{low}/f_{high} = v/c$. The most general assumption about the spectrum of high frequency MEs inside low energy MEs is that it is scale invariant in the sense that the intensity satisfies $I(f_{high}, f_{low}) = I(f_{high}/f_{low})$.

Low frequency negative energy MEs serve as correlates for remote quantum entanglement. High frequency MEs travel effectively like massless particles along the bridges defined by the low frequency MEs and can transform to boundary MEs serving as bridges between different space-time sheets at the receiving end, in which case their effective phase velocity is reduced to $v << c$. These MEs induce a leakage of ions between different space-time sheets, breaking of superconductivity and dissipative self-organization. This process which is analogous to the formation of hologram, is responsible for homeostasis and metabolism and gives rise to many-sheeted ionic flow equilibrium. Also many-sheeted lasers acting in a very wide range of frequencies become possible. The frequencies correspond to differences for the energies of ions at the space-time sheets involved. MEs parallel to axons can also act as Josephson junctions connecting space-time sheets which can correspond to different p-adic primes.

e) The experimental findings of the pioneers of bio-electromagnetism [9] demonstrate that electromagnetic radiation at the harmonics of cyclotron frequencies of various ions in Earth's magnetic field, in particular Ca^{+2} ion, are somehow involved with the biocontrol. The dropping of ions from smaller space-time sheets to the superconducting magnetic flux tubes of the Earth's magnetic field indeed generates cyclotron radiation. The generalization of this mechanism [5, D4] explains the findings of Gariaev [10] about radiowaves induced by laser irradiation of DNA.

1.2 The model for the generation of nerve pulse

The model for the generation of nerve pulse is based on the following picture. In the resting state the neuron interior and exterior correspond to $k = 169$ space-time sheets, which are disjoint so that ions cannot leak to the cell exterior. There are however bridges to $k = 151$ cell membrane space-time sheet from cell interior ($k = 169$) but not from $k = 151$ to the cell exterior. This picture explains the strange findings challenging the notions of ionic pumps and channels [11, 12, 13, 14], and suggesting a mechanism dramatically reducing the metabolic costs involved with the ionic pumping. The point is that pumps are needed only when the cell interior and exterior are connected by join along boundaries bonds, say during nerve pulse. The remote metabolism made possible by many-sheeted lasers reduces further the energy costs when pumping actually occurs. If communications between cell interior and exterior

utilize supra currents from atomic space-time sheet to super-conducting space-time sheet and back, a further reduction of the dissipative losses by membrane currents results.

Z^0 boundary MEs parallel to the axons act as bridges between cell membrane space-time sheet and $k = 169$ magnetic flux tubes of Earth's magnetic field in the cell exterior. They propagate with the conduction velocity of nerve pulse and make possible the leakage of matter from cell interior to exterior and induce Z^0 currents in turn inducing the reduction of the membrane potential. The reduction is proportional to Z^0 potential and for sufficiently strong Z^0 field the resulting depolarization is enough to trigger a nerve pulse. If Z^0 MEs have subcritical Z^0 electric field, only oscillations of the membrane potential result (such as micro- and miniature postsynaptic potentials in neuron body). These Z^0 oscillations could have fast enough dynamics for the realization of the memetic code [D1].

The molecular mechanism of the anesthetic action is a fascinating unsolved problem of neurophysiology [15]. The fact that many anesthetics are noble gases suggests that classical Z^0 force is the key player in the mechanism. It is known that the lipid solubility of the anesthetics correlates with their narcotic effect. This suggests that dissolved anesthetic molecules make the lipid cell membrane space-time sheets Z^0 charged and the repulsion created by this charge reduces the flux of ions from the interior of the axon so that nerve pulses cannot be generated and narcosis results as an outcome.

1.3 The role of electronic superconductivity

From the beginning it has been obvious that super-conductivity serves some important function in nerve pulse conduction. For instance, Josephson currents are optimal for quantal alarm clocks [D5]. The contact by Hafedh Abdelmelek and his group [21] meant a crucial step of progress in the understanding of this function. It became clear that geuine or effective electronic superconductivity (in the sense that Cooper pairs are dropped temporarily to larger space-time sheets implying dissipation) is most probably involved with the propagation of the nerve signal through the myelin sheathed portions of the axon. The resulting simple model explains the experimental findings at quantitative level correctly and makes several predictions. In particular, one can understand why physiological temperature can have only a rather restricted range, and why the breaking of the electronic superconductivity is an essential aspect of the ordinary nerve pulse conduction. Also the distinction between poikilotherms (such as frog) and endotherms (such as rabbit) can be understood.

1.4 What happens at the microtubular level during nerve pulse?

What happens at the microtubular level during the nerve pulse? How gel phase differs from sol phase? What occurs in sol-gel transition? These questions represent some of the principal challenges faced by quantum theories of consciousness.

There are two candidates for Bose-Einstein (BE) condensates associated with the ordered phases (say gel) of water. This derives from the fact that the zero point kinetic energy of hydrogen atom at space-time sheet k is in a good approximation same as the zero point kinetic energy of an electronic Cooper pair at space-time sheet $k+10$ (see the article "Time, Space-time, and Consciousness"

in this issue of JNLRMI). Thus both the BE condensates of hydrogen atoms at tubular $k = 139$ space-time sheets forming bundles behaving like liquid crystals and BE condensates of electronic Cooper pairs at $k = 149$ space-time sheets forming linear structures could accompany gel phase and ordered water phases. Positive and negative energy IR photons at energy of $\sim .125$ eV belong to the predicted fractal hierarchy of metabolic currencies, and allow to control the stability of this BE condensate so that a precisely targeted control of the cellular state by local sol-gel transitions becomes possible. Albrecht-Buehler [16] has demonstrated that photons with energy $E \sim .1$ eV have a maximal effect on cells.

The seesaw mechanism discussed in the article "Quantum model of sensory receptor" in this issue of JNLRMI minimizes dissipative losses and allows to understand how microtubular surfaces could provide dynamical records for the cellular sol-gel transitions, and thus define a fundamental microtubular representation of declarative long term memories.

1.5 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 [17, 18] discussed in the article "Time, Space-time and Consciousness" in this issue of JNLRMI.

a) Magnetic bodies forming a hierarchy are the fundamental volitonal 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 perceipts (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) There is a division of labour in the sense that em and Z^0 MEs would correspond to sensory and motor aspects of consciousness. Already at the enzyme level Z^0 interaction is involved with what might be regarded as the bio-chemical counterpart of the motor control. The division of labour could relate to the facts that the lightlike vacuum currents associated with em MEs generate coherent photons and em MEs can carry BE condensates of photons. Photons could serve as a universal "sensory currency" allowing brain to generate virtual sensory percepts, at least in the case of "brain senses" like vision and olfaction. The objection against complete universality comes from the TGD based model of hearing which involves classical Z^0 fields in an essential manner [D9].

c) Sensory representations are realized at the magnetic bodies associated with the sensory organs and sensory mental images are shared with the personal magnetic body by negative energy em MEs. Brain constructs only symbolic and cognitive 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. Also classical communications to the personal magnetic body are possible. A tree like structure with the root represented by sensory mental images and branches and leaves represented by various symbolic and cognitive mental images results.

Eventually the cascade of negative energy MEs ends up to the glial cells serving as metabolic sources. The population inverted many-sheeted laser system providing the energy source in brain or body would consist of ions or of they Cooper pairs in excited cyclotron state. 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. In the case of motor actions, the negative energy ZEG MEs received from Z^0 magnetic body communicate the desires of the magnetic bodies about motor actions to be performed and the response by positive energy Z^0 MEs would realize these desires as nerve pulse patterns.

d) Positive energy EEG type interior MEs correspond to MEs propagating with light velocity along interior of magnetic flux tubes of the personal magnetic body. These EEG MEs could relate to the classical communication of the symbolic representations constructed from the data processed in the brain to the magnetic body. For instance, the photons accompanying EEG MEs could result in cyclotron transitions when charged particles drop to the magnetic flux tubes of the Earth's magnetic field or of personal magnetic body. The sensory perception and memory differ only is that the time scale involved is different. Declarative memory corresponds to negative energy MEs sent from a point of the personal magnetic body at the distance $L = cT$ to the material body and reflected back as positive energy MEs. Thus the material body serves as the mirror unlike in the original variant of the mirror mechanism of memory. The distance $L = cT$ along magnetic flux proportional to the transverse area S of the flux tube $L \propto S$ tubes codes for the temporal distance to the geometric past by transforming it to cyclotron frequency scale. Positive energy ZEG type interior MEs would be involved with the classical communication of information related to motor action.

e) Also boundary MEs are involved and could perform control purposes in brain and body and realize third person aspects of long term memory at magnetic body of Earth.

i) The counterparts of EEG waves moving with a phase velocity $v << c$ result during the nerve pulse conduction, and correspond to boundary MEs associated with magnetic flux tubes. Boundary EEG MEs could be interior MEs temporarily transformed to boundary MEs, and continue propagation with light velocity as interior MEs along magnetic flux tubes.

ii) Boundary ME state could be also permanent and these MEs could be involved with the electromagnetic realization of declarative long term memories about sensory experience. Third person aspects of long term memory could be in question.

iii) Z^0 boundary MEs parallel to axons moving with the conduction velocity of nerve pulse induce nerve pulse sequences, which is also a motor action in a generalized sense. The third person aspects of long term memories related to motor action could be realized at the Z^0 magnetic body of Earth.

Concerning the generation of EEG following comments are in order.

a) The assumption that EEG results, when the ions "drop" to a high n cyclotron state at the magnetic flux tube of the Earth's magnetic field from some smaller space-time sheet, and that at least part of EEG results in the decay of the cyclotron state, explains the findings of the pioneers of bioelectromagnetism [9].

The band structure of EEG indeed corresponds to the periods of the periodic table [D8]. 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 [10] support this picture, in particular scaled up version of the band structure seems to be present at radio frequencies.

b) Nerve pulses generate positive energy EEG MEs and the frequency of the nerve pulses determines the rate at which EEG MEs are generated rather than the frequency of EEG MEs. This conforms with the frequency coding of the intensity of the sensory input. EEG frequencies are magnetic transition frequencies and thus do not correspond to the resonance frequencies for neural circuits as in the standard neuro science view. Pendulum metaphor [D5] suggests how spike patterns amplify EEG waves at frequencies which appear as resonances in the autocorrelation function of the spike sequence. The EEG waves generated by subsequent nerve pulses tend to interfere constructively for the frequencies in question.

Spectroscopy of consciousness has been the key vision in the attempts to understand EEG and ZEG. During the writing of this article a dramatic progress occurred in this respect. p-Adic primes $p \simeq 2^k$ and their powers define a hierarchy of cognitive codons with k bits and a duration determined by the p-adic time scale. The extreme non-linearity of TGD suggests that the MEs associated with different p-adic primes modulate each other so that also the sums and differences and actually arbitrary linear combinations of p-adic frequencies appear in the EEG. Just by calculating these universal frequencies one finds that they and their sums and differences correspond to the important resonance frequencies of EEG. The outcome is a precise view about the amount of information, a rough identification of the character of information, and an assignment with a region of cortex for the codes associated with EEG. A lot of correct predictions emerge, mention only the number of sleep stages and the difference between REM and NREM sleep.

p-Adic frequencies should correspond to cyclotron frequencies. The dropping of ions between magnetic flux tubes corresponding to different p-adic primes explaining the findings of Gariaev [10] explains also the modulation of p-adic frequencies by p-adic frequencies. Only the biologically most important ions are needed if one assumes that p-adically scaled versions of Earth's magnetic field are present, and are quantized as stripe like structures characteristic for a superconductor near criticality. The findings about disappearence and appearence of EEG bands as percepts are changed lead to the view that magnetic body is subject to intentional control by the generation of wormhole magnetic fields consisting of flux quanta with opposite time orientation and thus having vanishing net energy. Also a beautiful connection with the notion of feature introduced by Freeman [19] emerges.

Needless to emphasize, the recent view about EEG and nerve pulse is only one among many narratives which do not lead to obvious internal inconsistencies. Finding the correct interpretation is the most difficult part of the puzzle and it will take still a lot of argumentation forth and back to fix the details of the interpretation. The physics of many-sheeted space-time simply brings in so many new ideas and concepts not yet tested experimentally. An equally difficult challenge is to discover clearcut experimental tests.

2 A general view about the generation of nerve pulse

The basic philosophy behind the model of nerve pulse was summarized in the introduction and in the sequel more technical aspects are discussed. This picture has developed only slowly through several twists and dead allies. The evolution of the ideas is discussed in [D5].

2.1 Could Z^0 MEs control the nerve pulse generation?

The generation of EEG and ZEG associated with sensory and symbolic representations is understood satisfactorily. The problems are related to how the nerve pulse is generated. There are several open qestions.

a) Are nerve pulses direct correlates of cognition so that nerve pulse pattern gives rise to ZEG MEs defining representation at Z^0 magnetic body automatically?

b) The attractive interaction of neutrinos at $k = 169$ space-time sheet with the atomic nuclei implies negative energy for neutrino whereas antineutrino at $k = 151$ space-time sheet has a positive energy [D9]. These energies almost cancel each other so that it is easy to generate neutrino pairs and thus antineutrinos to $k = 151$ space-time sheet. The question is whether there is some deep reason for why antineutrinos should reside at $k = 151$ cell membrane space-time sheet. For instance, could antineutrinos at $k = 151$ space-time sheet act as very light Z^0 conducting particles and cancel the Z^0-electric field generated in the cell interior? Is

c) Does Z^0 force play a crucial role in the nerve pulse generation? Could it be that Z^0 MEs trigger the nerve pulse? Do neutrino pairs accompany Z^0 MEs automatically? If a ME carries constant transversal electric and magnetic fields , it must have near its boundaries charges serving as the sources of the fields. There are two options: vacuum charge densities or real elementary particles and their antiparticles. Since the current associated with ME is necessarily lightlike, the only possibility are vacuum charge densities unless the particles at the boundaries of MEs are in the TGD counterpart of Higgs=0 phase and thus mass-less. Does Z^0 ME have mass-less neutrinos and antineutrinos at its outer and inner cylindrical boundaries corresponding to the cell membrane boundary and cell exterior boundary? The lightness of neutrinos at the space-time sheets containing matter plus the almost vanishing total energy of the pair of $k = 169$ neutrino and $k = 151$ antineutrino would make Z^0 MEs with neutrinos unique. Em MEs can carry only em field generated by vacuum currents unless electrons and positrons are massless inside MEs. Even in the latter case the transfer of electron and neutrino to the material space-time sheets requires large energy. Thus only em MEs with vacuum currents are expected play an important role in the bio-control.

d) The complete Z^0 ionization of atomic nuclei means that they feel a strong Z^0 force. Therefore the state of the cell membrane should be very sensitive to the presence of Z^0 ME inducing Z^0 force. Could Z^0 force induce the leakage of matter, also neutral matter? Could even synaptic vesicles be regarded as Z^0 charged Z^0 plasmoids leaking in Z^0 field to the postsynaptic cell?

e) How the strange findings challenging the notions of pumps and channels [11] could serve as a guideline to guess the mechanism behind nerve pulse. What is the mechanism allowing ions and atoms to leak through cell membrane during the nerve pulse? In what manner many-sheeted space-time might help here?

The following scenario tries to integrate the ideas about the role of Z^0 MEs and cognitive neutrino pairs with the Hodkin-Huxley model of nerve pulse and throws considerable light to the questions made above. It however forces to give up the model of nerve pulse generation based on solitons of Josephson currents.

2.2 A possible scenario for the generation of nerve pulse

A possible simplified scenario for nerve pulse generation could be based on the following vision.

2.2.1 Many-sheeted view about cell membrane

Cell membrane ($k = 151$) and cell interior and exterior ($k = 169$) for both, are the basic space-time sheets involved with nerve pulse generation. Nuclear Z^0 gauge is fed to $k = 169$ magnetic flux tubes of thickmess of about 5 micrometer by wormhole contacts from quark space-time sheets whereas em flux is fed to $k = 131$ or $k = 137$ atomic space-time sheets of atomic size. Z^0 magnetic field resides (at least) at $k = 151$ and $k = 173$ Z^0 magnetic flux tubes: the memetic code can realized in terms of cyclotron transitions at $k = 173$ Z^0 magnetic flux tubes and in terms terms of neutrino spin-flip cyclotron transitions at $k = 151$ magnetic flux tubes.

When a particle enters the cell membrane from cell interior, the $k = 169$ ends of the wormhole contacts move along JABs from $k = 169$ cell interior space-time sheet to $k = 151$ cell membrane space-time sheet. The particle can get to the cell exterior only if there are JABs connecting $k = 151$ cell membrane space-time sheet to the cell exterior $k = 169$ space-time sheet. These JABs corresponds to the ionic and other channels and only in their presence matter can flow from the cell interior to the exterior and vice versa. There is no need for pumps since there is no connection between the cell interior and exterior unless such a connection is generated.

The scenario to be discussed below is just one option.

a) It is quite possible that both Z^0 and em MEs can form the $151 - 169$ bridge. In fact, the idea that Z^0 MEs correspond to cognition and cognitive expression (say speech) and em MEs to sensory representations and ordinary motor expression supports the idea that both MEs ar involved in the control of nerve pulse generation. The competing vision is that sensory-motor dichotomy corresponds to $em - Z^0$ dichotomy for MEs.

b) Also $169 - 173$ or $151 - 173$ bridge must be present in order that Z^0 cyclotron transition generation Z^0 MEs are possible. An open question is whether electroweak bosons could propagate as massless states along Z^0 MEs in which case genuine electroweak transitions would be in question. One could quite well argue that Z^0 MEs are correlates for mass-less Z^0 quanta [D10].

2.2.2 Z^0 charge neutralization by neutrinos and antineutrinos at $k = 151$ space-time sheet

Cell interior and exterior can be assumed to be Z^0 neutral and cell membrane contains conducting antineutrinos, which help to neutralize the Z^0 charge in the cell interior, The Z^0 charge can result only from the excess of neutrinos since antineutrinos and since antineutrinos and nuclei have same sign of Z^0 charge. Besides vacuum charge densities, the generation of cognitive neutrino pairs with neutrino at $k = 151$ and antineutrino at $k = 169$ or vice versa is one manner to guarantee the Z^0 neutrality. Neutrinos and anti-neutrinos are very light and

very easily leak to $k = 169$ cell exterior space-time sheet in the presence of JAB. The inverse process is not possible since neutrinos and antineutrinos are by a factor 10^{-2} lighter at $k = 169$ space-time sheet so that the leakage is possible only in one direction. For atoms and ions the leakage is possible in both directions.

The assumption that cognitive neutrino pair has a lifetime of order millisecond can be given up. It is enough to assume that nerve pulse or even mere Z^0 ME induces Z^0 magnetic field flipping the spins of the antineutrinos at $k = 151$ space-time sheet and changes of the direction of anti-neutrino magnetization. The sequence of the magnetization directions integrates to a conscious experience representing a sequence of 126 bits and of total duration of about .1 second (the original model was constructed without the notion of self and relied on non-determinism).

It is not necessary to have a nerve pulse to generate neutrino spin flips. Even the oscillation pattern of the Z^0 potential induced by Z^0 ME could be enough. In fact, auditory organs involve oscillating membrane potential and these oscillations might relate to Z^0 oscillations. Miniature potentials could also be induced by Z^0 MEs. A criticism against nerve pulse as the only manner to generate spin flips is that the minimum interval between nerve pulses seems to be slightly too brief for the interval required by memetic code (1/1260 seconds). Thus it would seem that frequency coding involves nerve pulses but memetic code involves small oscillations with more rapid dynamics. This also explains why higher level symbolic consciousness is so strongly bound to speech. "Internal speech" could be indeed identified in terms of the memetic code words not involving nerve pulse activity.

2.2.3 Z^0 MEs as a mechanism controlling the flow of matter between cell interior and exterior

Z^0 ME parallel to the axon and connecting $k = 151$ and $k = 169$ cell exterior space-time sheet could act indeed as a 151–169 bridge connecting the cell membrane to cell interior and in this manner control the transfer of the matter between the cell interior and exterior.

a) If Z^0 ME contains constant or aperiodic Z^0 electric and magnetic fields satisfying free Maxwell equations, it must contain opposite charged densitiese at the interior and exterior boundaries of the cylindrical Z^0 MEs. Charge densities could be vacuum Z^0 charge densities or due to the neutrinos at $k = 169$ boundary and antineutrinos at $k = 151$ boundary. In the latter case Z^0 pulse would be automatically accompanied by what might be called cognitive neutrino pairs. Z^0 MEs (not necessarily generating nerve pulse) could be used to control the number of antineutrinos at $k = 151$ space-time sheet.

b) The Z^0 pulse would come along Z^0 ME with light velocity, enter to the region, where Z^0 ME is glued along its boundaries to $k = 151$ and $k = 169$ space-time sheets along the axon and induces a leakage of matter through it. The direction of the leakage depends on the sign of Z^0 electric field. The ions leaking along Z^0 ME make it massive and the propagation of Z^0 field by light velocity must in some sense slowed down to the velocity of nerve pulse because of inertia. This resolves elegantly the problem caused by the small velocity of nerve pulse as compared to light velocity. The same mechanism could also provide a first principle description for the lowering of the light velocity in condensed matter.

What slowing down means at fundamental level? There is actually no need to assume that there is any change at the level of classical space-time dynamics.

Z^0 ME could be simply shifted towards the geometric future in in each quantum jump. This would effectively reduce the phase velocity of the classical Z^0 field since the increment of the phase would be smaller than for a non-shifting ME. The time reversal of this mechanism was proposed in [B1] applying to negative energy MEs (analogs of phase conjugate laser beams) to explain the observed effective super-luminal velocities explained usually in terms of photon tunneling.

The model for the scaling law of homeopathy [D2] involves also the transformation of low frequency ME wave lengths λ_l to much shorter wavelengths λ_h corresponding to the velocity v of the appropriate excitations ($f = c/\lambda_l$ is replaced with $f = v/\lambda_h$). The slowing down of ME by the inertia of the particles flowing along ME bridge and creating the excitation provides the desired mechanism. Since the excitation of wavelength λ_h generates high frequency photons/MEs with the same wavelength, the mechanism also explains why low and high frequencies automatically accompany each other.

c) The leakage of atoms and ions (Z^0 ions) induces a breakdown of the ordinary em charge equilibrium and the membrane potentials falls down. Nerve pulse accompanies the slowed down propagation of Z^0 field associated with Z^0 ME and is thus a secondary phenomenon controlled by Z^0 ME. Membrane potential obeys wave equation with velocity $v < c$ by the proposed slowing down mechanism. Thus Z^0 ME acts as the propagating control wave assumed to induce nerve pulse also in the catastrophe theoretic models of nerve pulse [20]. Also neutral particles could leak from the cell interior to the exterior or vice versa during Z^0 pulse and Z^0 pulses could provide an elegant tool to control the transfer of matter between cell interior and exterior. The generation of nerve pulse need not accompany this process.

d) The most conservative option also consistent with quantum criticality of TGD Universe is that Z^0 ME only reduces the membrane potential below the critical value for the triggering of the nerve pulse and does not have any appreciable role after that. This would guarantee that the standard model for the dynamics of ionic concentrations applies to the nerve pulse as such. Proton and electron couple weakly to the Z^0 field and they are not expected to play important role in the generation of the nerve pulse. The very small value of the proton's Z^0 charge might relate to its exceptional role in the metabolic cycle. One could test this by studying whether and how a partial replacement of the ordinary water with the heavy water D_2O affects the functioning of the biosystem.

e) The assumption that Z^0 ME only reduces the membrane potential below the critical value can be justified by the following argument. Z^0 charge is proportional to the total neutron number of the particle and in a reasonable approximation proportional to the net mass number. This implies that the ratio of the densities in cell interior and exterior given by the expression

$$\frac{n_{int}}{n_{ext}} = exp\left[\frac{(Qe\Delta V_{em} + NQ_Z(n)g_Z\Delta V_Z)}{T}\right] \times \frac{n_{int,0}}{n_{ext,0}} \quad ,$$

is em-Z^0 static chemical equilibrium exponentially sensitive to the mass number of particle if Z^0 force dominates. It is easy to convince that this does not make sense by looking what happens during the generation of the nerve pulse [20]. The Z^0-static chemical equilibrium can prevail only after the various ion currents have grown sufficiently large from their initial values to establish the equilibrium. One must assume that the equilibrium is not achieved before the triggering of the nerve pulse. It is also to be expected that the membrane potential changes and affects the situation. The change is expected to be proportional to the Z^0

potential of Z^0 ME.

2.2.4 The modification of the Hodkin-Huxley model

With these assumptions the model only extends Hodkin-Huxley model by adding to it the mechanism triggering the nerve pulse.

a) One can apply standard approach to study the near equilibrium dynamics. The current associated with a given ion is proportional to the sum of the electric and Z^0 forces experience by the particle:

$$I_X = g_X \left[Q_X e(V_{em} - V_X) + N_X Q_Z(n) g_Z \Delta V_Z \right] \quad .$$

In the catastrophe theoretic variant of the Hodkin-Huxley model [20], which also assumes a wave triggering the nerve pulse, the values of the ionic conductivities g_{Na}, g_{Cl} and g_K at resting state are $g_{Na} = 0$, $g_{Cl} = .15\ mmho/cm^2$ and $g_K = .24\ mmho/cm^2$ The values of V_X are $V_K = -77$, $v_{Na} = +50$, $v_{Cl} = -46$, when millivolt is used as unit. The value of the resting potential is $v_R = -65$ mV. The neutron numbers of Na^+,Cl^-,K^+,Ca_{+2} are $12, 18, 20, 20$.

This equation makes sense only during the presence of Z^0 ME since only during this interval the currents can flow. From this one can conclude that the duration of the contact with Z^0 ME is of order millisecond. This identification is consistent with the hypothesis that neuronal synchrony is due to the control action of Z^0 MEs oscillating with the frequency defining the duration of the bit of the memetic code work ($f \simeq 1260$ Hz) [D3, D1].

b) The vanishing of g_{Na} at the resting value and down to the point, when nerve pulse is triggered, is assumed in Hodkin-Huxley model and in the catastrophe theoretic model of the nerve pulse [20]. This assumption is somewhat un-natural in standard physics framework and might actually reflect the fact that Z^0 and em induced Na^+ currents compensate each other during the pre-triggering state of the nerve pulse generation.

This assumption actually fixes the model. The induced electromagnetic potential difference would be related to the Z^0 potential difference before the triggering of the nerve pulse by

$$e(V_{em} - V_{Na}) = -N_{Na} Q_Z(n) g_Z \Delta V_Z \simeq -6 g_Z \Delta V_Z \quad .$$

Note that $g_Z V_Z$ should rise effectively instantaneously to the value -2 meV. Note that Z^0 force favours the outward flow of matter from the cell interior (neutrinos flow inward). At the threshold for nerve pulse generation the value of Z^0 potential would be about $g_Z V_Z = -15$ meV, and is identifiable as the threshold value for the maximum of the potential difference $g_Z V_Z$ for Z^0 ME able to generate a nerve pulse. Below this threshold only oscillations of the membrane potential are generated.

c) Using this one can write the ohmic em currents in the effective form

$$I_X = g_X \left[Q_X e(V_{em} - V_X) - \frac{N_X}{N_{Na}} e(V_{em} - V_{Na}) \right] \quad .$$

One gets the standard form of ohmic currents by replacing the conductances with the effective conductances

$$g_X(eff) = g_X \left[1 - \frac{N_X}{Q_X N_{Na}} \frac{V_{em} - V_{Na}}{V_{em} - V_X} \right] \quad .$$

By identifying the conductances of the Hodkin-Huxley model as effective conductances and applying this equestion, one finds that the ration of the K and Cl

conductances at the resting state should be $g_K/g_{Cl} = .95$, which is rather near to unity so that the model might make sense and might simplify the Hodkin-Huxley model. Mote that the effective Cl conductance becomes infinite at $V_{em} = V_{Cl} = -46$ mV (Cl current itself remains finite), which is rather near to threshold of 40 mV. Threshold would naturally corresponds to the divergence of the $g_{Cl}(eff)$.

2.2.5 Anesthetic action and classical Z^0 force

The molecular mechanism of the anesthetic action is a fascinating unsolved problem of neurophysiology. The fact that many anesthetics are noble gases having very weak chemical interactions conforms with the hypothesis that the classical Z^0 force controls the generation of the nerve pulse. It is known that the narcotic effecy of anesthetics correlates with their solubility in lipids [15]. This suggests that anesthetic molecules dissolved into the lipid membrane are responsible for the narcotic effect, probably by hindering the generation of the nerve pulse somehow. How this happens can be understood. Cell membrane space-time sheet becomes effectively Z^0 charged since it receives the Z^0 gauge flux of the anesthetic molecules. When Z^0 ME propagates along the axon, neutrinos (nuclei) from the cell exterior flow to the cell interior (exterior) in the normal situation. The presence of Z^0 charge in the membrane space-time sheet however acts repulsively on the nuclei in the interior so that the flow from the interior is reduced and nerve pulse cannot be generated.

2.2.6 The role of Ca^{+2} ions in synaptic contact and Z^0 MEs

The Ca^{+2} the ratio of neutron number to em charge is $20/2 = 10$ whereas for Na^+ the ratio is 12 and thus almost the same. Hence the Z^0 force almost compensates em force in case of Ca_{+2} during the initial period of nerve pulse. Hence Ca^{+2} ions might play a role analogous to that of Na^+ ions. Ca_{+2} waves are indeed central tool of bio-control and their velocities span a very wide range. I have already earlier proposed that Z^0 MEs somehow induce Ca^{+2} waves [D3, D2].

The action potential is known to trigger the transfer of Ca^{+2} ions into the presynaptic terminal and the presence of Ca^{+2} ions is essential for the emission of the neurotransmitters. The synaptic vesicles containing neuro-transmitters fuse with the presynaptic membrane and neurotransmitters are released. Neurotransmitters bind to the postsynaptic proteins in the postsynaptic membrane changing their conformation, which in turns leads to ion flows and the generation of micropotentials generated by transmitter molecules summing up to miniature synaptic potentials. It is known that the emission of the synaptic vesicles is a quantum process and that the emission of a single synaptic vesicle gives rise to a miniature synaptic potential of amplitude of about 1 mV [22]. This suggests that resonant Ca^{+2} ionic currents from the cell exterior to interior occurring at EEG frequencies which are multiples of Ca cyclotron frequency $f_{Ca_{+2}} = 15$ Hz could have important role in initiating the self-organization process leading to the emission of neurotransmitters.

Ca^{+2} currents are related to the conformational changes of proteins, in particular microtubules, and are believed to be somehow involved with the delocalization of electrons. Ca^{+2} ions are also involved in local sol-gel transitions associated with the actin microfilaments driving cell motility, which involves generation of long range order and can be regarded as a self-organization process. Sol-gel transitions occur cyclically and the natural unit for rate is 10 cycles per

second. This suggests that multiples of Ca^{+2} cyclotron frequency determine the rates and that the process is quantum controlled by EEG. Ca^{+2} ions are also involved with GTP-GDP hydrolysis.

3 Many-sheeted neuron

TGD approach allows to make educated guesses concerning the interpretation of various phenomena in neuronal level.

3.1 Neuronal consciousness

The fractality of consciousness encourages the view that neurons are conscious organisms having receiving sensory input and forming sensory representations at their magnetic bodies, and generating motor actions. One can see associations at neuronal level as a process in which neuronal subself induces mental images inside the postsynaptic neuronal self. Neuron could be seen as a fractally scaled down version of a sensory pathway.

The sensory input of a neuron is determined by the inputs from active presynaptic neurons. Postsynaptic receptors are analogs of ordinary sensory receptors and they determine the sensory qualia and primary sensory mental images of the neuron (also ordinary cells have sensory receptors and sensory representations). Microtubuli inside dendrites are the analogs of sensory pathways, and cell membrane and cell nucleus could play the role of the neuronal skin and brain. Both could give rise to sensory representations. Sensory representations at the magnetic and Z^0 magnetic body of nucleus would be generated by DNA. Neurons would have sensory qualia and neuronal receptors and receptors at the surface of any cell could give rise to the analogs of tastes and smells. Cells could also see a and hear at some wave length ranges and the microtubuli associated with the cilia span a length scale range containing visible frequencies.

The neuronal sensory input leads to a generation of a sensory representations at the magnetic body of neuron. A rough estimate for its size results by assuming that the ratio of the length of MEs involved to the size of the system is constant. By scaling from the size of brain hemisphere of about 8 cm corresponding to EEG frequencies to cell nucleus size of about one micrometer, one finds that frequencies involved are above 10^5 Hz. Also neuronal membrane can give rise to sensory representations as probably does skin, and for a neuron size about .1 mm the counterparts of EEG frequencies would be above kHz. Frequencies of MEs must indeed be above kHz in order that the magnetic body of the cell has enough time to generate the motor action as a response. Part of the motor action of neuron is generation of nerve pulse pattern by Z^0 ME from Z^0 magnetic body.

3.2 New view about ionic pumps

The findings described in [11] challenge the notion of ionic pumps: metabolic costs would be gigantic if the pumps were functioning all the time. The many-sheeted space-time however solves this problem. Ionic pumps are needed only when there are join along boundaries bonds connecting the cell interior with the cell exterior (say during nerve pulse). This means a dramatic reduction in the metabolic costs.

The simplest picture about the action of the ionic pump is as a provider of the energy allowing to transfer ions against the force defined by the concen-

tration gradient and the em and Z^0 electric fields through the cell membrane. In the thermodynamical description the chemical potential μ characterizes the interaction of the ion with the environment and chemical potentials are fixed by the concentrations of ions. Assuming that it is possible to use chemical potential to characterize the microscopic interaction energy with the environment in a reasonable approximation at least, the energy needed to transfer the ion of charge ne and neutron number $A-Z$ is the difference of the ion's energy

$$\Delta E = ne\Delta\Phi_{em} + (A-Z)g_Z\Delta\Phi_Z + \Delta\mu_I \quad (1)$$

over the cell membrane. This energy should correspond to an increment of some zero point kinetic energy so that the concentrations of ions should tend to be quantized to preferred values.

The simplest case that one can image corresponds to a situation in which the difference of the chemical potential is small as compared to the electric potential energy difference and Z^0 electric potential energy difference can be neglected. This is the case for electron and proton (having very small Z^0 charges) assuming that their densities do not differ too much from equilibrium values in cell interior and exterior. Indeed, the value of the cell membrane resting potential is near to a zero point kinetic energy. There are two options again corresponding to proton-electronic Cooper pair symmetry.

a) The $k = 139$ Bose-Einstein condensate of hydrogen atoms could be responsible for .125 eV energy quantum crucial for sol-gel phase transitions controlled by micro wave MEs. Also electronic Cooper pairs dropping from $k = 149$ space-time sheet to much larger space-time sheets liberate the same energy when dropping by the approximate p-2e symmetry. For $k = 149 \to 151$ transition the energy is about .094 eV.

b) H_2 and/or Cooper pairs of protons correspond to energy of .0625 eV (recall that there is small numerical uncertainty involved). Also electrons dropping from $k = 151$ lipid layer space-time sheet would liberate this energy. Since the resting potential is .065 eV, this energy is very near to the energy needed/gained by singly charged particle when it traverses cell membrane. The zero point kinetic energy .125 eV of H atoms in turn correspond to the energy needed to carry doubly charged ion such as Mg^{2+} or Ca^{+2} through the cell membrane. This leads to the hypothesis that the TGD counterparts of ionic pumps are based on remote metabolism, that is sending of negative energy MEs inducing the dropping of H, H_2 and possibly 2p from $k = 169$ space-time sheet or dropping of electronic Cooper pair from $k = 149$ and electron from $k = 151$ space-time sheet.

In a more general situation the metabolic currencies are not optimal for the simplest possible transfer process unless the concentrations are quantized. Also more complex scenarios in which the utilization of, say, single ATP molecule allows the transfer of several ions at once through the cell membrane might be necessary.

3.3 Functions of nerve pulse

Nerve pulses inducing generalized motor action represent pushes and pulls in spin glass energy landscape of brain. These pushes and pulls induce motion in the spin glass landscape and generate somehow both neuronal and our emotions. Transmitters mediate nerve pulses from presynaptic neuron to postsynaptic neuron and modify the properties of the synapse and of the postsynaptic neuron.

Fast neurotransmitters controlling directly ion channels are involved with the process and the relevant time scale is one millisecond. No long term change of the postsynaptic neuron is involved. Slow neurotransmitters involving second messenger action are involved with the modulation of the response of the postsynaptic neuron, and the time scales can be of order of minutes. In this case the properties of the postsynaptic neuron are changed. Emotional reactions involve typically slow transmitters and their effect can be regarded as a generalized motor action inducing motion of the neuron in the spin glass energy landscape of the neuron.

3.3.1 What the specialization of sensory pathways to sensory modalities means?

Sensory pathways are specialized to produce some specific sensory qualia. How this specialization correlates with what happens at the neuronal level?

a) If one accepts the notion of magnetic body, it is not too difficult to accept the idea that the magnetic bodies associated with the sensory organs are the seats of the sensory representations whereas higher levels of CNS are responsible for symbolic and cognitive representations accompanying sensory representations. TGD based view about long term memories makes it possible to defend this view against standard objections such as phantom limb phenomenon, projected pain, and the stimulation of sensory hallucinations electrically. One cannot exclude the possibility that even the sharing of mental images with the objects of external world contributes to the conscious experience.

b) An almost diametrically opposite view is that qualia are like colors of a map and coloring is decided at quite high level of sensory processing.

These views need not be mutually exclusive. Sensory qualia seated at sensory organs can serve as the colors of the map if sensory receptors and brain form single quantum system in which entanglement with and back projection to the structures defined by sensory receptors is essential. This back projection could transform the primary mental images. This view would also explain the rapid eye movements during REM sleep and oto-acoustic sounds.

The axons for which temporal sequences of cognitive neutrino pairs identifiable as bit sequences determine the contents of the experience, would give rise to a 'Boolean modality' representing higher level cognition. The assumption that the electric oscillations induced by auditory input with the mediary of Z^0 MEs is responsible for the generation of memetic codons, gives further support for the idea that entire sensory pathway and sensory receptors are responsible for the qualia.

In this picture association areas could be seen not as cognitive areas, where sensory input is transformed to cognitive ouput, but areas in which the mental images associated with various symbolic and cognitive pathways fuse to a single mental image. Therefore the term association would be somewhat misleading. A genuine association can be seen to result when a subself wakes up sub-self by nerve pulse patterns and is experienced by a higher level self as two subsequent mental images.

3.3.2 Could nerve pulse patterns realize the memetic code?

TGD based model of cognition allows to construct a model for memetic code in which sequeces of 126 cognitive neutrino pairs of total duration of about .1 second correspond to Boolean statements or also integers in the range $\{1, 12^{126}\}$ in binary representation. The model for the physical realization of the memetic

code is discussed in more detail in [D1] and here only the basic idea will be described.

The model for the memetic code assumes that antineutrinos resides in the strong Z^0 magnetic field associated with the cell membrane and having the direction of the axon. The antineutrinos have suffered spontaneous Z^0 magnetization. Memetic codons consisting of (almost) 127 bits are realized as temporal sequences of spontaneous Z^0 magnetization of antineutrinos at $k = 151$ cell membrane space-time sheet. The ground state with all bits in the direction of the Z^0 magnetic field does not represent conciously anything so that the number of representable bit sequences is $M_{127} = 2^{127} - 1$ which corresponds to almost 127 bits.

Memetic codons are generated by Z^0 magnetic pulses reversing the direction of local Z^0 magnetization. The magnetic transition frequency is energy difference for states $(n + 1, up)$ and $(n, down)$ for cognitive antineutrinos of opposite spin in the strong Z^0 magnetic field of the axonal membrane. There is however a "miracle" involved. The magnetic transition frequencies of muonic and tau neutrinos for the transitions between states $(n+1, up)$ and $(n, down)$, are in the range of ELF frequencies and that for the largest possible value of the axonal Z^0 magnetic field this frequency is slightly higher than the maximal frequency of nerve pulses. Hence the duration of nerve pulse implies automatically that it generates harmonic perturbation giving rise to spin flips of neutrinos [D1, D9].

The basic objections against the idea that nerve pulses generate memetic codons are following.

a) The minimum time interval between nerve pulses is slightly longer than required by memetic codon.

b) The prediction would be that high level linguistic cognition is everywhere in brain. Rather, higher level cognition should be associated with the neurons at multimodal associative regions of cortex [D1] or with cognitive neural pathways leading to these areas. Only humans possess the parietal-occipital-temporal association region combining somatosensory-, visual- and auditory inputs into associations and giving meaning to the objects of the perceptive field. Perhaps the emergence of this associative region associating Boolean statements with sensory features has led to Homo Sapiens.

c) Ordinary nerve pulse patters suggest strongly frequency coding rather than refined memetic code. In the case of memetic code it would mean roughly 64 nonequivalent codons. This in fact might be enough to understand the basic phonemes of language as expressions of memetic codons.

These arguments suggest that nerve pulse patterns give rise only to a frequency coding such that only the frequency of the bits differing from the standard value is of significance. The intensity of sensory input, motor output, and emotional expression could be coded in this manner. Z^0 MEs can generate also oscillations of the membrane potential and it is known that this kind of oscillations accompany hearing. These oscillations could also induce reversal of Z^0 magnetization and could allow to realize memetic code in full complexity.

3.3.3 Generation of declarative long term memories at microtubular level

The TGD based model of declarative long term memories is based on the mirror mechanism with brain and body effectively serving as timelike mirrors from which negative energy MEs are reflected as positive energy MEs. Long term memories are coded to subjectotemporal changes of the microtubular conformations [D4] which allow a huge number of almost degenerate configurations,

and the transitions between these configurations generate Z^0 MEs (or equivalently, gravitonic MEs) with ultralow frequencies determined by the time span of the long term memory. The natural first guess is that the nerve pulse patterns accompanied by Z^0 MEs are an essential part of the process of building long term memories by inducing the motion of the axonal microtubuli in the spin glass energy landscape. Nerve pulse could be also accompanied by a separate wave propagating along the axonal microtubuli and containing much more detailed information about the sensory input specifying the content of declarative long term memories. This would mean huge information storage capacity and also explain why the axonal lengths associated with the sensory pathways are maximized.

A model for the cognitive code associated with with microtubuli is discussed in [C2]. The model is based on $13 \times 13 = 169$ bits defined by single full turn for 13 helical tubulin strands consisting of 13 tubulins each. Since only the changes of tubulin conformations contribute to the microtubular conscious experience, only $2^{169} - 1$ patterns code for conscious experiences. Therefore the code represent only 168 full bits and the remaining almost bit could define some kind of parity bit. The presence of a sufficiently strong external electric field along the microtubule would imply that the change of bit is replaced with a pattern of $b \to b + 1 \to b$ transitions leading from the ground state to excited state and back to the ground state.

An interesting possibility is that microtubuli define a cognitive code above the memetic code in the hierarchy of cognitive codes so that biology would not reduce to neither genetic nor memetic code. The changes of the microtubular conformation patterns could be coded to 2^{126} memetic codons represented by field patterns associated with MEs. The $64 \to 21$ correspondence for DNAs and aminoacids would be generalized to $2^{169} - 1 \to 2^{127} - 1$ correspondence such that 168 full bits would be mapped to 126 full bits. The degeneracy would be $6log(2)/log(21) \simeq 1.39$ for the genetic code and $168/126 = 1.33$ for the microtubular code.

3.4 Functions of transmitters

It is an interesting challenge to try to understand the role of various information molecules, in particular neurotransmitters, in TGD inspired conceptual framework.

3.4.1 Information molecules as quantum links in quantum web?

One particular challenge is to find convincing "reason why's" for what happens in the synaptic contacts. Why myriads of neurotransmitters are needed: inhibition, excitation and neuromodulation could indeed be carried out in much simpler manner?

a) Information transfer is certainly in question and a natural assumption is that the information is conscious quantum information. If so, it is not the transfer of the neurotransmitter molecules which is essential but the transfer of bound state entanglement of these molecules with the environment and thus of conscious information. This is in accordance with the computer metaphor: neurotransmitters would be like links to different pages in the web activated in the transfer process analogous to sending an email containing a list of links plus text. Also a transfer of usable energy could be involved: the positive energy MEs transferred could provide their energy to the postsynaptic cell unless they are used to energize the transfer process. Besides neural transmitters blood

cells and various molecules transmitted by blood and lympha could be carriers of quantum links and hormonal action at the deeper level would be quantum communication in this sense.

b) When information molecules and receptors form a quantum bound state, macrotemporal quantum coherence is generated and this correspond at the level of conscious experience a multiverse state of 'one-ness' and from the point of information processing a quantum computation like process [D4]. One could also see information molecules and receptors as representative of opposite molecular sexes. The resulting non-entropic mental image corresponds to sensory qualia of the neuron analogous to smells and tastes. In principle, each neurotransmitter gives to a distinct neuronal taste or smell. Also neuronal analogs of vision and hearing are possible. Microtubuli indeed give rise to infared vision in case of bacterial cells.

3.4.2 Excitation and inhibition

Excitation and inhibition are seen as basic functions of neurotransmitters. More precisely, the attribute excitatory/inhibitory can be assigned with a given transmitter-receptor combination. Gardener metaphor states that brain is a gardener allowing particular plants, now mental images having neural firing patterns as neurophysiological correlates, to flourish. One could argue that this kind of selection is reasonable in order to use metabolic resources optimally. One must be however very cautious here. Paradoxically, the metabolism during synchronous firing does not seem to increase [23]. This finding has two mutually non-exclusive explanations.

a) Remote metabolism involving the generation of negative energy MEs received by glial cells serving as a storage of metabolic energy is involved.

b) Inhibition could require actually more energy than excitation: neural firing would occur spontaneously when the energy feed to the system is subcritical. At least for the inhibition caused by hyperpolarization this view might make sense. One can say that the gardener would actively prevent the growth of some plants. Inhibition would be censorship preventing a spontaneous generation of mental images in accordance with the vision of Huxley about brain as a filter which prevents conscious experience rather than creates it. The hypothesis that biocontrol is quite generally based on this principle is attractive since it is easier to prevent a complex process to occur spontaneously than to force a complex process to occur in a desired manner.

Option b) would explain several paradoxal looking findings about the correlation of inhibition with the level of self control. The amount of inhibition increases and the behaviour becomes more controlled and "civilized" as one climbs up in the evolutionary tree being highest for humans. Inhibition is higher for adults than for children as is also the level of self control. Inhibition is dramatically reduced during the process of physical death. In all these cases the reduced inhibition would naturally correlate with the reduction of the metabolic feed. Inhibition is also reduced during several altered states of consciousness and these states of consciousnes involve also a high level of relaxation.

If the reduced inhibition means a reduction of energy feed, a depletion of energy resources is an unavoidable outcome. This leads to a spontaneous generation of negative energy MEs by starving neurons making possible remote entanglement and remote metabolism. In particular, synchronous neural firing would involve also remote metabolism so that option a) is not excluded by b). The generation of episodal long term memories and various kinds of remote mental interactions would be an automatic side product. The memory feats

of synesthetes indeed correlate with a dramatic reduction of metabolism in left cortex; various remote mental interactions are reported to occur during altered states of consciousness; and there are reports about the association of telepathy, precognition and poltergeist type phenomena with the physical death of a close relative or intimate friend.

On the other hand, if inhibition means heightened metabolic energy feed, it also reduces the need to generate negative energy MEs. The reduction of entanglement with the environment means among other things fewer shared mental images. Therefore the increase of inhibition would be a correlate for the increasing privacy of conscious experience. Ironically, the physical well-being would more or less unavoidably lead to the alienation and unhappiness suffered by so many members of postmodern society.

4 A model for the effective electronic super-conductivity in axons

Hafedh Abdelmelek and collaborators [21] have found evidence for effective superconductivity in the sciatic nerves of both endotherms (rabbit) and poikilotherms (frog). The basic finding is that the resistance of the sciatic nerve is reduced by a factor of about ten below a critical temperature at the lower edge of the range of the physiological temperatures. The reduction of the temperature occurs inside a narrow temperature range ΔT, $\Delta T/T_c \sim .04$. This suggests effective super-conductivity. Furthermore, the critical temperature T_c for the breaking of the effective super-conductivity raises from 240 K to 300 K in the transition from poikiloterms (say frog) to endotherms (say rabbit).

These findings seem to be consistent with the following view.

a) Nerve pulse generation involves a mechanism inducing a flow of ions between axonal interior and exterior and induces at the same time the breaking of super-conductivity [D5]. At too low temperatures nerve pulses cannot be generated because the breaking of the super-conductivity is not possible. Therefore the critical temperature must be below the range of physiological temperatures and explains the difference between poikiloterms and endotherms.

b) In myelin sheathed regions the breaking of the effective super conductivity does not occur or the critical temperature is higher and the signal carried by the nerve pulse is transformed to an effective or genuine supra current. A small pulse like perturbation of the membrane potential could propagate still.

c) Poikiloterms can survive only if nerve pulse conduction is possible down to about 240 K which represents lower bound for the temperature of environment. Endotherms can keep the body temperature above 300 K and so that T_c can be as high as 300 K. This is good for survival purposes since high T_c minimizes ohmic losses related to nerve pulse conduction.

4.1 Many-sheeted space-time and connection between thermal de Broglie wavelength and size of the space-time sheet

The concept many-sheeted space-time is needed to understand super-conductivity and breaking of super-conductivity. Parallel space-time sheets with distance about 10^4 Planck lengths form a hierarchy. Each material object (...,atom, molecule, ..., cell,...) corresponds to this kind of space-time sheet. The p-adic primes $p \simeq 2^k$, k prime or power of prime, characterize the size scales of the

space-time sheets in the hierarchy. The p-adic length scale $L(k)$ can be expressed in terms of cell membrane thickness as

$$L(k) = 2^{(k-151)/2} \times L(151) \ , \tag{2}$$

$L(151) \simeq 10$ nm. These are so called primary p-adic length scales but there are also n-ary p-adic length scales related by a scaling of power of $\sqrt{p}$ to the primary p-adic length scale.

The characteristic temperature scale for particles of mass M in a thermal equilibrium at the space-time sheet characterized by $L(k)$ is given in terms of the zero point kinetic energy associated with the space-time sheet

$$T(k) \quad = \quad n \times E_0(k) = n \times n_1 \times \frac{\pi^2}{2ML^2(k)} \ , \tag{3}$$

where n and n_1 are numerical constants not far from unity (for convenience the units $k_B = 1$, $\hbar = 1$, $c = 1$ are used). $T(k)$ decreases very rapidly as a function of the p-adic length scale $L(k)$. This equation relates the p-adic prime of space-time sheet to T and M of particles present in the sheets forming join along boundaries condensate. Of course, the size L of space-time sheet characterized by k can vary in the range $[L(k), L(k_>]$ and $T \propto 1/L^2$ is an attractive guess for the dependence of the temperature on the size of the space-time sheet. One can interpret $T(k)$ as a critical temperature at which the p-adic prime characterizing the space-time sheet changes.

4.2 Magnetic flux tubes as effective super-conductors and breaking of super-conductivity

The model for biosuper-conductivity and its breaking relies on the following picture.

a) Magnetic flux tubes of Earth's magnetic field (in particular) characterized by $k = 169$ and having a minimal thickness about 5 μm correspond to tubular space-time sheets. In the absence of both larger and smaller space-time sheets, they can act as 1-D super-conductors since cyclotron energy scale, which by the quantization of the magnetic flux behaves also as $1/L^2(k)$, is larger than de Broglie temperature for sufficiently high values n of the magnetic flux (implying thicker flux tube). More generally, one can consider the possibility of a hierarchy of magnetic flux tubes inside magnetic flux tubes corresponding to the sequence $k = 169, 167, 163, ...$ Each of these flux tubes can be a super-conductor. Bio-super-conductivity is assumed to be due to this mechanism. Of course, only space-time sheets corresponding to only some of these p-adic length scales could be present and this would be crucial as far as super-conductivity and its breaking is considered. The study of the effects of external magnetic fields on the axonal conductivity might provide valuable information about the role of magnetic fields.

b) Super-conductivity can be broken by a temporal leakage of the Cooper pairs to larger space-time sheets if present. These Cooper pairs are kicked back by thermal photons. System is an effective superconductor in the sense that Cooper pairs are not destroyed in the breaking of superconductivity and an effective ohmic conductor in the sense that dissipation is present. Super-conductivity can be also broken by thermal kicking of the Cooper pairs to smaller space-time sheets. In this case there is however a restriction posed by the

fact that the zero point kinetic energy of the particle increases from $E_0(k)$ to $E_0(k_<)$, where $k_<$ ($k_>$) is the largest (smallest) the prime smaller (larger) than k. Thermal energy is needed to achieve this. For the leakage to occur, one must have

$$T > nE_0(k) \quad = \quad T(k) \ . \tag{4}$$

Some numerical constant n is involved here. Note that the temperature at super-conducting space-time sheets is much lower than the critical temperature and the temperature at atomic space-time sheets.

c) The prediction is that the conductivity decreases in a stepwise manner at temperatures $T = T(k)$ as the temperature increases, and that the smallest value of k for current carrying space-time sheets gradually decreases as $k = 169 \to 167 \to 163 \to 157 \to 151 \to ....$ The behaviour of the conductivity in the sciatic nerve seems to represent one particular step of this kind. The primes $k = 167, 163, 157, 151$ are expected to be especially important in living matter since they corresponds to the so called Gaussian Mersennes and p-adic length scales in the range 10 nm-2.56 μm [C3].

d) For a space-time sheet having $k = k_0$, the leakage of supracurrent is induced by the formation of join along boundaries bonds between $k = k_0$ space-time sheets and $k \geq k_0$ space-time sheets. The leakage to the smaller space-time sheets can be also induced by radiation with frequency corresponding to the increment of the zero point kinetic energy and the transversal electric field involved with radiation can be regarded as inducing the force driving the particles to smaller space-time sheets or back.

e) The strange findings indicating that DNA can behave like a super-conductor [24], an ohmic conductor [25], or an insulator could be perhaps understood in terms of the local architecture of the many-sheeted space-time. If only atomic space-time sheet is present, DNA would behave as insulator. If larger space-time sheets are present DNA behaves as an effective ohmic conductor in the sense that dissipative effects are present. If only single larger space-time sheet is present, super-conductivity is possible so that the manufacturing of super-conductors should reduce to space-time engineering.

4.3 Quantitative model for the breaking of super-conductivity

The dropping (or leakage) of electronic Cooper pairs from $k = k_0$ (say $k_0 = 151$ corresponding to cell membrane thickness) space-time sheet to larger space-time sheets possibly present and followed by a thermal kicking back to $k = k_0$ space-time sheet is a good candidate for the mechanism causing the breaking of magnetic super-conductivity.

The conductivity as a function $\sigma(k)$ of the p-adic length scale $L(k)$ should characterize the mechanism quantitatively. If the thermal energy $E_{th} = T$ satisfies the condition

$$\begin{aligned} E_0(k) - E(k_>) < T < E_0(k_<) - E(k) \ , \\ E_0(k) = n_1 \times \frac{\pi^2}{4m_e L^2(k)} \ , \end{aligned} \tag{5}$$

one can say that the space-time sheet k is the effective carrier of the current.

The mechanism predicts that the increase of the temperature is accompanied by a sequence of phase transitions in which the value of k characterizing the

effective carrier of the current decreases in a stepwise manner: $k = 169 \to 167 \to 163 \to 157 \to 151 \to ....$ These transitions occur at temperatures $T(k) = n \times E_0(k)$, n a numerical constant. This picture is consistent with the observation that the reduction of resistance occurs in a very short temperature interval ΔT: $\Delta T/T \sim .04$.

A more concrete picture is obtained by decomposing the friction force to a sum of forces resulting from dropping from say $k = 151$ to $k = 157163, 167, ...$ and being kicked back. This gives

$$\begin{aligned} F &= K(k)v \ , \\ K(k) &= \sum_{k_i>k} \kappa(k_i) = \kappa(k_>) + K(k_>) \ . \end{aligned} \tag{6}$$

The condition $F = qE$, $q = 2e$, gives for the conductivity defined by $j = nv = \sigma(k)E$, E electric field, the expression

$$\frac{1}{\sigma(k)} = \frac{K(k)}{nq} = \frac{\kappa(k_>)}{nq} + \frac{1}{\sigma(k_>)} \ . \tag{7}$$

What this means that the space-time sheets correspond effectively to resistors in series.

From the experimental findings for frog, for the transition from $k = 157$ to $k = 151$ the term $\kappa(157)$ must be by about a factor 10 larger than the sum of terms term $\kappa(k)$, $k > 157$. The fractal scaling

$$K(k) \propto \frac{1}{L^\alpha(k)} \propto 2^{-\alpha k/2} \tag{8}$$

with $\alpha \simeq 1.1$, suggests itself.

The standard classical model for the dissipative force implies that the force is inversely proportional to the free path $l(k)$ of the particle and by naive scaling symmetry l would be naturally proportional to the p-adic length scale $l \propto L(k)$ giving $\alpha = 1$. $\alpha > 1$ for $K(k)$ means that the free path has a fractal dimension slightly larger than one. The anomalous dimension is due to the many-sheeted nature of the free paths implying the presence of the higher order terms in the expansion of $K(k)$. Indeed, in the lowest order the model based on the naive scaling dimension -1 for $\kappa(k)$ predicts

$$\frac{\sigma(151)}{\sigma(157)} \simeq 1/8 - 1/64 \simeq .11 \tag{9}$$

in consistency with the measured reduction of the resistivity. Needless to say, this prediction provides a strong support for the p-adic length scale hypothesis and the notion of many-sheeted space-time.

4.4 Application at axonal level

It is interesting to apply the model for the breaking of super-conductivity in the case of axon.

4.4.1 Understanding the critical temperature

The model for the nerve pulse generation predicts that "bridges" are formed between $k = k_0 > 151$ (say $k_0 = 169$) and $k = 151$ space-time sheets making possible the flow of ions between cell interior and exterior. Super conductivity is broken provided that the temperature is sufficiently high. For electron Cooper pairs ($M = 2m_e$) the zero point kinetic energy at the cell membrane space-time sheet is from Eq. 5

$$E_0(k = 151) = n_1 \times 312.25 \text{ K} \ . \tag{10}$$

n_1 is some numerical constant not too far from unity. $n_1 = 1$ corresponds to a temperature 42.25 C. The identification as the critical temperature gives quite satisfactory agreement with the experimental values varying from 240 K to 300 K. Note that the requirement $T > T_{cr}$ for the physiological temperatures means that $k = 151$ cell membrane space-time sheet is the effective current carrier in the presence of larger space-time sheets.

If the join along boundaries bond connecting $k = 169$ and $k = 151$ space-time sheets contains a strong enough transversal electric field, the supra current can flow only in one direction. It seems that in the case of cell membrane the leakage of electronic Cooper pairs to the negatively charged cell interior is forbidden by this mechanism. The absence of the join along boundaries bonds between cell membrane and cell exterior assumed to be generated during the nerve pulse in the TGD based model of the nerve pulse [D5] in turn implies that the leakage cannot occur to or from $k = 169$ space-time sheets at all. Therefore both $k = 151$ and $k = 169$ space-time sheet might be genuinely super-conducting and only nerve pulse conduction would be accompanied by the breaking of super-conductivity.

4.4.2 Predictions for the critical temperature and resistance

Fractality allows to make definite quantitative predictions for the critical temperature.

a) For $k = 163$ conductivity the critical temperature is predicted to be by a factor $2^{157-151} = 64$ lower than for $k = 157$ conductivity. This gives $T_c(163) = 4.9$ K for $T_c(157) = 300$ K. The upper bound $T_c = 4$ K for the critical temperature for super-conductivity in molecular crystals is reported in [26]. This would correspond to $T(157) = 240$ K measured in the case of frog. The predicted lowering of the resistance at this critical temperature for nerve conduction might be testable.

b) The observation that DNA attached between carbon and rhenium electrodes becomes super-conducting below the critical temperature of about 1 K for rhenium [24] allows the possibility that DNA becomes super-conducting already at about $T_c(163) \simeq 4 - 5$ K but that the rhenium acts as the weak link in the super-conducting circuit.

c) Cell membrane thickness L might vary and the natural guess is that the critical temperature is inversely proportional to $1/L^2$. If this is the case, the ratio of cell membrane thicknesses for frog and rabbit should be

$$\frac{L(frog)}{L(rabbit)} = \sqrt{\frac{T(rabbit)}{T(frog)}} = \sqrt{5/4} = 1.12 \tag{11}$$

for $T(rabbit) = 300$ K and $T(frog) = 240$ K.

d) A further prediction following from the fractal model for the conductance (Eq. 8) is that also the $k = 157 \rightarrow 163$ at about 4-5 K involves a 10-fold reduction of resistance. Also this prediction might be testable for nerves.

4.4.3 What happens in saltation?

An interesting question is what happens in the saltation over the myelin sheathed portions of the nerve. According to the TGD based model of nerve pulse [D5], the Z^0 ME ("massless extremal", "topological light ray" moving with effective velocity equal to the conduction velocity of nerve pulse acts as a bridge between cell membrane ($k = 151$) and cell exterior ($k = 169$) space-time sheets and in this manner allows the leakage of ions from cell interior to exterior and vice versa inducing the physiological effects of nerve pulse. Z^0 ME could propagate along the myelin sheath rather than along the axon inside. Therefore nerve pulse would not be generated. The following picture about saltation suggests itself.

a) The transformation of the nerve pulse to an electronic $k = 151$ or $k = 169$ supra current propagating rapidly through the myelin sheathed portion would make possible a rapid signal transmission without physiological effects. Inside myelin sheathed portions of the axon the leakage to $k = 169$ space-time sheets would be impossible by the mechanism described above irrespective of the value of the critical temperature.

b) Nerve pulse conduction involves also communication and interaction between different space-time sheets and therefore necessitates the leakage of electronic Cooper pairs from $k = 151$ cell membrane space-time sheet. Therefore the critical temperature must be below the range of the physiological temperatures. Endotherms have an evolutionary advantage since the higher critical temperature implies that the dissipative effects associated with the nerve pulse conduction are weaker.

Whether electronic supra current in the myelin sheathed portions of the axon propagates along $k = 151$ or $k = 169$ space-time sheet or along both plus possibly along some other space-time sheets, remains unclear. The fact, that cyclotron transitions for ions in the Earth's magnetic field generate ELF radiation in EEG range [D3, D5], supports the view that $k = 169$ space-time sheet is involved. Note that the critical temperature in myelin sheathed regions could be higher than the physiological temperature.

It is interesting to notice that Evan Harris Walker [27] has developed a quantitative theory in which the tunneling of electrons through the synaptic contact is the basic step of synaptic transfer. The theory applies also to ephapses in which electric transfer of the nerve pulse takes place. Theory explains the differences between ephapses and synapses and also the morphology of synapses and ephapses finds natural explanation. This kind of tunneling might be induced by the formation of 151-169 Z^0 ME contacts at presynaptic cell and 169-151 Z^0 ME contacts at the postsynaptic cell.

5 Relating the model of nerve pulse with the microtubular level

The relationship of the presumed quantum dynamics of the cell interior to the nerve pulse is the basic topic of quantum consciousness theories. Microtubular conformational dynamics; gel-sol phase transition of the cytoplasmic water

inducing the depolymerization of the actin polymers; the parallelization of microtubuli possibly making possible a coherent generation of infrared em radiation; and Mg^{+2} and Ca^{+2} ions as controllers of polymer stability, are some of the most important pieces of the jigsaw. The hierarchical model of Alex Kaivarainen emphasizing these aspects provided crucial pieces of information [28] allowing to construct many-sheeted view about this process. The hierarchy of condensed matter excitations introduced by Kaivarainen corresponds in TGD framework to the hierarchy of space-time sheets whereas the molecular Bose-Einstein condensates of Kaivarainen correspond to BE condensates of various bosonic atoms/ions and Cooper pairs at various cold space-time sheets. The classical article of Nanopoulos summarizing basic facts and various ideas about microtubuli [29] has been a continual source of information and inspiration and is warmly recommended.

Perhaps the most important new element are negative energy IR MEs having phase conjugate laser beams [6] as physical counterparts. First of all, they make possible intentional action at the microtubular level: even the TGD based model of mRNA-protein translation involves intentional aspects. Negative energy MEs are crucial for the understanding of the macrotemporal quantum coherence and have inspired the notions of remote metabolism and quantum credit card. The notion also leads to what might be called seesaw mechanism of energy metabolism, and allows to understand how microtubular surfaces provide dynamical records for the cellular sol-gel transitions and thus define fundamental microtubular representation of declarative long term memories.

5.1 General ideas

TGD provides several new physics concepts whose role in biochemistry is now relatively well understood thanks to the insights provided by the construction of the model of prebiotic evolution [D12]. Hence there are hopes of understanding the basic principles of cellular control at macromolecular level, and to apply these principles to understand what happens during nerve pulse in the interior of neuron. It is not possible to overestimate the importance of the fact that p-adic length scale hypothesis makes the model quantitative and reduces the number of alternatives dramatically.

5.1.1 Increments of zero point kinetic energies as universal metabolic currencies

The protons and also various other ions and possibly even electrons liberate their zero point kinetic energy while dropping to larger space-time sheets. This process and its reversal define metabolism as a universal process present already during the prebiotic evolution rather than as an outcome of a long molecular evolution [D12]. ATP-ADP transformation, polymerization by dehydration, and its reversal are key examples of the many-sheeted dynamics involving the dropping of protons from $k = 137$ space-time sheet liberating about .4-.5 eV of zero point kinetic energy and the reversal of this preocess. In TGD framework metabolism generalizes to a fractal metabolism involving a large number of metabolic currencies.

Negative energy MEs make possible remote metabolism realizing what might called quantum credit card. This makes energetic economy extremely flexible. F-actin polymerization [28] is an interesting application of this notion.

a) Each G-actin unit of F-actin is stabilized by Ca^{+2} ion and contains one ATP molecule. The polymerization of G-actin molecule is accompanied by an

ATP-ADP transfromation involving the dropping of a proton to a larger space-time sheet.

b) The fact that F-actin polymerization does not require energy [28] suggests that the zero point kinetic energy liberated in this manner is used to kick one proton to an atomic space-time sheet in G-actin molecule needed in dehydration inducing the polymerization.

c) This is achieved if the G-actin molecule emits a $.4 - .5$ eV negative energy photon inducing the hopping of proton to an atomic space-time sheet associated with G-actin. The negative energy photon is received by the ATP molecule and induces the dropping of proton from atomic space-time sheet associated with the ATP molecule. This energetic seesaw could be controlled by a precisely targeted intentional action of the G-actin molecule by the generation of p-adic ME transformed then to negative energy ME. The seesaw mechanism can be generalized to a mechanism controlling the occurrence of sol-gel transitions.

A natural guess is that the emergence of larger space-time sheet with sizes characterized by p-adic length scales is a correlate for the evolution of more refined control and information processing structures utilizing smaller energy currencies. The situation is essentially quantal: the longer the length scale, the smaller the quantum of the metabolic energy. Microtubuli and other intracellular organelles represent excellent candidates for this kind of higher level metabolism refining the standard metabolism based on .4-.5 eV energy currency.

Since negative energy MEs with energies above thermal energy scale cannot induce transitions to lower energy states, a good guess is that negative energy MEs corresponding to metabolic currencies above the thermal energy $T_{room} \sim .03$ eV can be utilized for entanglement purposes. This is only a rough rule of thumb since the energy spectrum of systems at a given space-time sheet is expected to have an energy gap. Therefore negative energy MEs, even those below the ELF frequency range, are expected to be important.

Allowing n-ary p-adic length scales, this would mean in the case of hydrogen atom the upper upper bound $L(3,47)" = "L(141) = 2L(139)$ for the p-adic length scales in the hierarchy of water clusters. For electron the upper bound is cell membrane thickness $L(151) \simeq 10$ nm, which corresponds to the effective axonal electronic superconductivity with the metabolic currency $.025 - .03$ eV. Interestingly, the water at room temperature contains flickering structures of size of order 20-30 nm with lifetime of order .1 ns [30]. MEs at energy $\simeq .03$ eV could stabilize these structures by kicking the dropped Cooper pairs back to k=151 space-time sheets. One can also ask whether microwave MEs at GHz frequency, perhaps generated in the rotational transitions of water molecules, modulate the generation of .03 eV MEs and are thus responsible for the flickering.

5.1.2 Liquid crystal phase of water as stabilizer of biopolymers

The second key element is the understanding of the role of the liquid crystal [31] water in the stabilization of various biopolymers. The reason is that the water molecules making possible depolymerization by hydration (also other means, say by the addition of heavy water or the increase of salt concetration, of reducing water activity have a stabilizing effect) are frozen to the liquid crystal. Thus the control at the level of biopolymers could reduce to the control of whether cellular water is in sol or gel phase and to the understanding of what sol-gel difference means in the many-sheeted space-time.

Local gel-sol transitions could also provide a fundamental mechanism of cellular locomotion applied by, say, amoebae. Quite generally, various conformational changes needed in the cellular control are made possible by a local

melting of the gel to sol followed by the conformational change in turn followed by a local sol-gel transition stabilizing the resulting conformation. The technological counterpart of this process is welding. The ME-controlled local melting and solidification of metals might in future technology make possible machines changing their structure routinely.

Local sol-gel transitions could also make possible the control of the conformations of the tubulin dimers expected to be sensitive to the di-electric constant of the water between the alpha and beta tubulin. This would mean that sol-gel phase transition and its reversal could define the bit of the declarative long term memory. Em MEs inducing gel-sol phase transition could provide a precisely targeted control of this kind. This would mean that coherent BE condensed photons associated with MEs could induce the sol-gel phase transition.

5.1.3 What distinguishes between sol and gel phases?

Sol-gel transition is crucial for the polymerization of actin molecules and microtubuli, and this dynamics probably involves something more refined than the molecular $k = 137$ metabolism. The dropping of protons/hydrogen atoms or of protonic Cooper pairs from $k = 139$ space-time sheet to larger space-time sheets is thus a unique candidate for what is involved with sol-gel transition.

The liberated zero point kinetic energy would be .1 eV for the dropping of proton or hydrogen atom (if .4 eV is the fundamental metabolic quantum). For protonic Cooper pairs the energy would be .05 eV. According to the findings of Albrecht-Buehler [16], the response of cells to IR radiation at .1 eV photon energy is maximal. Hence hydrogenic Bose-Einstein condensate at $k = 139$ space-time sheet might distinguish between the liquid-crystalline gel phase and sol phase. The particles of this effectively 2-dimensional liquid would be loosely bound tubular structures having a radius of about $L(139)$ and the BE condensate of the dropped hydrogen atoms would bind the water molecules to form this structure. Ordinary water would result when the hydrogen atoms at $k = 139$ space-time sheet drop to larger space-time sheets. $k = 139$ space-time sheets would be also associated with small sized water clusters.

The model for the effective electronic superconductivity discussed above generalizes to the case of Bose Einstein condensates, and allows to develop a more precise picture. At the room temperature the thermal photons have energy lower than the zero point kinetic energy .1 eV so that the BE condensate can be maintained only by feeding IR photons kicking the hydrogen atoms back to $k = 139$ space-time sheet with a high enough rate. Therefore the stabilization of the gel phase requires an expenditure of metabolic energy. The simplest view is that in the ground state the entire interior of the cell is in gel phase so that the cell interior would have tonus analogous to muscular tonus.

By stopping the feed of the energy by IR MEs to a particular region of cell, gel-sol transition with its various outcomes would occur spontaneously. A faster and energetically more economic manner to achieve the same outcome is to generate negative energy IR MEs which induce the dropping of the hydrogen atoms from $k = 139$ space-time sheets. This mechanism also guarantees the stability of polymers by making hydration impossible. A more clumsy manner to guarantee this is to feed protons back to $k = 137$ space-time sheet where they induce dehydration: this process would probably cost much more energy.

5.1.4 IR MEs inducing sol-gel phase transitions as controllers of the cellular dynamics?

In TGD framework cell nucleus is the brain of the cell and acts as the fundamental controller of the cellular dynamics. Genetic expression is the slow part of this dynamics analogous to a rebuilding of the computer hardware. Software corresponds to memes, sequences of memetic codons realized as sequences of 21 DNA triplets in the intronic part of the DNA. Memetic codons are the language with which the cellular programs are written.

Memes express themselves as temporal patterns of IR radiation amplified by microtubuli of length $\sim$ 12.4 micrometers. Of course, in accordance with the fractality, also wavelengths corresponding to other metabolic currencies are probably realized. Single memetic codon carries 126 bits and single bit has a duration of about 1/1026 ms, the basic time scale of the neuronal dynamics. These patterns of IR radiation control at .1 eV induce temporal sequences of sol-gel transitions representing memes physically. The beauty of MEs is that as topological field quanta of radiation they allow a precisely targeted local control not possible in Maxwellian electrodynamics. In particular, temporal sequences of microtubulin conformations could represent long term declarative memories expressed in a universal language using memetic codons as basic units.

The most economical model for the gel-sol transition is based on the generation of negative energy IR photons by the microtubules. The photons are received by the Bose-Einstein condensed hydrogen atoms of the gel phase and therefore dropping to larger space-time sheets. The liberated zero point kinetic energy is utilized remotely by microtubuli and induces a population inversion of hydrogen atoms in the microtubular gel water phases. Microtubuli can therefore act as quantum antennae producing IR photons by the dropping of hydrogen atoms and amplified resonantly, when the microtubule has a length of about 12.4 micrometers. The re-emission of these photons would in turn re-establish the gel phase. This energetic gel-sol seesaw is obviously ideal for the minimization of the dissipative losses.

Microtubuli or the cell nucleus controlling them could even act as conscious entities able to perform precisely targeted intentional actions by generating first p-adic MEs representing the intention to suck energy and momentum from a particular part of the gel phase and transformed then to negative energy IR MEs by p-adic-to-real transition. Negative energy IR MEs would also serve as space-time correlates for the bound state quantum entanglement responsible for the generation of a multi-neuron macroscopic and -temporal quantum state.

Phase conjugate laser beams are the most plausible standard physics analogs for negative energy MEs and the coherent photons generated and Bose-Einstein condensates of photons contained by them. Since the energy .1 eV is above the range of the thermal energies, the negative energy photons can be absorbed only resonantly and thus very selectively. This view is supported by the demonstration of Feinberg showing that it is possible to see through chicken using phase conjugate laser beam [7].

5.1.5 Do Ca^{+2} ions induce dropping of protons from atomic to larger space-time sheets?

Ca^{+2} waves are known to be a fundamental cellular control mechanism and might perhaps be seen as the predecessor of the control based on IR MEs. Ca^{+2} ions are known to induce a depolymerization of microtubules even in micromolar concentrations whereas Mg^{+2} ions having much smaller ionic radius are known

to favour the polymerization of the actin molecules [28]. Ca^{+2} ions which are more abundant in the cell exterior have a large ionic radius of order .099 nm whereas Mg^{+2} ions, which are abundant in the cell interior, have much smaller ionic radius. All this supports the view that these ions have dual roles in cellular control.

As positive ions both Ca^{+2} and Mg^{+2} ions tend to increase the probability of the dropping of protons from the atomic $k = 137$ space-time sheets by repelling the protons from $k = 137$ space-time sheets to larger space-time sheets. This tends to increase the rate of depolymerization by hydration. On the other hand, both Ca^{+2} and Mg^{+2} tend to bind with themselves water molecules which lowers the rate of polymerization by hydration. For Mg^{+2} with a small ionic radius the latter tendency wins: one can also say that Mg^{+2} is too small to act as a seed for depolymerization.

5.2 What happens inside neuron during nerve pulse?

As an application of above general view one can consider a model for what might happen during the nerve pulse inside neuron or axon (this time interval can be as long as .5 seconds). The known pieces of information [28] indeed fit nicely with the above general principles and one ends up with the following scenario.

a) The positive IR radiation by MEs ceases temporarily or is replaced by generation of negative energy IR MEs and induces gel-sol transition. Ca^{+2} ions flowing into the cell interior favour further the depolymerization of actin molecules. Microtubules must receive the stabilizing IR radiation still and must be insulated so prevent the penetarion of Ca^{+2} ions inside them.

b) The hydration of actin molecules means that the activity of the water is reduced inside cell and water molecules from the cell exterior rush to the cell interior. The resulting swelling of the cell tears the positively charged ends of the microtubuli from the cell membrane. The microtubuli are now free to change their conformations and the microtubuli associated with different cells can arrange themselves in parallel configurations temporarily. Therefore they can generate coherent IR light needed to re-establish the gel phase very effectively: in an ideal case the power radiated is proportional to N^2, N the number of synchronously firing neurons.

c) Gel phase is re-generated. Actin molecules re-polymerize and microtubuli stick again to the cell membrane. Synaptic contacts and the distribution of the ionic channels in neuronal membrane are re-structured in the process and this means that learning occurs in the sense that cell begins to respond slightly differently to neuronal inputs. This does not correspond to conscious long term memories, which are represented as temporal conformational patterns of tubulin dimers. These memories are in the geometric past, and can change, and are re-experienced by sharing of mental images or communicating the memories classically as field patterns associated with MEs using memetic code.

d) Tubulin dimers are electrets and can be regarded as miniature capacitor plates containing 18 Ca^{+2} ions at the other plate and 18 electrons at the other plate [28, 29]. The average increments of the configuration space zero modes in the quantum jump sequence giving rise to the change of the conformation defines a two-valued geometric quale characterizing single bit of the long term memory. In [C2] a microtubular spatial cognitive code based on 13×13 bits is discussed. Temporal pattern extends this code to $13 \times 13 \times 126$ bit code.

e) The proposed seesaw mechanism for the cellular control by microtubuli means that sol-gel transition in tubulin induces a gel-sol transition in the controlled part of the cell. Thus it would automatically construct microtubular

declarative long term memory representation as a record about sol-gel transition history in various parts of the cell or cell substructure coded by the positions of tubulin dimers at the tubulin cylinder. These dynamical maps about the active structures in the cell interior would be analogous to neuronal maps in cortex. If cell nucleus is the fundamental controller, also chromosomes might be seen as structures analogous to brain hemispheres forming dynamical sensory and motor maps about the interior of the cell. The static conformations would not represent memory bit. Rather, the changes of the conformations would represent the bit in accordance with the view that moments of consciousness correspond to quantum jumps between histories, and that the sequence of quantum jumps effectively integrates to a single quantum jump during macrotemporal quantum coherence.

6 Quantum model of EEG and ZEG

The general ideas behind the interpretation of EEG and ZEG were already discussed in the introduction. In nutshell: magnetic body corresponds to "me" as an experiencer and intentional agent having material body as its sensory and motor organ and sensory perception, motor action, and memory recall rely on the same basic mechanism. In the following a quantitative model of EEG and ZEG is developed. p-Adic length scale hypothesis is applied to predict preferred resonance frequencies in EEG. Tests for the coding of the time span of memory to the length of the magnetic tube are proposed. The notion of "feature" introduced by Freeman [19] is interpreted in terms of the memetic code. Finally, a model for neuronal synchronization based on Z^0 MEs is developed.

6.1 EEG and ZEG

The interpretation of EEG and ZEG is based on following assumptions.

a) Negative energy interior MEs entangle and communicate desires for various kinds of activities to the geometric past by the sharing of mental images. If the mirror mechanism of memories is realized using body and brain as time-like mirror, then the EEG frequency correlates directly with the distance from brain along the flux tube of the personal magnetic body to the point at which the negative energy ME representing the desire to remember is generated.

b) Positive energy boundary MEs for which effective phase velocity equals to a typical EEG phase velocity realize these desires by inducing various kinds of self-organization activities. They can leak the system as interior MEs propagating with light velocity along magnetic flux tubes in which case they can communicated symbolic representations about motor activities and sensory perceptions. Boundary MEs propagating along the magnetic flux tubes of the Earth's magnetic field could be also involved with the realization of declarative long term memories. The time spans of memories are indeed measured in years for MEs in EEG frequency range.

c) Em MEs, in particular EEG MEs, are specialized to all related to the sensory perception whereas ZEG MES are specialized to all that relates to motor actions, also symbolic representations. Justification for this comes from several findings. Classical Z^0 fields are ideal for control purposes already at molecular level (enzyme action involving chiral selection) since atomic nuclei are completely ionized Z^0 ions. The control would be based on the variation of the density of neutrino Cooper pairs affecting Z^0 screening. Em MEs are accompanied by both coherent and BE condensed photons and they could act

as universal sensory currencies making it possible to generate virtual sensory experiences. This might make sense in case of "brain senses" at least (with hearing and tactile senses excluded, see the article "Quantum model of sensory receptor" in this issue of JNLRMI).

6.1.1 EEG and sensory perception

Negative energy EEG MEs would be involved with various control functions involved with the sharing of sensory mental images between magnetic body and brain and the construction of sensory percepts. The latter includes the direction of attention, selection between percepts, communication of the desire to remember something related to sensory perception, etc...

Negative energy em MEs at a wide frequency range could be generated by time reversed cyclotron transitions of ions at the magnetic flux tubes of the Earth's magnetic field and also at the flux tubes associated with magnetic hierarchy accompanying DNA (this view is supported by Gariaev's findings [10]). For instance $k = 163$ flux tubes would correspond to kHZ frequency scale for ions. Electron's $\Delta n = 1$ spin flip transitions generate frequencies of about 900 kHz in Earth's magnetic field.

Positive energy EEG MEs would be involved with the classical communication of symbolic representations to the magnetic body.

a) The EEG generated by the dropping of ions to magnetic flux tubes and the harmonics of cyclotron frequencies should appear as resonance frequencies for the symbolic representations at the magnetic body. Nerve pulse sequence gives rise to what might be regarded as propagating EEG waves. The propagation with the phase velocity of EEG wave can have different meanings.
i) The propagation of EEG MEs could be induced by the propagation of the nerve pulse serving as the source of EEG/ZEG MEs which would be interior MEs transversal to the axon. The propagation of ME would be achieved by a Lorentz boost in the direction of axon. At the limit of trivial Lorentz boost standing EEG waves would result. These MEs generated by cyclotron transitions associated with oscillations of the membrane potential in soma and possibly also gap junction connected groups of neurons and glial cells.
ii) For a boundary EEG ME parallel to axon the slowing down can be understood to reflect the shifting of ME towards geometry future quantum jump by quantum jump. This shift would be induced by the stucking to the boundary. Note that the model of nerve pulse does not require em boundary MEs , and one must keep mind open for the possibility that only ZEG boundary MEs are there. These boundary MEs can be transformed to interior MEs inside magnetic flux tubes of the magnetic body.

In both cases the real classical propagation of the classical signal is in the direction of MEs and occurs with light velocity. Alpha waves are indeed known to propagate with velocity which is of order of nerve pulse propagation velocity, and it would be rather peculiar if also other EEG waves could not propagate (this does not mean that EEG waves must progate always). Llinas has provided evidence for the propagation of also 40 Hz EEG waves [32].

b) The experienced world has two basic components: static objects and dynamical events. These could have standing and moving EEG and ZEG waves as correlates. Note that the reduction of the effective phase velocity of EEG wave allows velocities reducing to the velocities of nerve pulse. Besides nerve pulses there is rich repertoare of various waves such as Ca^{+2} waves probably generated by Z^0 MEs and these could serve as correlates of the dynamical part of the sensory experience at some levels of self hierarchy.

c) It is usually believed that EEG resonance frequencies result as resonances in neuronal loops and thus correspond to the frequencies associate with autocorrelation functions of spike patterns. TGD based explanations is obviously not consistent with this explanation. Correlations are however possible. The pendulum metaphor suggests that the dropping of ions to the magnetic flux tubes induced by a nerve pulse sequence for which autocorrelation function has the harmonics of the cyclotron frequency as resonance frequencies, implies that the resulting EEG MEs tend to interfere constructively so that EEG correlates with resosnance frequencies of the autocorrelation function.

6.1.2 ZEG and motor action

ZEG would be involved with various aspects of motor action such as the communication of the desire to generate particular motor action, symbolic representations related to motor action, and memory representations about motor action. Motor actions is defined in very general manner: for instance, shift of attention involves motor action at some levels of the hierarchy of magnetic bodies.

a) The motor part of ZEG serves control purposes by generating nerve pulse patterns: the ZEG ME is necessarily parallel to the axon and corresponds to boundary ME. The frequencies involved are multiples of a basic frequency of order 1 kHz, which is the frequency involved with the neuronal synchrony. $\Delta n =$ 1 spinflips of neutrinos at $k = 151$ space-time sheets of the Z^0 magnetic body of neuron could generate the harmomics of this frequency. Thus neutrinos would be in a central role in the generalized motor control. If Z^0 magnetic field at $k = 173$ space-time sheet satisfies the scaling law $g_Z B_Z = eB/16$, the electronic Z^0 cyclotron transition frequency is 750 Hz, which by a factor of 3/4 too small.

b) ZEG MEs responsible for symbolic representations about motor actions at personal Z^0 magnetic body result in cyclotron transitions and have frequencies which are harmonics of fundamental which is near to 10 Hz for all particles except proton and electron and thus in alpha band. The reason is that the Z^0 charge to mass number ratio N/A appearing in the cyclotron frequency is near to $N/A = 1/2$. Z^0 pulse sequences coding for memetic codons are also coded to intensity variations of cognitive ZEG. For cyclotron transitions of particles with nonvanishing neutron number $N = A - Z$ at $k = 173$ space-time sheet in brain distance coding is allowed by resonance condition only for representations in the nearby Z^0 magnetosphere, where Z^0 magnetic field is not appreciably weaker. The Z^0 charge of proton is by a factor of $\sim 1/50$ weaker than that of neutron. Hence the protonic Z^0 cyclotron transitions occurring inside brain generate Z^0 MEs making it possible for heavier atoms and ions of Z^0 magnetosphere to serve as representatives up to distances $3.7R$. This region corresponds to the inner magnetosphere. Electronic cyclotron transitions in magnetosphere have frequencies scaled up by a factor $2 \times 10^3/50$ from those for neutron and nuclear Z^0 cyclotron transitions in brain having frequencies around 10 Hz could be represented up to distances $5.4R$ by electronic Z^0 cyclotron transitions.

c) The fast part of ZEG (harmonics of kHz) is modulated by slow part below kHz determining thus the nerve pulse pattern. Hence EEG waves could affect the frequencies associated with the spike patterns if a coupling between EEG and ZEG exists. The existence of the coupling is suggested by the fact that alpha band contains both strongest resonance frequencies of EEG and Z^0 cyclotron frequencies for particles with a non-vanishing neutron number (only N/A ratio matters). The presence of this coupling between EEG and ZEG would naturally result from the simultaneous presence of both Z^0 and em type wormhole contacts feeding nuclear charges to $k = 169$ space-time sheet. This

space-time sheet could be seen as a space-time sheet where motor and sensory representations interact.

d) One should also understand how postsynaptic miniature potentials [33] are generated. Sufficiently large quantized packets of neural transmitter (such as ACh) generate miniature potentials and are regarded as superpositions of large number of micro-potentials generated by the molecules of neural transmitter. If the packets of neural transmitters are Z^0 charged one could see them as Z^0 plasmoids emitted in the strong Z^0 potential difference between pre- and post-synaptic neurons. The transfer of charge to the postsynaptic neuron makes it Z^0 charged and bridges connecting the interior to exterior are necessarily generated. This in turn means generation of Z^0 currents inducing oscillations of Z^0 potential and thus also of membrane potential. The higher the mass of the transmitter molecule, the stronger and more long lasting its effect should be.

6.1.3 Tests for the basic assumptions

1. How to teste the frequency coding for the span of memories?

The first interpretation suggested for EEG frequencies was in terms of place coding for the distances of the the objects of perceptive field. An alternative hypothesis suggested by the model of memory is that frequency codes for the time span of the memory. This could make sense for both personal magnetic body and for magnetic Mother Gaia which would correspond to interior and boundary EEG MEs respectively. These hypothesis reduce to each other in case that spatial gradients are coded to temporal gradient as in case of saccadic motion. In fact, the general vision that only changes are experienced and that they are coded to subjecto-temporal gradients supports this idea.

The hypothesis that basically temporal distance is coded could in principle be tested whether a conscious shift of attention in short term memory induces a shift of peak EEG frequency.

The hypothesis that EEG frequencies in narrow EEG bands code for the distance of an object of perceptive field, possibly by coding first the distance to subjective time, can be tested in an analogous manner. If subject person directs attention to a moving object of the perceptive field, the peak frequencies inside the narrow EEG bands responsible for the place-coding should shift.

2. How to test the hypothesis that primary sensory representations occur at the level of sensory organs?

That retinas are involved with the attention is known for some time: directing the attention to an object of the visual field does not necessarily imply directing the gaze to the object [43]. The amplification of the back-projections from frontal lobes to the part of retina in question is enough, and if the feedback exceeds a critical value the direction of the gaze is changed. This suggests that the mental image of the object of the perceptive field is realized at the retina and corresponding magnetic body and directing of attention to it feeds metabolic energy to this mental image. If the fundamental visual representation occurs at the level of retinas, the selection of the visual percept in the visual rivalry might be detectable at the level of retinas.

80 Hz frequency is known to be associated with retinas, and one can wonder whether this would determine the size of magnetic body associated with retina (the size would be slightly below Earth radius!). It would be worth of testing whether the pattern of 80 Hz activity associated with retinas correlates with

the selection of the sensory percept say in case of sensory rivalry: certainly this is not what standard neuroscience would suggest but would be worth of testing.

6.2 Scaling law and EEG

A decisive step of progress in the attempts to understand the origin of EEG came from the explanation of the scaling law of homeopathy [8, D2] stating that high and low frequencies f_{high} and f_{low} inducing biological effects accompany each other in a pairwise manner in the living matter. The scaling law can be interpreted as relating the fundamental frequencies for high frequency MEs propagating inside low frequency MEs. Scaling law is certainly an idealization. The most general assumption about the spectrum of high frequency MEs inside low energy MEs and consistent with scaling law is that it is scale invariant in the sense that the intensity satisfies $I(f_{high}, f_{low}) = I(f_{high}/f_{low})$.

6.2.1 Scaling law of homeopathy and the mechanism generating EEG

The TGD based explanation of the scaling law generalizes the law and predicts also a spectrum of possible values for the ratio of the high and low frequencies. The law provides also some additional understanding to how EEG results in the many-sheeted space-time.

a) The most natural interpretation is that high frequency MEs propagate along low frequency MEs like mass-less particles. There is in principle a hierarchy of these MEs within MEs and its generation is TGD correlate for the decoherence of Maxwell field meaning that the Fourier components associated with the frequencies involved do not interfere anymore.

Low frequency MEs induce cyclotron transitions and more general magnetic transitions occurring coherently for superconducting magnetic flux tubes and thus defining what might be called magnetic qualia, kind of "simple feelings of existence". High frequency MEs induce self-organization by kicking ions between two different space-time sheets (that is, by generating a 'bridge' between the space-time sheets involved). For instance, in the case of axon em ME can be parallel to axon and serve as longitudinal bridge between $k = 137$ and $k = 169$ space-time sheets. In this kind of situation their velocity is reduced dramatically.

This picture applies to both positive and negative energy MEs. Negative energy MEs serve as quantum entanglers inducing sharing of mental images. They always affect the geometric past and represent desire to achieve something. Positive energy MEs and various neural signals realize this desire. It is now however not clear whehther the velocity of negative energy MEs increases or whether it becomes superluminal.

b) The ratio $f_{low}/f_{high}(k) = v/c$ equals to the ratio of the cyclotron frequency in Earth's magnetic field to the frequency corresponding to the zero point kinetic energy at the space-time sheet labelled by k: $f_{high}(k)$ scales like $p \simeq 2^k$ by the p-adic length scale hypothesis. According to the scaling law, v is identifiable as some characteristic velocity of the system which also corresponds to the effective phase velocity of the positive energy boundary ME. The law generalizes in obvious manner to the case when magnetic field corresponds to some other space-time sheet by assuming that magnetic field strength scales as $1/L^2(k)$. Law applies also to Z^0 MEs with Z^0 magnetic field replacing the Earth's magnetic field: now one cannot speak of photon emission but only classical field.

c) The simplest assumption is that MEs and photons corresponding to $f_{high}(k)$ result when ion drops to the magnetic flux tube and liberates it zero

point kinetic energy difference as a radiation. MEs and photons corresponding to f_{low} result from the decay of the high n cyclotron state resulting when the ion drops to the magnetic flux tube. The transfer of ions from, say, cell membrane space-time sheet to the magnetic flux tubes of the Earth's magnetic field generates EEG at harmonics of cyclotron frequency. The periods of the periodic table indeed seem to correspond to the bands of EEG [D7, D8].

The longitudinal momentum along magnetic flux tube implies that the frequencies of the cyclotron transitions are not actually discrete but one has good reasons to expect that EEG has cyclotron frequencies as resonance frequencies. Also the local value of Earth's magnetic field affects the frequency scale and allows frequency coding by the scale of cyclotron frequencies. EEG is predicted to have scaled up counterparts at magnetic flux tubes associated with shorter p-adic length scales than $k = 169$ ($k = 151, 157, 163, 167$ in particular). The finding of Peter Gariaev [10] that the irradiation of DNA by laser light generates radiowaves gives support for the presence of the scaled up versions of EEG in living matter [D4].

d) For $k = 151$ corresponding to the cell membrane space-time sheet, the value of the velocity is from the scaling law of homepathy about $v \simeq 7$ m/s and is inversely proportional the local magnetic field, which is probably subject to homeostatic regulation. This velocity corresponds to the phase velocity of the alpha waves at the surface of skull. This would suggest that EEG results when ions drop from $k = 151$ space-time sheet to the flux tubes of Earth's magnetic field. for $k = 149$ the velocity is 12 m/s. The velocity of alpha EEG waves at the surface of cortex is indeed twice the velocity at the surface of skull. The interpretation is that during the generation of nerve pulse the Z^0 ME serving as bridge between $k = 151$ and 169 space-time sheets allows the leakage of ions from cell membrane space-time sheets. There are also n-ary p-adic length scales associated with $k < 149$: for instance, $k = 143 = 11 \times 13$ corresponds to $L(11, 13)$ and to the velocity $v = 96$ m/s which could be involved with axons from sensory receptors. The testable prediction is that velocities for EEG waves should tend to come in ratios which are powers of $\sqrt{2}$. In this case however both $(151, 169)$ Z^0 bridge and $(k, 169)$ em bridge are required.

e) The scaling law of homeopathy states also that low frequencies generate high frequencies. In this case the slowing down of the boundary ME is would be caused by the generation of inertial mass of ME due to the particles flowing along boundary ME bridge between the space-time sheets. Slowing down means that the wavelength of ME effectively becomes much shorter, of the size of the brain structure involved. Consequently high frequency MEs with this wavelength are generated. For instance, alpha waves should be accompanied by microwave MEs of wavelength of about skull size and Ca^{+2} waves by MEs with wavelength of size of order neural structure involved.

6.2.2 Evolution as emergence of lower frequency scales

Scaling law suggests an entire hierarchy of magnetic bodies. The prediction is that evolution should correspond to the emergence of higher level selves characterized by decreasing EEG frequency scales. The reduction of the EEG frequency scale would directly correspond to the growth of the personal magnetic body and the increase of the time span of memories. This prediction seems to make sense.

1. Candidates for the resonance frequencies of EEG

There is a wide variety of special frequencies in ELF range which can act as

resonance frequencies for the interaction of MEs with the Alfwen waves associated with magnetic flux tubes (transverse oscillations of the flux tube propagating with light velocity). These frequencies are discussed in detail in [D8], where also detailed tables for various transition frequencies in Earth's magnetic and Z^0 magnetic fields can be found. A more general discussion about the possible role of resonance frequencies can be found in [D11].

a) The cyclotron frequencies of various ions in the magnetic field of Earth span EEG range and that various EEG bands seem to correspond to the periods of the periodic table. Spin flip frequencies are in general above EEG range with few exceptions. The homeostatic variation of the local magnetic field widens these frequencies to narrow bands and the slow variation of frequency along magnetic flux tube could code for temporal and spatial distances.

b) p-Adic length scales define good candidates for important EEG frequencies via the formula $f(k) = c/L(k)$. This spectrum contains the fundamental frequencies 5, 10, 14, 28, 40 Hz and their harmonics are known to be resonance frequencies of EEG. Since these frequencies represent constants of Nature in TGD framework, the success of this prediction provides a strong support for TGD.

c) Schumann resonances represent also important resonance frequencies presumably important for collective consciousness and remote mental interactions induced by magnetic Mother Gaia. The lowest resonance corresponds to 7.8 Hz. The effectively 2-dimensional waves in narrow Schumann cavity of thickness about 80 km have lowest resonance frequency in a good approximation equal to 10 Hz so that the fundamental frequency of the memetic codon, which is also the peak alpha frequency, is realized also magnetically.

d) Assuming that Z^0 magnetic field corresponds to the p-adic length scale $L(k)$, $k = 173$, the Z^0 magnetic cyclotron frequencies for the nuclei containing neutrons are in alpha band and could couple to to EEG frequencies. An idea whose detailed consideration might be very rewarding is that alpha band could be seen as a direct signature of the classical Z^0 magnetic force.

2. Support for the prediction that lower frequencies correspond to higher levels of cognition

EEG is possessed only by vertebrates and lowest EEG frequencies are associated with the highest levels of information processing. Also resonance frequencies above EEG spectrum are present and some of the could correspond to spin flip frequencies.

a) For instance, the dominating rhytm in cerebellum is about 200 Hz and could correspond to some magnetic spin flip frequency. Representative examples of spinflip frequencies for ions in the magnetic field of Earth [D8] 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.

b) The spinflip frequencies in EEG range of various ions are discussed in detail in [D8] and are $f_s(Cl) = 82$ Hz and $f_s(Rb) = 81$ Hz (80 Hz microtremor 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 [34]), $f_s(Au) = 14$ Hz (the sleeping spindle frequency).

Cyclotron frequencies are in EEG range. 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 a high level mental function distinguishing sharply between humans and other species. This sug-

gest a cortical 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, lowest level cortical symbolic representations would correspond to gamma frequencies, in particular frequencies near 40 Hz; more complex and integrated 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 ($f = 1/T$ for interior MEs and $f = (c/v) \times 1/T$ for boundary MEs).

It deserves to be emphasized that all conscious experiences and therefore also various representations are about changes: the lower the EEG frequency, the more abstract and more holistic the change in the percept.

As already noticed, in TGD framework one must also 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 available.

3. Does ontogeny recapitulates phylogeny principle hold true for EEG?

It is interesting to test whether ontogeny recapitulates phylogeny principle (ORP) holds true also in the case of EEG. According to [35], the wake-up EEG of infants before 3 months age consists of 'fast' background activity: this might indeed be interpreted in terms of ORP.

At three months posterior delta rhytm appears at 3-4 Hz and gradually shifts to 6-7 Hz during the first life year. According to [36], 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 symbolic representations.

According to [37], for infants the counterpart of the alpha band appearing in darkness is the occipital rhytmic activity in the range $5.2 - 9.6$ Hz with peak frequency at about 7 Hz and increases gradually. Perhaps color black, which also infants could see "cognitively", could be place-coded by frequencies in this frequency range. 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 rhytm of about 13 Hz of adults. It would be interesting to know whether the sensorymotor rhytm is eventually established via a continuous shift of this band or not. In any case, 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 magnetic body get gradually stretched (thinner) during the growth so that the increasing distances of the body extremities from head are coded by increasing magnetic transition frequencies.

The naive application of ORP would suggest that gamma, beta, alpha and theta bands should emerge in this order during the development. Alpha rhytm and sensorymotor rhytm however emerge from theta band and gradually shift to higher frequencies. The conflict with ORP might be only apparent if magnetic nursing is involved. The work of Jaynes [38] 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 rhytms in theta band could indeed be seen as an indication for a kind of magnetic nursery provided by higher level magnetic selves, in particular magnetic Mother Gaia, and responsible for the third person aspect of consciousness and making also possible long term mem-

ory realized in terms of boundary MEs at EEG frequencies. In TGD framework even prebiotic evolution is guided by magnetic Mother Gaia providing primitive nervous system, metabolic circulation and universal metabolism from the beginning [D12]. Rather interestingly, according to Jaynes [38], sitting in mother's lap can induce EEG in infants not possessing stable EEG yet. A highly interesting question is whether mother's EEG shows a strong correlation with that of infant and whether it deviates from ordinary EEG in theta band.

The interpretation for the shift of the peak frequency is inspired by the view that cognitive and intentional growth, which is basically p-adic, evolves from small to large in p-adic sense and therefore from long to short length and time scales in real sense. For instance, motor skills develop from rough whole body sketches to detailed performances like carving of a 4-D statue. EEG should reflect cognitive evolution and thus indeed proceed from low to high frequencies. In this case magnetic nursery would mean that non-automatic motor action involves a full conscious attention of the personal magnetic body.

The shift of the EEG peak frequency from low to high frequencies could relate with the fact that child begins to have long term declarative memories only after the age of about four years and that childhood memories are the most stable ones. Suppose that EEG boundary MEs with positive energy associated with the magnetic flux tubes of Earth are responsible for the automatically generated declarative memories. The lower the frequency the longer the time span of the memory, and the earlier the memory the later it can be recalled in later life. This would suggest that the earliest childhood memories could be possible only towards the old age and appear spontaneously.

6.3 Basic facts about EEG in TGD framework

The following represents an attempt to interpret basic facts about EEG in TGD framework.

6.3.1 EEG rhytms in contrast to evoked and event related potentials

EEG involves two components: EEG rhytms and evoked and event related potentials. There is a temptation to relate this dichotomy to the negative-positive energy dichotomy for MEs. For negative energy MEs serving as mere entanglers the details of the temporal pattern of the classical field do not matter. This is also true in the case of EEG rhytms. Hence EEG rhytms could be induced by the rhytms associated with negative energy MEs: memory recall as a time-like reflection for ME is a good metaphor for what would be involved.

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 symbolic 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 [39].

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 rhytm is about 200 Hz and cerebellum indeed takes care of microtemporal 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 the 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 inprobable 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.

6.3.2 Coherence of EEG

If the EEG measured at skull relates closely to the symbolic representations about sensory data, it must inherit a high coherence from the high coherence from the hierarchy of magnetic bodies. Also a 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 [34], 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 [34], 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 realized at the level of sensory organs 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 [34], 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 [34], 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 n general 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 [19] 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.

6.3.3 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. An alternative but not necessarily exclusive interpretation for the propagating EEG waves (possibly moving EEG MEs) is as an outcome of nerve pulse activity induced by Z^0 MEs propagating with the effective phase velocity equal to the phase velocity of alpha waves.

In TGD framework it is not obvious how to define the notions of standing and propagating EEG waves. Classically ME represents always a signal propagating with a light velocity accompanied by a lightlike vacuum 4-current. 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. For Z^0 MEs responsible for nerve pulse and EEG the reduction of effective phase velocity should occur in this manner. The effective phase velocity could even reduce to zero in this manner and one would have a standing wave as an outcome. Ca^{+2} have extremely wide velocity spectrum and the suggestion is that they are correlates for Z^0 MEs propagating with the same velocity, and play key role in the bio-control, and also in the realization of non-episodal long term memories as classical communications from the geometric past.

There are also other manners to understand the reduction of the effective phase velocity from light velocity. For instance, EEG MEs resulting during nerve pulse propagation in cyclotron transitions at the magnetic flux tube of Earth would have finite velocity component in the direction of axon equal to the velocity of Z^0 ME responsible for the generation of the nerve pulse. Essentially drifting of em MEs would be in question. Also membrane oscillations controlled by slowly propagating Z^0 MEs could induce EEG MEs, which are comoving in this sense. TGD based model of nerve pulse and EEG predicts the presence of propagating ZEG and EEG waves with a wide velocity spectrum, and one cannot distinguish very slowly propagating waves from standing waves.

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.

6.4 Spectroscopy of consciousness

The basic finding made by the pioneers of bio-electromagnetism [9] was that the irradiation of biomatter with the cyclotron frequencies of various ions in the magnetic field of Earth induces various kinds of biological effects. The only conclusion seems to be that macroscopic quantum phases requiring extremely low temperatures impossible in living matter in standard physics universe are involved. Many-sheeted space-time allows the BE condensates of bosonic ions and of Cooper pairs of fermionic ions at the magnetic flux tubes so that cyclotron transitions could be amplified quantum coherently to quantum phase transitions generating coherent EEG radiation.

What made bells ringing was the observation that ionic cyclotron frequencies in the Earth's magnetic field are in EEG range and that EEG bands correspond to the periods of the periodic table. This lead to the vision about spectroscopy of consciousness. In physics it is possible to deduce the composition of the astrophysical object from its radiation spectrum. In a similar manner, EEG and ZEG spectrum could allow to deduce detailed information about the contents of consciousness. In fact, the function of EEG and ZEG indeed would be a purposeful classical communication of information about the contents of consciousness.

The next step of progress was the realization that these communications could be based on symbolic (cognitive) representations based on various cognitive codes. Typically p-adic prime $p \simeq 2^k$, k prime or power of prime, would define a primary cognitive code with k-bit codeword and the duration of codon would be defined by the corresponding p-adic time scale. Also n-ary cognitive codes corresponding wo n-ary p-adic length scales and with $1/n$-fold reduction of information content from primary codes are possible. What is so remarkable that p-adic frequencies are universal as are also their sums and differences expected to result in extremely non-linear interactions of MEs. Of course ,all linear combinations of the frequencies result by modulation in higher orders and in a resonable approximation frequencies are expressible as integers in the algebraic extension of 2-adic numbers by $\sqrt{2}$. Thus the EEG spectrum could be universal and fixed by p-adic length scale hypothesis alone without a single word about extremely complex brain dynamics!

The most important magnetic transition frequencies are various cyclotron frequencies, spin flip frequencies and combined spin flip-cyclotron frequencies and their harmonics, and possibly also Schumann resonance frequencies. The idea is that the values of magnetic fields should be homeostatically tuned to guarantee that magnetic transition frequencies correspond to universal p-adic frequencies.

6.4.1 p-Adic cognitive representations at EEG frequencies

In the sequel the spectrum of p-adic frequencies relevant for EEG is studied in detail. It must be emphasized that arbitrary low frequencies 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.

1. p-Adic frequencies in EEG range

The interpretation of p-adic frequencies is based on following assumptions.

a) The narrow EEG frequency bands at p-adic resonance frequencies $f(k) = 1/T(k)$ define a hierarchy of sensory magnetic bodies with varying sizes $L(k) = c/f(k)$ and backwards referral times $\tau(k) = 1/f(k)$. Libet's findings [18], discussed in the article "Time, Space-time, and Consciousness" in this issue of JNLRMI, suggest that our level corresponds to a frequency band located around $f(k) \sim 3.5$ Hz in this hierarchy and that all higher frequencies correspond to levels below us not directly conscious to us. One must however take this kind of conclusion very cautiously.

b) Symbolic representations rely on various 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 $[248, 262]$.

d) Bands are assumed to modulate each other. In particular memetic frequency $f_m = 10$ Hz could both modulate higher cognitive frequencies and be modulated by the lower frequencies. The modulation by lower cognitive frequencies f_n would yield frequencies $f_m + f_n$ in beta band $f_m - f_n$ below alpha band. In this manner higher level cognitive representations would result. The fact that EEG spectrum is effectively continuous suggests that very low frequencies below the EEG range are involved with the modulation of EEG. Fractality encourages to see entire universe as a kind of p-adic computer communicating with all possible p-adic cognitive codes.

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.

2. Interpretation of the modulating frequencies as correlates of colors and geometric qualia

The fact that alpha band becomes active when eyes are closed could mean that 11 Hz peak in visual cortex could correlate with the symbolic representation for the color black. The disappearence of beta and gamma bands when eyes are closed could be interpreted as disappearence of the modulations of the memetic band at 10 Hz by other than lowest frequency 1.25 Hz below alpha band. The modulating energy would be however conserved and be transmitted to the 1.25 Hz band.

If the resonant beta frequencies result by the modulation of the alpha band by lower cognitive bands these frequencies could correspond to six primary colors (black and white are counted as colors) so that corresponding cognitive repre-

sentations would code information about parts of the visual field with this color. An analogous memetic representation is expected in other sensory modalities and the representation might apply to all kinds of symbolic representations.

a) The simplest option is that for the lowest frequencies $f_1 = 1.25$ Hz, $f_2 = 1.77$ Hz and $f_3 = 2.5$ Hz the frequencies $f_m + f_i$ and $f_m - f_i$ represent primary colors and their conjugate colors. f_1 would represent color black and two primary colors and their negatives would represent conjugate colors. Note that the numbers of bits would be lowest for black and white and presumably highest for red and green. What is nice that all the six colors would be represented by frequencies in alpha band. The modulation of other resonance bands such as 28 Hz and 40 Hz would produce secondary representations of colors. In particular, 40 Hz resonance band 37.5-42.5 Hz would contain the representations of 6 primary colors.

b) $f_4 = 3.54$ Hz, $f_5 = 5$ Hz, and $f_6 = 7$ Hz would code for some other information, most naturally 6 geometric qualia representing various kinds of geometric information. The flag-manifold F_6 characterizing various choices of color quantization axis appears in the TGD based model [D7] of the honeybee dance [49]. F_6 is a 6-dimensional symplectic manifold allowing in a natural manner 3 coordinates Q_i and their canonical conjugates P_i. These coordinates could represent all kinds of geometric information: also position and momenta in 3-D space. The values of these coordinates would be naturally represented by the EEG intensities associated with the frequencies $f_m \pm f_i$ for $i = 4, 5, 6$. f_5 would correspond 256 bits and whereas f_4 would correspond to 257 bits. The over-emphasis of f_4 and f_5 as compared to f_6 (17 bits) would mean an effective reduction of F_6 to 4-D space. The 2-dimensionality of the retina suggests that coordinates and momenta for a 2-D motion are in question. The general reason for this reduction would be very mundane: gravitational force constraints us to move along the surface of Earth.

c) Also scaled up copies of the basic color and flag manifold representations obtained by modulating higher p-adic frequencies are possible. These representations would naturally correspond to the hierarchy of sensory and motor areas. Primary areas would correspond to 40 Hz, secondary areas most naturally to 28.3 Hz,, tertiary areas to 14 Hz, and associative areas to the p-adic frequencies in alpha, theta and delta bands. 40 Hz band could result by a modulation of 40 Hz p-adic frequency by the 3 delta frequencies below 3.54 Hz plus possible lower frequencies. The interpretation would be in terms of colors in the case of visual cortex. The modulation by the frequencies $3.5, 5$ and 7 Hz would provide secondary representation of the geometric information.

d) Also the p-adic resonance frequencies above 10 Hz should define resonance frequencies associated with the secondary representations obtained by modulating these frequencies with lower p-adic resonance frequencies. The modulation of 40 Hz frequency by the frequencies $f_i = 14.1, 20, 28.3$ Hz would yield also 3+3 representation possibly having an interpretation in terms of the geometric information represented in terms of flag manifold F_6 characterizing the choices of color quantization axis. The numbers of bits associated with the representations would be 23, 9, 251 and and the information associated with the coordinates represented by the 251-bit codon would dominate. The corresponding narrow EEG peaks would be at 11.7 Hz and at 68.3, which could be excited during REM sleep.

In this case the situation would be effectively 2-dimensional and the representation would be more primitive than the one resulting by the modulation of the memetic code. Interestingly, for the model of honeybee dance [49, D7]

flag manifold effectively reduces to a certain 2-dimensional space corresponding to the planar motion of honeybee without any information about velocity. The effective 2-dimensionality of the 40 Hz sensory representations could correspond to the well where-what division of the information processing in lower sensory areas and to the 2-dimensionality of the retina. For the alpha band representation the separately processed dynamical and static information would be integrated. Interestingly, dreaming is known to develop as a cognitive skill during childhood and the first dreams represent static visual images.

d) Also the sub-alpha p-adic bands can modulate each other and give rise to further representations so that rather complex frequency spectrum results. It would seem that modulation is the manner how various type of symbolic representations associated with each other. The non-linear interaction involved with the modulation is analogous to a fusion of two particles such that energy is conserved $(f_1, \pm f_2) \to f_1 \pm f_2$.

6.4.2 Comparison with experimental data

In the sequel the predicted p-adic frequencies and the frequencies defined by their sums and differences are compared with basic experimental data about resonance spectrum of EEG.

1. p-Adic frequencies below beta band

10 Hz 126-bit memetic code

the duration of the bit of this code is .79 ms and somewhat below the duration of nerve pulse. This suggests realization in terms of em or Z^0 field patterns and the relationship with kHz neuronal synchrony suggests itself. Also the realization in terms of cognitive neutrinos might be considered. The activation of the alpha band is associated with the generation of meditative and 'creative' states of mind. This could be naturally due to the especially high information content of the memetic code. One cannot exclude the possibility that alpha band activation corresponds to the projection of some information to the possible multibrained sensory/cognitive representations associated with higher level collective selves. This interpretation is supported also by the observation that the lowest Schumann frequency about 7.8 Hz crucial for the horizontal entanglement between personal magnetic bodies is in alpha band: the modulation by 1.25 Hz p-adic frequency indeed yields a frequency near Schumann frequency. Also Z^0 magnetic cyclotron frequencies are in alpha band: this encourages to think that the alpha band in EEG interacts strongly with ZEG.

7.1 Hz 17-bit code.

Anterior 6-7 Hz theta rhytm is a characteristic rhytm appearing between 3 and 6 years and is strongest at the age of 13-15 years. Also the analogs of the 14 Hz spikes and sleeping spindles at 6 Hz frequency appear in EEG during sleep. 6 Hz spindle could result as the modulation of 7.1 Hz code by 1.25 Hz frequency. The 6-7 Hz band suggest that the modulation by lower frequencies representing higher levels of the self hierarchy is also involved. The presenceof only frequencies below 7 Hz are present suggests that negative energy MEs are responsible for the modulation. The first memories appear after the age of about four years and the generation of memories is most effective at young age. Hence long term memories might be represented as "features" involving a modulation of cyclotron frequency of about 6 Hz.

5 Hz 256-bit code

The band at 5 Hz would correspond to the extremely information-rich 256-

bit code with bit having in good approximation the duration of the memetic codon .78 ms suggesting that also this code is realized in terms of field patterns or cognitive neutrinos. 5 Hz theta band is activated during tasks requiring mathematical skills and 256-bit code could naturally relate to sub-conscious logical thinking.

3.5 Hz 257-bit code.

This extremely information rich code would correspond to our sensory magnetic body. This code could correspond to those short term memories that we interpret as symbolic representations for sensory percepts. The corresponding frequency is 3.5 Hz and time scale .28 seconds very near to the 300 ms time scale associated with P300 response preceiding conscious response to the sensory percept, which means consistency with Libet's findings if magnetic body is the conscious perceiver [18].

The duration of the bit would be 1.1 milliseconds, which is consistent with the average duration of the nerve pulse and slightly longer than the duration of the bit of the memetic codon of .79 ms. The too short duration of the memetic bit has been a long standing head ache in the attempt to interpret nerve pulse patterns in terms of the memetic code. The frequency 909 Hz defined by the duration of the bit is very near to the $n = 3$ cyclotron frequency of proton and spin flip-cyclotron transition frequency of electron in the Earth's magnetic field. These observations inspire the view that our sensory magnetic body correspond to $k = 257$ and that nerve pulse activity defines $k = 257$ code with maximal possible information content whereas cell membrane oscillations in alpha band could correspond to the memetic code already present at the level of DNA.

During deep sleep only 3 Hz band is present. This band emerges first also during the development of infant. This raises the question about whether only the generation of declarative memories ceases during deep sleep and consciousness actually continues at the level of the magnetic body and that that the delta band around 3 Hz transfers information with maximum possible rate from the sleeping brain. The fact that delta band weakens during ageing would mean that the information transfer also weakens.

2.5 Hz 43-bit code, 1.77 Hz 37-bit code, and 1.25 Hz 13-bit code

Three narrow delta bands at $\tau = 400, 566$ and 800 ms corresponding to $k_{eff} = 258, 259, 260$ are also predicted. $k_{eff} = 260$ corresponds to a cognitive code with $k = 13$ bits. This is the number of bits of the code associated with microtubular strands assumed to play key role in the coding of declarative long term memories. It would be natural that declarative long term memories would be coded by frequencies below those associated with our sensory percepts.

.44 Hz 29-bit code and .31 Hz 131-bit code

The presence of these codes is suggested by the 3 Hz EEG peak during deep sleep, which cannot result by the modulation of 10 Hz memetic code by 7.1 Hz code but could be due to the modulation of 3.54 Hz code by these codes and presumably also codes with lower frequencies. These codes could be involved with the transmission of information during deep sleep from brain. The corresponding narrow delta bands would be at $\tau = 2263, 3200$. What is highly interesting is that the duration of the bit of 131-bit code is 40.9 Hz. The duration of the bit of 29-bit code is 12.8 Hz, the upper edge of the alpha band.

3. p-Adic frequencies above alpha band

14 Hz 23-bit code.

14 Hz sleeping spindle frequency corresponds to $k = 253$ and 23-bit code with

$\tau_b = 3.1$ ms and $f_b = 325$ Hz. Sleeping spindles could result from the disappearence of higher modulating frequencies for 14 Hz p-adic resonance frequency when the EEG power is transferred to the lower frequencies. This would imply that the EEG power dispersed in a range of EEG frequencies around 14 Hz is concentrated around 14 Hz. The same mechanism would yield enchanced alpha peak when eyes are closed.

20 Hz 9-bit code.
The band at 20 Hz would correspond 9-bit code with $\tau_b = 5.6$ ms and $f_b = 180$ Hz. If the representations based on modulation by frequencies below 10 Hz are present, narrow bands around 20 Hz are expected. Interestingly, audible frequencies are above 20 Hz.

28.3 Hz 251-bit code.
In this case one would have $\tau_b = .14$ ms $f_b = 7.1$ kHz. The realization might be based of cell membrane oscillations (hearing involves oscillations up to 2×10^4 Hz). A very high number of cyclotron harmonics would be required. Of course, it could occur that only a part of codons are realized due to the neurophysiological limitations on the harmonics of the fundamental frequency. The EEG of a dog subject to oscillatory monochromatic illumination exhibits a cortical resonance around 27 Hz. An alternative interpretation is as a frequency resulting by the modulation of 20 Hz frequency by 7.1 Hz frequency or of 40 Hz frequency by 14.2 Hz frequency.

40 Hz 125-bit code.
40 Hz band has a width of about 6 Hz, contains several cyclotron frequencies, is associated with the primary sensory areas and disappears during sleep. The code is very information rich which explains why 40 Hz band is so important. The frequency defined by the duration of the bit is $f_b = 5$ kHz so that full realization of the code might be based on membrane oscillations: also Z^0 magnetic realization analogous to that involved with hearing can be considered The origin of 40 Hz band has been already discussed. 40 Hz frequency would correspond to a magnetic body with a size which is fraction 3/40 of the size of our sensory magnetic body would be in question. Interestingly, the lowest Schumann frequency associated with the Earth's inner core is around 40 Hz [D11, D12]!

56.7 Hz 3-bit (or 83-bit) code and 80 Hz 2-bit (or 31 bit) code.
During deep sleep a frequency band in the range 60-70 Hz appears. This band could result as a modulation of 56.7 band by frequencies below beta band. 80 Hz is the microtremor frequency of retina. For 31-bit code (31 is Mersenne prime) the duration of bit is $\tau_b = .4$ ms and essentially one half of that for memetic codon.

2. Comparison with the findings of Nunez about narrow resonances

It is interesting to compare the predictions of the proposed model with the existig evidence for narrow EEG bands [34]. Rather encouragingly, all the frequencies identified by Nunez correspond within experimental accuracy to the frequencies resulting as a modulation of the memetic frequency band by sub-alpha p-adic frequency bands.

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 [34]. Many of these bands are near but not exactly equal to the frequencies defined by cognitive codons assuming $T(2, 127) = .1$ s. 7 Hz band forms an exception. There is also a scale uncertainty but this does not help to

scale the frequencies to the p-adic frequencies.

17 Hz band is not near to any p-adic frequency. What is important that the frequencies 3,5, 7 Hz differ by 10 Hz memetic frequency from the frequencies 13, 15, 17 Hz. This supports the view that the peaks in beta band result as a modulation of the memetic band by lower p-adic bands. This leads to a following picture.

a) 11.25, 11.77, 12.5, 13.54, 15, and 17.1 Hz bands are obtained by shifting the cognitive bands below 10 Hz by the memetic frequency 10 Hz. Besides the narrow peaks near to those identified by Nunez also peaks at 11.77, 12.5 and 13.54 Hz are predicted, the latter frequency being rather near to the sleeping spindle frequency.

b) Modulation yields also difference frequencies below alpha band. Hippocampal theta band (which actually extends from about 4 to about 12 Hz) could contain the cognitive bands around 3.5, 5, 7 and 10 Hz (257, 2, 17 and 127 bits or 256, 2, 16, and 126 bits) and the bands at 6.5, 7.5, 8.23, 8.75, 11.25, 11.77, and 12.5 Hz resulting by the modulation of the alpha band by the lowest cognitive bands. Modulation would yield also 3 Hz frequency which could be the peak identified by Nunez so that all peaks identified by Nunez are predicted by the theory. Note that the peak at 7.5 Hz is very near to the Schumann resonance and 8.75 Hz frequency belongs to alpha band.

c) The alpha peak around 11 Hz and has a width of order 1 Hz. Within experimental accuracy this frequency would result by modulation of memetic frequency $f_m = 10$ Hz by 1.25 Hz frequency. If this frequency corresponds to some cyclotron frequency, 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.

6.4.3 Realization of the resonance frequencies as magnetic transition frequencies

There are several questions to be answered about the realization of p-adic frequencies as magnetic transition frequencies.

1. What ions are plausible for the realization of cyclotron frequencies?

The requirement that only ions with full electronic shells are possible is very restrictive but not strong enough. The observation that EEG bands correspond to the periods of the periodic table led to the idea that the new physics at magnetic flux tubes might allow a wide range of elements but this idea is quite too general to allow any concrete model and led to un-natural constructions. In order to get lost to (or rather, to return from!) a garden of branching paths one could be very conservative and assume that only the biologically important ions are involved. For K^+ (7.5 Hz), Cl^- (8.5 Hz), Fe^{+2}(10.8 Hz), Na^+ (13 Hz), Ca^{+2}(15 Hz), Mg^{+2} (26 Hz), Li^+ (42.9) cyclotron frequencies are near to the p-adic frequencies 7.1, 10, 14.2, 27.3, and 40 Hz. Note that 20 Hz frequency is lacking. Alpha band contains also Al_+ (11.1 Hz) which might be of biological relevance. All the ions of trace elements Cr, Cu, Fe, Se, Zn, Co or of simple molecules of them might be of significance: the cyclotron frequencies of Zn^+ and Cu^+ are 9.4 Hz and 9.6 Hz. Alpha band is clearly strongly represented.

In TGD framework the molecules containing only hydrogen and some heavier atom are in a very special role since hydrogen has vanishing Z^0 charge. Thus also the ions of molecules of form AH_n might be involved. Examples are PH_2^- and SH^- (9.1 Hz) (alpha band again), NH^-, CH_3^- (20 Hz), and CH_2^{-2} (42.8 Hz). This would bring in also 20 Hz p-adic frequency.

2. What p-adically scaled versions of the Earth's magnetic field are plausible?

The spectrum of sferics (electromagnetic perturbations of the atmosphere) co-incides above 20 Hz with that of audible frequencies and extends up to 2×10^4 Hz. In delta band the spectrum of spherics resembles the delta band of EEG [40]. If one assumes that the spectrum of spherics is relevant for brain consciousness as the notion of magnetic body suggests, then the most plausible values of k_{eff} are $163, 166 = 2\times 83, 167, 169$ and 173. A little expection show that if the value of magnetic field scales as $1/L^2(k)$, it is not possible to obtain theta and delta bands for the ions discussed above since the scaling $169 \to 173$ is $1/64$ and quite too large taking even 40 Hz frequency below 1 Hz. If the value of the magnetic field scales as $1/L(k)$, the situation however changes since $k = 169 \to 173$ means 1/8-fold scaling and the resulting frequency range is in $.1 - 5$ Hz for $k = 173$ so that all EEG bands result in this manner.

$1/L(k)$-scaling could be understood as resulting from the near-criticality of the superconductor involved. The point is that for type I superconductors near criticality magnetic flux quanta are not flux tubes but consist of stripe like structures. If the thickness of the stripe defines the p-adic length scale involved, then a correct scaling indeed results. Criticality is also required on general grounds: biosystem must be extremely sensitive and transitions from superconductive to non-superconductive phase can be used for control purposes. Also the realization of intentionality as a generalized motor action of the magnetic body requires criticality.

Scaled up frequencies at $k = 167$ space-time sheet are in 14-80 Hz range. At $k =_{eff} = 166$ the range is $27.3 - 113$ Hz. At $k = 163$ the range is $56 - 320$ Hz. The cerebellar resonance frequency is around 200 Hz. It could correspond to the p-adic frequency 226.3 Hz realizing 49-bit representation with the duration of memetic codon equal to 4.4 ms and frequency defining by the duration of bit equal to $f_b = 1.1 \times 10^4$ Hz belonging to the range of audible frequencies. For the 61-bit representation for 320 Hz (realized by Li_+) the duration of the bit would correspond to frequency $f_b = 19.5kHz$ Hz at the upper limit of the audible frequency spectrum and also of the spectrum of sferics.

3. What is the many-sheeted dynamics of the modulation of frequency bands by frequency bands?

The dropping of ions between magnetic flux quanta corresponding to different p-adic primes could give rise to frequencies which are linear superpositions of the cyclotron frequencies associated with the two space-time sheets. The experimental findings of Peter Gariaev [10] were explained by using this model. If one assumes interaction with the final state particles in the dropping process this mechanism produces both $n_1f_1 - m_2f_2$ and $n_1f_1 + m_2f_2$ type frequencies as required by the symbolic representation of qualia and their conjugates.

For instance, if the BE condensate of ions at the larger space-time sheet, call it b, contains ions in states $n_b = 0$ and $n_b = m_2$, the dropping $(n_a = n_1, n_b = m_2) \to (n_b = 0, n_b = 0)$ involving the interaction of ions at the larger spacetime sheet liberates the energy $n_1\omega_1 + m_2\omega_2$ whereas the dropping $(n_a = n_1, 0) \to (n_b = 0, n_b = m_2)$, liberates the energy $n_1\omega_1 - m_2\omega_2$. Depending on whether there is population inversion at the larger space-time sheet, either of these transitions dominate. This would give rise to either $f_1 + f_2$ or $f_1 - f_2$ type EEG frequencies.

4. Can one speak about intentional motor control of the magnetic body?

The cyclotron frequencies of the ions involved are not precisely equal to the p-adic frequencies and the question is how it is possible to tune the magnetic transition frequencies. Here the intentional variation of the local value of the Earth's magnetic field suggestes itself in accordance with the idea that magnetic body is able to perform motor activities. The simple variation of the thickness of an existing flux tube intentionally does not seem plausible: p-adic variants of magnetic flux quanta should be involved somehow.

The hint comes from the observation that the changes of percepts demonstrate the appearence and disappearence of EEG bands. This suggests that magnetic flux tubes corresponding to given p-adic prime can disappear and appear and this could be due to intentional action at some level of the magnetic self hierarchy. Here the old idea of wormhole magnetic field defined as a pair of parallel magnetic flux quanta with opposite time orientations and vanishing total energy suggests itself [C4]. Only the positive energy flux quantum would carry ordinary ions. An intentional creation and annihilation of wormhole magnetic fields would provide the magnetic body with a topological dynamics leading to a disappearence or appearence of new EEG bands and modulations of bands by bands. The TGD based explanation of the Comorosan effect [41] in [C4] was based on wormhole magnetic fields at the level of enzyme-substrate interaction. This suggests that intentionality might be realized also at the level of molecular magnetic bodies.

5. What about spin flip frequencies?

Spin flip frequencies could define simple symbolic representations analogous to flag variables in computers. All p-adic frequencies down in EEG range down to 14 Hz are realized as spin flip frequencies in the Earth's magnetic field.

a) The spin flip frequencies near 226.3 Hz are $f_s(Na^+) = 222$ Hz, $f_s(Al^+) = 218$ Hz and $f_s(Mn^-) = 208$ Hz. 80 Hz corresponds to the spin flip frequencies of Cl in a good approximation. Spin-flip frequency for K (39 Hz) could define simple symbolic representations in 40 Hz band. The spin flip frequency of Au (which might have some relevance for consciousness) equals to the sleeping spindle frequency 14 Hz.

b) The scaled down versions of these frequencies at $k = 173$ space-time sheet are 27.3 Hz, 10 Hz, 5 Hz and 1.77 Hz so that all p-adic frequencies except 7.1 Hz and 3.54 Hz, 1.25 Hz are realized as spin flip frequencies.

6.4.4 How EEG spectrum reflects the change of percept?

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 by Revonsuo using autostereograms [42]. There was no detectable difference in the power spectrum at 36-44 Hz range in the situation when autostereogram 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.

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 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 were much wider than the widths of the narrow sub-bands reported masked by other EEG activity according to [34].

The lapse of time would correspond to the fact that sensory experience is geometric memory with time span of about 300 ms as demonstrated by Libet's experiments. There could be also some time lapse between the unified percept and 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 sensory representation at the sensory magnetic canvas has been generated. The observing self would be indeed the magnetic self rather than brain.

The temporary increase of the EEG power could be assigned to the emergence of the symbolic mental image in the cortex representing the new percept. For the autostereogram the unified percept is constructed essentially by a back projection to the sensory organ and the enhanced activity could be a correlate for the back projection. One could also argue that the EEG power correlates with the experience about change of the percept and is thus represents rather high level information.

The replacement of the visual representation by a new one could involving resetting of the old representation: this is much akin to what occurs when the image on computer screen is updated. The model for the symbolic representations based on modulation suggests that the situation is same as in the case when eyes are closed. The enhanced alpha activity results due the fact that most of the frequencies modulating memetic frequency disappear and the conserved EEG power goes to $f_1 = 1.25$ Hz band and yields 11.25 Hz or 8.75 Hz. In present case also some modulating frequencies in beta band besides those below beta band could disappear, and the power of 40 Hz band dispersed in wide frequency range would concentrate in a narrow band. If only 14 Hz, and 20 Hz modulating frequencies disappear, then narrow beta bands would not suffer changes. In order to test this model the fate of various narrow bands below 40 Hz and the detailed redistribution of power in 40 Hz band should be studied.

According to [45] the transition to meditative states replaces alpha waves by gamma waves in $40 - 45$ Hz range followed by alpha dominance and finally by the dominance of $4 - 5$ Hz theta. The model for the transition is based on the idea that EEG bands are like boxes containing some maximum amount of EEG power with the total EEG power being constant. The energy in alpha band is first transferred to delta and theta bands: the modulation of 40 Hz band by alpha band is transformed to a modulation by delta and theta bands and 40-45 Hz band results. Then the energy in 40 Hz band can flow to alpha band whereas the energy from theta band flows to delta band: alpha band is enhanced since the modulation is by delta band only. After this alpha band energy can flow to theta band. Concluding, it would seem that both 40 Hz enhancement during changing percept, the enchancement of the alpha peak when eyes are closed, and sleeping spindles at 14 and 6 Hz are based on the same basic mechanism.

6.4.5 Sleep, wake-up and the notion of magnetic body

The amplitudes associated with the higher EEG frequencies get much weaker during sleep. This is what the notion of magnetic body allows to expect since both sensory representations and the associated symbolic and cognitive representations are absent. This is achieved if the 10 Hz, 14 Hz and 40 Hz and possibly also 56 Hz representations are de-activated. Analogous conclusion holds true to motor representations. It is indeed 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 rhytm of 200 Hz. It is natural to assume that these subselves remain in wake-up state and take care of the basic functioning of the body.

As already found the theory allows to understand both the enhancement of alpha band during relaxed state and the occurrence of sleeping spindles at 14 and 6 Hz as resulting from the disappearence of lower modulating frequencies so that the EEG power dispersed by the modulation is concentrated around corresponding p-adic frequency.

The theory predicts also correctly the well-known division of the sleep to different phases [44]. Sleep cycle divides into 4 NREM periods and REM period. NREM stages correspond to a relaxed state dominated by alpha rhytm and 3 stages during which lower EEG frequencies begin to dominate. During deep sleep the dominating frequencies are around 3 Hz which could be interpreted as resulting from the modulation of 3.54 Hz band by .31 Hz 131-bit band with very high information content and duration 24.4 ms of single bit ($k_{eff} = 262 = 2 \times 131$) or by .44 Hz 29-bit p-adic band ($k_{eff} = 261$). The prediction is that the sleep stages correspond to the transition sequence $\rightarrow 10\ Hz \rightarrow 7.1\ Hz \rightarrow 5\ Hz \rightarrow 3.5\ Hz$, where the frequency in question gives the largest p-adic frequency appearing as a resonance frequency in the EEG. During REM sleep the frequency band 60-70 Hz appears and can be interpreted as excitation of sub-beta frequencies modulating 10 Hz and 56.7 Hz p-adic frequencies. Probably also 40 Hz frequency is excited.

Mesoscopic patterns with a duration of about 400, 566 and 800 ms during sleep corresponding to frequencies below 3 Hz are predicted. If the size of these structures scales with frequency as $L = v/f$, v EEG phase velocity, it would be of order $6.7 - 13.4$ cm and thus of order size of brain hemisphere and entire brain. Hence this level could correspond to the macro level in the hierarchy of the coherent EEG patterns. What is interesting is that 1.5 Hz frequency is near to the frequency of breathing.

The fact that theta and delta bands are active during sleep suggests that there could be a transmission of abstract information from brain during sleep. The process known as a consolidation of long term memories could be one activity of this kind. 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. Sleeping brain is indeed in a metabolically ideal state for receiving negative energy MEs. Wake-up brain would be specialized in making memory recalls and sleeping brain in answering them.

One could consider the possibility that EEG MEs at these frequencies project some features to the 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.

6.5 Features as AM modulated non-periodic mesoscopic EEG patterns represented by MEs and the relationship to genetic and memetic codes

The notion of p-adic cognitive representation seems to have an impressive explanatory power. These representations are however local in the spatial degrees of freedom, and the further challenge is to understand how the p-adic codons from various points of cortex are combined to more complex features/symbolic mental images. The work of Freeman with odour perception gives valuable guidelines in this respect [19]. The findings of Freeman suggests that neurons in a given cortical area define temporally synchronous patterns, features. The temporal synchrony would mean that all spatial points correspond to the same p-adic codon in the temporal domain. There is however an arbitrary dependence of the feature on the two transversal coordinates of the cortical surface for a given time value. Hence the situation is 3-dimensional but the third dimension is time rather than space.

Also for MEs it is possible to choose arbitrarily the behaviour of the field pattern on the coordinates of the 2-D transversal cross section of ME. Temporal coherence in turn corresponds to the arbitrary but synchronous dependence of the field pattern on the temporal coordinate at this cross section. Thus MEs are ideal for the communication of the information contained by features to the magnetic body. The following discussion is restricted to the memetic code but generalizes to all p-adic codes in an obvious manner.

6.5.1 Features as AM modulated EEG patterns

The coherence lengths for EEG inside cortex are n general much shorter than on the surface of the skull and complex patterns are encountered. In particular, synchoronous cortical EEG patterns with coherence length of order 1-2 cm appear (size of Brodmann's areas). Freeman identifies these patterns as basic units, 'features', of perceptual activity (the activity related to subjective experience rather than sensory input) [19], and calls these patterns mesoscopic activity as opposed to the microscopic activity represented by nerve pulse patterns. According to Freeman these patterns are observed besides olfactory bulb also in visual, auditory and somatic cortices.

These synchronous EEG patterns have a non-periodic time dependence which does not depend on position: this would be consistent with the frequency coding of the time span of declarative memory. The amplitude is spatially amplitude modulated. The AM patterns are measured at two-dimensional surface so that the question whether the spatial amplitude modulation is 3-dimensional or 2-dimensional remains open. The patterns are recurring 2-7 times per second, which corresponds to theta band in frequency space. This conforms with the assumption that memories are coded by the same features as direct experiences and that carrier frequency is in theta range unlike for purely symbolic representations of sensory experiences for which it is in gamma range. The duration of the patterns is $T = 80 - 120$ ms.

6.5.2 MEs as AM patterns representing features

MEs with transverse cross section of about 1-2 cm are excellent candidates for TGD counterparts of AM patterns. MEs allow arbitrary direction and magnitude of transversal polarization and arbitrary time dependence which does not depend on position. 2-dimensional instead of 3-dimensional AM patterns are

predicted. Note that MEs in question are like lightfronts going through the two-dimensional surface where the measurement is performed. One might argue that the character of MEs as topological field quanta of classical radiation means that they are not suffiently general to model the nearby ELF fields in brain. This might be the case. On the other hand, the solution ansatz defining MEs is extremely general [C4]. In geometric optics picture this means that paths of light rays inside MEs can be also curvilinear lightlike curves expressible as gradient lines for a Hamilton Jacobi funtional S whereas the transverse polarization is defined by a gradient of a polarization function E.

For boundary MEs the effective phase velocity might be EEG phase velocity along the entire magnetic flux tube of the Earth's magnetic field and a representation of third person aspects of declarative long term memories could be in question. For interior MEs representation of sensory data would be in question. Nothing excludes the possibility that both options are realized.

6.5.3 Genetic code and odours

The interpretation of AM patterns as subselves representing standardized mental images is natural. The average duration of these subselves is of 100 ms which is the duration of the memetic codeword [D1]. According to Freeman, the time dependence of AM patterns is chaotic: this does not however mean that it is random. That also time coding is involved looks plausible because both temporal and spatial patterns of nerve pulses are crucial for the neural coding of odours [46].

The first thing to come in mind that temporal patterns correspond to memetic code words having length of almost 127 bits ($2^{127}-1$ patterns are possible) and representable as superpositions of Fourier components with frequencies $f_n = n/T$, $n = 1, ..., 127$ with coefficients which in suitable units are one or zero (with certain error margins of course). Only 126 bits would represent information and the the remaining almost full bit would be kind of error correction bit.

There are however some objections against this identification.

a) p-Adic length scale hypothesis would predict duration of 100 ms for AM patterns representing memetic code words. The length variation for MEs is however possible and 100 ms MEs predicted by p-adic length scale hypothesis could be interpreted as resonant MEs in this picture, ELF frequency counterparts of on mass shell particles whereas other durations would correspond to off-mass shell 'virtual' MEs. This interpretation is consistent with the generalization of the ideas of Jaynes (see the chapters about semitrance in the last part of [4]).

b) That memetic code could be represented also in terms of MEs conforms with the computer metaphor which suggests myriads of representations of the memetic code. On the other hand, the highest frequency involved would be of order kHz and outside EEG range. Furthermore, AM patterns should represent abstraction and classification of temporal nerve pulse patterns associated with the memetic code words.

The simplest thing one can imagine is that a compression of the $2^{127}-1$ neuronal memetic codewords to genetic code words having length of 7 bits giving 127 code words occurs: in this case the the highest frequency would be in the range $58.3 - 87.5$ Hz which relates very naturally to the EEG frequency range and is above the 40 Hz band and various lower bands related to the place coding.

One can however argue that just as at DNA level only the 64 mutually consistent Boolean statements amongst the $2^7 - 1 = 127$ Boolean statements are realized physically. This would allow a realization as a "fast amplitude

modulation" of the fundamental frequency $f_0 \in [8.3 - 12.5]$ Hz carrier alpha wave by multiples nf_0, $n = 2, 3, 4, 5, 6, 7$ of f_0. What is highly non-trivial and encouraging that the carrier wave frequencies would be in alpha band! Alpha band would act provide the universal carrier waves and placecode for features whereas gamma band would code for simple sensory qualia. For 80 ms *resp.* 120 ms *resp.* 100 ms the range of modulating frequencies would be $25 - 87.5$ Hz *resp.* $16.7 - 58.3$ Hz *resp.* $20 - 70$ Hz. What is fascinating that (at least) odour perception indeed involves characteristic frequencies in the interval $20 - 80$ Hz [19]!

A further fascinating accident is that also the range of audible frequencies starts around 20 Hz! In case of hearing the presence of frequencies $f_n = nf_0$ outside the EEG range up to 1 kHz, which is in fact very special frequency for hearing, is not excluded. Perhaps in case of hearing memetic code at the level of AM patterns does not reduce to the genetic code anymore. This would explain the completely exceptional role of language in evolution. This hypothesis is testable by studying EEG in Wernicke and Broca areas.

One can imagine also other reductions of the memetic code to the genetic code. For instance, if only the number of positive binary digits in the code word matters, there would be only 127 different codons. For nerve pulse patterns the duration of single nerve pulse is however longer than 1/1027 seconds so that the number of nerve pulses per .1 seconds could actually vary from 1 to about 64, and genetic code would result. This option looks natural in the case of rate coding with almost random time intervals between nerve pulses. If stochastic resonance forcing the autocorrelation function of the nerve pulse pattern to have peaks at the multiples of the forcing frequency is involved, then the number of distinguishable code words would be also around 64.

6.5.4 Magnetic representation of the genetic codewords

Genetic code for odours is consistent with the assumption that the frequencies in the range $20 - 80$ Hz are involved with the assignment of the AM patterns as features with the active sensory projector MEs at the surface of cortex taking care of place coding and correspond to harmonic multiples of the cyclotron frequencies of single ion.

The atoms in Neon period of the periodic table (Mg, Si, Na, Al, P, S, Cl, Ne) have cyclotron frequencies in the the alpha band with Ne itself excluded ($f_c = 15$ Hz) and Na ($f_c = 13$ Hz, sensory-motor rhytm) marginally included. For even multiples of cyclotron frequencies cyclotron transitions occur with much slower rate than for odd multiples and this might be a problem.

Codewords could be represented consciously at the magnetic body using a code in which the occurrence or non-occurrence of cyclotron transition with frequency $f = nf_0$, $n = 2, ..., 7$ codes something about the percept. Note that in case of 40 Hz band coding for sensory percepts, the harmonics of the carrier frequency are not present and place coding codes only for place. This partially explains why the number of odours is so large as compared to the number of, say, basic colors and tastes. Of course, also the spatial pattern representing percept is important. Note that in case of odour perception of humans the objects of the odour field should be rather diffuse although probably present.

In this framework the cyclotron frequencies in the alpha band would naturally represent carrier waves coding for the distance of the object of perceptive field on the sensory magnetic canvas. This prediction could be tested by looking whether attention directed to a moving object is accompanied by a shift of some

cyclotron frequencies in the alpha band. Also theta band might have similar role in the storage of memories as modulation patterns.

In the case of vision trivial code word ('darkness') would correspond to mere alpha wave which indeed begins to dominate when eyes are closed. Alpha wave would assign both the color quale black and the mental image 'darkness'/'no sensory input' to the region of the perceptive field.

6.5.5 Data compression as frequency cutoff and threshold coding

Some comments about the compression process and about the plausiblity of the representation of Boolean statements at the level of conscious experience are in order.

a) The compression process simply drops away the bits corresponding to the frequencies above 80 Hz. This kind of frequency cutoff is precisely what is carried out in quantum field theories when the effective action for low energy theory is constructed. Technically this means functional integral over the frequencies and wavelengths above the cutoff frequency and cutoff wavelength. Thus brain would apply the counterpart of the same procedure as quantum field theorist or statistical physicist uses to build simplified models applying in time and length scales above the inverse of the cutoff frequency and cutoff wavelength.

b) The values of the EEG potentials need not be discrete to yield bit representation at the level of the conscious experience if magnetic quantum phase transition is induced only if the intensity of the oscillatory magnetic perturbation defined by ME is above certain threshold value. Threshold coding is actually what is expected since phase transitions should occur as a kind of domino effect. There is also an upper bound for the harmonics of the cyclotron frequency which can be amplified to a macroscopic quantum phase transition. This yields automatically frequency cutoff even in absence of a frequency cutoff for EEG waves.

6.6 Does neuronal synchronization allow to understand the role of Z^0 MEs and how p-adic cognition is realized?

Cognitive functions like perception, memory and language are based on parallel and highly distributed information processing. One of the major unresolved questions of brain science is how the information can be integrated and how coherent representational states can be established. Temporal binding has been suggested as a mechanism making this possible. The synchronized neuronal firing has been proposed as an underlying mechanism of temporal binding inside and between various cortical areas. The assemblies of neurons firing synchronously could even define neuronal correlates for objects of perceptive field. Synchrony mechanism would apply also to motor actions and allow selection of perceptually and behaviourally relevant information. Temporal binding has been proposed by Crick and Koch as a necessary and sufficient condition for the generation of conscious percepts.

In TGD framework the synchronously firing neuronal assemblies are excellent candidates for sub...selves. Synchrony should result from the presence of a TGD counterpart of a computer clock ticking with a frequency of order kHz associated with the memetic code. What came as a surprise was that the question about the origin of this clock relates so closely to two fundamental open questions in TGD inspired theory of consciousness, namely:

a) What is the fundamental role of Z^0 force and Z^0 MEs at brain level?

b) How are p-adic cognitive representations generated from real sensory input and how p-adic intentions are transformed as real actions at the level of brain? Shortly: how is the interaction between p-adic and real physics realized?

The most plausible explanation for the synchrony is as resulting from the presence of Z^0 MEs. This hypothesis fits nicely with the model of nerve pulse based on Z^0 MEs and with the millisecond time scale of nerve pulse duration. Z^0 MEs would induce oscillations of membrane potential and in turn force synchronous firing and bring thus order into neuronal chaos so that self-organization patterns begin to develop.

6.6.1 Temporal binding by synchronization

The article of Engel *et al* [47] provides an excellent representation about the development, motivations and the recent empirical status of temporal binding by neuronal synchrony. The article contains also references to the original work and the references to the results represented below can be found from this article and are not separately mentioned.

There are many reasons why for binding by synchronization.

a) Synchrony provides the counterpart of computer clock making possible a precise presynaptic summation of the neural inputs in turn implying fast and precise and fast neural processing. Synchrony makes also possible coordinated changes of the synaptic efficacies: this is of obvious importance for the associative learning at synaptic level. Also the robustness of neural processing is implied: army does not need single man.

b) Synchronized neuronal assemblies define natural candidates for the neural correlates of conscious percepts and synchronization might be a basic mechanism of attention.

c) The information processing in brain is known to be highly parallel and distributed: for instance, there are about 30 distinct visual areas in monkey brain. Synchronization between various sensory, motor and associative areas has been proposed as a candidate for the mechanism generating coherent gestalts.

d) Synchronization has been proposed as key element for functions like learning and short term memory. Quite generally, it seems that non-synchronized brain regions are analogous to a computer without a global computer clock and thus seats of neural chaos.

e) Synchronization has been also suggested by Crick and Koch to be a necessary and sufficient condition for conscious experience to occur. From the TGD point of view and on general philosophical grounds this hypothesis seems to be too far-fetched. Rather, synchronization seems to provide the counterpart of computer clock in TGD framework feeding order in neuronal chaos. Synchronized regions define however natural correlates for sub...selves.

6.6.2 Empirical evidence for synchronization

Neuronal synchronization is by now a well established phenomenon (see [47] and references therein).

a) Synchronization inside and between sensory, motor and associative areas has been established. Synchronization has been observed also inside subcortical structures such as lateral geniculate nucleus, superior colliculus and brain stem and even in retina [47]. Synchronization has also found even between areas belonging to different hemispheres.

b) Synchronization in visual system predicts synchronization inside visual areas and between areas across large cortical distances. These predictions have been verified. For instance, two neurons fire synchronically only if they respond to the same visual object but not otherwise. It has been found that the basic criteria for the gestalt formation (such as continuity and coherent motion), shown to support by perceptual grouping, are also important for the formation of a synchrony between the neurons of the visual cortical. Synchronization has been studied also in non-visual modalities: synchronization in the olfactory systems of various vertebrate and invertebrate species has been found and both auditory and somatosensory cortex has been demonstrated to show precise synchronization. Synchronization has been observed also in hippocampus and frontal cortex.

c) Synchronization has been observed in motor areas and between areas of sensory and motor system. For instance, the study of cats performing visuomotor tasks has shown that the synchronization between visual and parietal as well as visual and motor areas occurs in those task epochs where the animal processes attentively information to direct the required motor response.

d) Synchronization seems to serve as a neural correlate for conscious percepts [47]. For instance, in binocular rivalry, the neuronal activity in V1 does not change when the consciously perceived stimulus changes. However, highly synchronous firing is what distinguishes the perceived stimulus from the non-perceived one. In TGD framework this would mean that the entanglement with magnetic body serving as the correlate for the directed attention would have synchronization as a neural correlate. If sensory organs are sites of the primary sensory qualia, Z^0 MEs responsible for the synchronous firing would be correlates for the direction of attention and giving among other things to the selection of the consciously perceived stimulus and which is motor action in a generalize sense. Also negative energy Z^0 MEs entangling with the sensory pathway, perhaps with sensory organ, would be involved.

6.6.3 Does neuronal synchronization with millisecond precision require Z^0 MEs?

The time precision for the synchronization is in the millisecond range. This amazing precision for synchrony is something which I personally find difficult to understand in terms of neural circuits. Computer metaphor suggests strongly the presence of a counterpart of a computer clock producing a kHz rhytm. Neither 40 Hz frequency or any frequency in EEG range is enough to achieve this. Indeed, in [47] gamma activity between 20-70 Hz is carefully distinguished from synchronization. The fact that kHz corresponds to the duration of single bit for the memetic code suggests that synchronization is closely related to the realization of the memetic code whose presence is one of the basic predictions of TGD based approach to conscious brain. Gamma band synchrony would be a consequence rather than the reason in this framework and associated with EEG patterns represented by MEs providing compressed mesoscopic representations of information at neuronal level and thus representing what might be called features.

Thus kHz rhytm suggests strongly itself as a fundamental rhytm defining the counterpart of a computer clock in brain and the basic question relates to the origin of this rhytm. Concerning the physical realization of synchronization there are two possibilities in TGD framework: millisecond rhytm is either in EEG or ZEG.

1. Is millisecond rhytm present in EEG?

Electromagnetic MEs oscillating with kHz frequency are the first candidates for the synchronizing agents: they would induce oscillations of membrane potential leading to the synchronization of the neuronal firing. Thalamocortical synchrony could be realized if a bundle of radial em MEs emerging from the thalamus takes care of the synchronization of neural firing (much like march song serves as a pacemaker). The dynamical selection of the objects of the perceptive field as synchronized regions could be realized by transitions transforming em MEs to Z^0 MEs and vice versa by color rotations.

There is an objection against this option: this kind of synchronous oscillation of membrane potentials should have been already observed at the level of EEG and MEG unless it has very low amplitude. EEG and MEG studies demonstrate that high frequency components of sensory evoked potentials exhibit precise neuronal synchrony in the awake state but disappear in deep anesthesia [47]. Also gamma synchronization is enhanced during arousal and focused attention as well as during a conscious perception of distinct auditory events and of coherent visual stimuli during attentive visual search. All these findings are however related to the part of EEG which reflects reactions to the stimuli and therefore they do not provide support for the presence of background kHz rhytm in EEG.

2. Is millisecond rhytm present in ZEG?

In TGD framework one must consider seriously the possibility that Z^0 force could have a crucial role in brain functioning: in particular Z^0 MEs could act as synchronizers of the neuronal activity. The lack of appropriate measurement techniques for ZEG would explain why the memetic rhythm has not observed directly yet. The mechanism predicts that the evoked responses in EEG and MEG should reveal synchrony and this is what has been found.

The rough formulation of the model goes as follows.

a) Classical Z^0 force emerges at cellular length scale but is assumed to be present also in cell membrane space-time sheets in the model for the realization of the memetic code [D9]. What is of crucial importance is that Z^0 interactions become very strong at cell length scales since Z^0 charge densities can be very high. Z^0 interactions of cells could be possible even over astrophysical distances which inspires rather science fictive possibility of biocontrol over astrophysical distances. What makes this more than mere weird speculation is the abundance of various anomalies finding explanation in terms of the classical Z^0 force: in particular, the correlation of radioactive decay rates and chemical reaction rates with astrophysical periods has been reported [48].

b) The join along boundaries contacts of Z^0 MEs with cellular and cell membrane space-time sheets would induce naturally synchronization since atomic nuclei are Z^0 ions and have thus a strong coupling to the classical Z^0 fields.

c) The proposed realization of the memetic code in terms of cognitive neutrinos requires an oscillatory Z^0 field with a frequency defined by the duration of the bit of the memetic code and thus of order kHz (1260 Hz is the precise value implied by the p-adic length scale hypothesis).

d) p-Adic–real phase transition of Z^0 ME would transform intention to a desire about real action or sensory input to a a thought and real Z^0 ME would in turn induce synchrony. For strong enough intensities of Z^0 field nerve pulses would result.

6.6.4 What is the dynamics of volition and thought?

The proposed simplified view leaves open some fundamental questions which basically relate to how the geometric correlate of matter-mind interaction as p-adic–real transformations for space-time regions takes place at brain level. The are two basic questions.

1) How the dynamics of thought generation is realized?
The understanding of the feedback from the sensory (real) level to the cognitive (p-adic) level is required. More precisely, how sensory (real physics) input is transformed to cognition involving generation of p-adic MEs? There are also questions related to the role of neutrinos. What is the role of the spin flips of real(!) cognitive neutrino pairs representing memetic codewords in this process? Are also cognitive neutrino pairs needed besides Z^0 MEs. Do p-adic–real transitions occur for neutrinos?

2) How the dynamics of volition is realized?
Typically, the transformation of p-adic Z^0 MEs to real ones in some part of the cortex induces synchronous neural firing excitating or inhibiting some other regions. In excitatory case this should somehow lead to a cascade in which p-adic Z^0 MEs of excited regions are transformed to real ones. The basic question is what mechanism induces the transformation of the p-adic Z^0 MEs to real ones.

p-Adic length scale hypothesis suggests that some kind of a resonance dynamics possible at kHz resonant frequency and involving a feedback between p-adic and real physics is involved. This leads to the following view about what is involved with volitional action and in the generation of thought.

a) Volition would be volition of personal magnetic body and induce a cascade of volitional acts transformin p-adic MEs to negative energy real MEs in shorter length scales. p-Adic-to-real transformation of Z^0 negative energy ME could occur with a high probability when p-adic Z^0 ME oscillates with a frequency which corresponds to the duration of the bit of the memetic code word which is related to an appropriate p-adic length scale in a simple manner. When out of tune, p-adic Z^0 negative energy ME would transform to a real ME with a low probability.

This would suggest the realization of volition by frequency tuning. Tuning would mean that p-adic and corresponding real ME would have a maximum number of common rational points. Volition is involved also with the selection between percepts (not always by us however) in situations like binocular rivalry. The difference of an imagined almost real motor action and actual motor action would be that the imagined motor action is not induced by the negative energy ME entangling with motor organs but with some higher level of motor pathways. For sensory imagination entanglement would also occur with some higher level of sensory pathway than sensory organ.

b) Nothing precludes the occurrence of also real-to-padic phase transitions and the dynamics of thought could the reversal for the dynamics of volition. Again syncronization and resonance condition would be important. p-Adic length scale hypothesis favours synchronization frequencies which correspond to p-adic length scales. If this picture is correct, volition and thought would be in well a defined sense time reversals of each other with respect to subjective time development.

c) The counter intuitive aspect of the p-adic topology is that p-adic space-time sheets having arbitrarily large size in real sense can be arbitrarily small p-adically. Hence p-adic space-time sheet of infinitesimal size could have contact with systems separated by a real distance of the order of the size of the

observable universe and even larger. If the energy of negative energy ME is by quantization argument of the order $E = 2\pi c/L$, negative energy ME of astrophysical size can result with very low energy costs as p-adic ME is transformed to a real one. These paradoxal aspects are however consistent with the view about the role of magnetic body and MEs for consciousness, and the attempt to deduce in detail the implications might be very rewarding.

6.6.5 A general view about the role of synchrony

The hypothesis that synchronization is due to the presence of p-adic and real Z^0 MEs suggests the following general view about how conscious brain functions.

a) The basic states for the various areas of brain could represent more or less chaotic neuronal activity without synchrony. During sleep primordial neuronal chaos might be realized in the scale of the entire cortex. Negative energy Z^0 ME would select from this sea of chaos islands of order and generate objects of perceptive field or behaviour (by sensory-motor analogy one might perhaps speak of 'behavioural field') realized as subselves. Sensory input or spontaneous neuronal activity could serve as a seed generating p-adic Z^0 MEs at kHz resonant frequency and these would transform to real ones. Real negative energy Z^0 MEs would feed negentropy to the neuronal primordial chaos and generate macrotemporal quantum coherence and thus sharp subselves lasting for a sufficiently long time to contribute significantly to the contents of consciousness and behaviour (note the analogy with a social group: very shortlived member does not contribute significantly to the development of the social group).

b) The question whether there exist non-neuronal correlates for consciousness s definitely settled in this framework: they do exist and correspond to both p-adic and real Z^0 MEs besides em MEs and the synchronous firing of neurons provides a direct experimental evidence for these correlates visible already at the primary sensory areas.

c) The mesoscopic feature level visible in EEG and reflecting the synchrony of Z^0 MEs represents higher abstraction level in which memetic code at Z^0 ms level is compressed to the genetic code: many-sheeted space-time allows to understand the emergence of this level naturally.

Summarizing, this view combined with the general vision about the realization of the various representations represents the first coherent view about the functioning of conscious brain combining all TGD inspired ideas about conscious brain.

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[C1] The chapter *Self and Binding* of [3].

[C2] The chapter *p-Adic physics as physics of cognition and intention* of [3].

[C3] The chapter *Biosystems as superconductors* of [3].

[C4] The chapter *Quantum antenna hypothesis* of [3].

[C4] The chapter *Wormhole magnetic fields* of [3].

[D1] The chapter *Genes and Memes* of [4].

[D2] The chapter *Homeopathy in many-sheeted space-time* of [4].

[D3] The chapter *Macroscopic quantum coherence and quantum metabolism as different sides of the same coin* of [4].

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[D5] The chapter *TGD inspired model for EEG and nerve pulse* of [4].

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[D7] The chapter *General Theory of Qualia* of [4].

[D8] The chapter *Spectroscopy of consciousness* of [4].

[D9] The chapter *Quantum model for hearing* of [4].

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[D12] The chapter *Prebiotic evolution in many-sheeted space-time* of [4].